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EN MECANIQUE

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CALCUL DE FACTEURS D'INTENSITE DE CONTRAINTES DANS UN DISQUE ET UN ANNEAU CHARGES DIAMETRALEMENT AVEC FISSURES SYMETRIQUES DANS LE PLAN DE CHARGEMENT

ANNEXES

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ANNEXE A1

DISQUE COMPORTANT UNE FISSURE CENTRALE

MÉTHODE DE SUPERPOSITION

```
      DIMENSION TET(11),TET1(11),TET2(11),B(11),Y(11),X(11),H(11),Q(11)
      DIMENSION RX(10),RY(10)
      DIMENSION R(20),A(20,20),RO1(11),RO2(11)
      DIMENSION TS(21),COF(21,11)
      INTEGER P
      REAL K1,CB(21,21),KO ,LW
      DATA LC/7/,IMP/8/
      DATA TET(1)/0./,TET1(1)/0./,TET2(1)/0./,B(1)/0./,Y(1)/0./,X(1)/1./,
      DATA Q(1)/0./
    1 READ(LC,10)AF,M
   10 FORMAT(F3.1,I2)
      WRITE(IMP,15)AF
   15 FORMAT(1HO,55X,'A=',F3.1,3(/))
      PI=4*ATAN(1.)
      C=-1/(2*PI)
C
C     CALCUL DES PARAMETRES
C     *********************
C
      H(1)=1-AF*AF
      RO1(1)=1-AF
      RO2(1)=1+AF
      M1=M+1
      M2=2*M
      WRITE(IMP,16)
   16 FORMAT(3X,'N',6X,'TET(N)',5X,'TET1(N)',5X,'TET2(N)',6X,'B(N)',8X,'
     1Y(N)',8X,'X(N)',7X,'RO1(N)',6X,'RO2(N)',7X,'H(N)',8X,'Q(N)')
      DO 100 N=2,M1
      TET(N)=(N-1)*PI/M2
      SI=SIN(TET(N))
    9 CO=COS(TET(N))
      IF(TET(N).EQ.1.570796)CO=0.00
      TET1(N)=ATAN(SI/(CO-AF))
      IF(TET1(N))2,5,3
    2 TET1(N)=PI+TET1(N)
    3 TET2(N)=ATAN(SI/(CO+AF))
      B(N)=(TET1(N)+TET2(N))/2.
      Y(N)=SI
      X(N)=CO
      RO1(N)=SQRT(Y(N)*Y(N)+(X(N)-AF)*(X(N)-AF))
      RO2(N)=SQRT(Y(N)*Y(N)+(X(N)+AF)*(X(N)+AF))
      H(N)=SQRT((1+AF*AF)*(1+AF*AF)-(4*AF*AF*CO*CO))
      Q(N)=SI/SQRT(H(N))
      WRITE(IMP,17)N,TET(N),TET1(N),TET2(N),B(N),Y(N),X(N),RO1(N),RO2(N)
     1,H(N),Q(N)
   17 FORMAT(3X,I2,10(3X,F9.7))
  100 CONTINUE
C
C     CALCUL DES COMPOSANTES DES RESULTANTES DE ETAT B SUR CHAQUE SEGMENT
C     *******************************************************************
C
      DO 200 I=1,M
      RX(I)=2*C*(Y(I+1)-Y(I)+Q(I)*COS(TET(I)-B(I))-Q(I+1)*COS(TET(I+1)-B
     1(I+1)))
```

```
      RY(I)=2*C*((X(I)-X(I+1))+SQRT(H(I+1))*COS(B(I+1))-SQRT(H(I))*COS(B
     1(I))+Q(I+1)*SIN(TET(I+1)-B(I+1))-Q(I)*SIN(TET(I)-B(I)))
  200 CONTINUE
      WRITE(IMP,90)
   90 FORMAT(1HO,10X,'COMPOSANTES HORIZONTALES DES RESULTANTES DE L''ETA
     1T B',///)
      WRITE(IMP,110)((I,RX(I)),I=1,M)
  110 FORMAT(1HO,50X,'RX(',I2,')=',E13.7)
      WRITE(IMP,25)
      WRITE(IMP,120)
  120 FORMAT(1HO,10X,'COMPOSANTES VERTICALES DES RESULTANTES DE L''ETAT
     1B',///)
      WRITE(IMP,130)((I,RY(I)),I=1,M)
  130 FORMAT(1HO,50X,'RY(',I2,')=',E13.7)
C
C     CALCUL DES COEFFICIENTS DE LA MATRICE (SAUF GAMMA(I,J))
C     *******************************************************
C
      DO 300 I=1,M
      DO 300 J=1,M
      K=2*I-1
      L=2*I-2
       A(J,I)=2*(Q(J+1)*COS(K*TET(J+1)-B(J+1))-Q(J)*COS(K*TET(J)-B(J)))
      A(J,I+M)=2*((SIN(K*TET(J+1))-SIN(K*TET(J)))/K+Y(J+1)*COS(L*TET(J+1)
     1))-Y(J)*COS(L*TET(J)))
      A(J+M,I+M)=2*(Y(J)*SIN(L*TET(J))-Y(J+1)*SIN(L*TET(J+1)))
  300 CONTINUE
C
C     CALCUL DES COEFFICIENTS GAMMA(I,J)
C     **********************************
C
      CALL COMBI(CB,20)
      DO 700 N=1,M
      IF(N.NE.1)GO TO 4
      DO 1000 J=1,M
      A(J+M,1)=2*(SQRT(H(J))*COS(B(J))-SQRT(H(J+1))*COS(B(J+1))+Q(J)*
     1SIN(TET(J)-B(J))-Q(J+1)*SIN(TET(J+1)-B(J+1)))
 1000 CONTINUE
      GO TO 700
    4 N1=N-1
      DO 800 P=0,N1
      EX=2*P+1
      LW=1
      IF(P.NE.0)LW=CB(N1,P)
      KO=LW*AF**(2*(N1-P))
      IF(P.EQ.N1)GO TO 6
      DO 800 J=1,M
      COF(1,J)=0.
      COF(P+2,J)=COF(P+1,J)+((2*KO)/EX)*(H(J)**(EX/2)*COS(EX*B(J))-H(J+1)**(
     1)**(EX/2)*COS(EX*B(J+1)))
  800 CONTINUE
    6 DO 900 J=1,M
      A(J+M,N)=COF(N,J)+2*((KO*H(J)**(EX/2)*COS(EX*B(J)))/EX-(KO*H(J+1)
```

```
     1**(EX/2)*COS(EX*B(J+1)))/EX)+2*((Q(J)*SIN(EX*TET(J)-B(J)))-(Q(J+1)
     1*SIN(EX*TET(J+1)-B(J+1))))
  900 CONTINUE
  700 CONTINUE
C
C     RESOLUTION DU SYSTEME
C     *********************
C
      WRITE(IMP,140)
  140 FORMAT(1HO,10X,'MATRICE DES COEFFICIENTS',///)
      WRITE(IMP,80)((A(I,J),J=1,M2),I=1,M2)
   80 FORMAT(10(E11.4,1X))
      WRITE(IMP,25)
      DO 210 I=1,M
      R(I)=-RX(I)
      R(I+M)=-RY(I)
  210 CONTINUE
      M=M2
      N=1
      EPS=0.0000001
      CALL GELG(R,A,M,N,EPS,IER)
      IF(IER.NE.0)GO TO 55
      WRITE(IMP,20)
   20 FORMAT(1HO,35X,'COEFFICIENTS DES TERMES DE LA PREMIERE SERIE',///)
      M=M2/2
      WRITE(IMP,30)(I,R(I),I=1,M)
   30 FORMAT(1HO,50X,'A(',I2,')=',F10.6,/)
      WRITE(IMP,25)
   25 FORMAT(1HO,///)
      WRITE(IMP,40)
   40 FORMAT(1HO,35X,'COEFFICIENTS DES TERMES DE LA DEUXIEME SERIE',///)
      WRITE(IMP,50)(J,R(J+M),J=1,M)
   50 FORMAT(1HO,50X,'B(',I2,')=',F10.6,/)
C
C    CALCUL DU COEFFICIENT D'INTENSITE DE CONTRAINTES
C     ************************************************
C
      TS(1)=0.
      DO 600 I=2,M1
      J=I-1
      TS(I)=TS(J)+(R(J)*AF**(2*J-1))/AF
  600 CONTINUE
      K1=1.+TS(J+1)*2*PI
      WRITE(IMP,45)
   45 FORMAT(1HO,35X,'COEFFICIENT D''INTENSITE DE CONTRAINTES')
      WRITE(IMP,65)K1
   65 FORMAT(1HO,50X,'K1=',F7.5,)
   55 WRITE(IMP,60)IER
   60 FORMAT(1HO,10X,'IER=',I3)
    5 WRITE(IMP,35)
   35 FORMAT(1HO'ERREUR SUR TETA1')
   70 STOP
      END
```

```
      SUBROUTINE COMBI(CB,M)
      REAL DI(21),NU(21),CB(21,21)
      CB(1,1)=1
      DO 301 J=2,M
      NU(1)=J
      CB(J,1)=J
      DO 101 I=2,M
      IF(I.GT.J)GO TO 201
      DI(1)=1
      DI(I)=DI(I-1)*I
      NU(I)=NU(I-1)*(J-I+1)
      CB(J,I)=NU(I)/DI(I)
  101 CONTINUE
  201 CB(J,I)=1
  301 CONTINUE
      RETURN
      END
```

R(S)

ANNEXE A2

DISQUE COMPORTANT DEUX FISSURES SYMÉTRIQUES

MÉTHODE DE SUPERPOSITION

```
      SUBROUTINE INT
      COMMON TETA(101),RPRO(101),STET(101),A(11,101),AP(11,11),CP(11,11)
      COMMON CX(11),CY(11),TSB1(12),TSB2(12),Y(11),Z(11),ANUM(11,10)
      COMMON RX(10),RY(10),R(21)
      COMMON B(21,21),X(11),SUP(11)
      COMMON PI,MM,M1,LC,IMP,NM,B22,B12,CON,CONS,B1,B2,M,GAMMA
C
C     CALCUL NUMERIQUE DES INTEGRALES
C     *******************************
      H=PI/(20*M)
      NDIM=11
      L=0
      NM=10*M-9
      DO 300 I=1,NM,10
      L=L+1
      DO 302 N=1,M1
      DO 301 J=1,11
  301 Y(J)=A(N,I+J-1)
      CALL QSF(H,Y,Z,NDIM)
  302 ANUM(N,L)=Z(11)
  300 CONTINUE
      UPS1=B1*1.E-03
      UPS2=B2*1.E-03
      X(1)=B1+UPS1
      H=(B2-B1-UPS1-UPS2)/10
      V=SQRT(B22-B12)
      DO 105 N=1,M1
      DO 106 I=1,11
      IF(I.GT.1)X(I)=X(I-1)+H
      X2=X(I)*X(I)
      PD=SQRT((X2-B12)*(B22-X2))
  106 Y(I)=X(I)**(2*N-1)/PD
      CALL QSF(H,Y,Z,NDIM)
      S1=SQRT(2*UPS1)*(B1**(2*N-1))/(V*SQRT(B1))
      S2=SQRT(2*UPS2)*(B2**(2*N-1))/(V*SQRT(B2))
      SUP(N)=Z(11)+S1+S2
  105 CONTINUE
      RETURN
      END
```

R(S)

```
      SUBROUTINE GAM
      COMMON TETA(101),RPRO(101),STET(101),A(11,101),AP(11,11),CP(11,11)
      COMMON CX(11),CY(11),TSB1(12),TSB2(12),Y(11),Z(11),ANUM(11,10)
      COMMON RX(10),RY(10),R(21)
      COMMON B(21,21),X(11),SUP(11)
      COMMON PI,MM,M1,LC,IMP,NM,B22,B12,CON,CONS,B1,B2,M,GAMMA

      CALCUL DE GAMMA
      ***************
      AK=SQRT(B22-B12)/B2
      CALL CEL1(RES,AK,IER)
      F=RES
      AZ=1.
      BZ=1.-AK*AK
      CALL CEL2(RES,AK,AZ,BZ,IER)
      E=RES
      GAMMA=B22*E/F-(B12+B22)/2.
      WRITE(IMP,50)
   50 FORMAT(////)

      CALCUL DES RESULTANTES DE L'ETAT B
      **********************************
      CON=(B12+B22)/2.+GAMMA
      WRITE(IMP,70)
   70 FORMAT(1H ,30X,'ARC',20X,'RX',20X,'RY',/)
      CONS=-1./PI
      DO 400 I=1,M
      RX(I)=CONS*(CY(I+1)*(1.-AP(2,I+1)+CON*AP(1,I+1))-CY(I)*(1.-AP(2,I
     S)+CON*AP(1,I)))
      RY(I)=CONS*(CX(I)-CX(I+1)+ANUM(2,I)-CON*ANUM(1,I))+CY(I+1)*CONS*(
     SCP(2,I+1)-CON*CP(1,I+1))-CY(I)*CONS*(CP(2,I)-CON*CP(1,I))
      WRITE(IMP,80)I,RX(I),RY(I)
   80 FORMAT(1H0,31X,I2,17X,F9.6,13X,F9.6,//)
  400 CONTINUE
      RETURN
      END
S)
```

```
      SUBROUTINE RESOL
      COMMON TETA(101),RPRO(101),STET(101),A(11,101),AP(11,11),CP(11,11)
      COMMON CX(11),CY(11),TSB1(12),TSB2(12),Y(11),Z(11),ANUM(11,10)
      COMMON RX(10),RY(10),R(21)
      COMMON B(21,21),X(11),SUF(11)
      COMMON PI,MM,M1,LC,IMP,NM,B22,B12,CON,CONS,B1,B2,M,GAMMA
      M3=2*M+1
C
C     CALCUL DES COEFFICIENTS ET DEFINITION DE LA MATRICE DU SYSTEME
C     ***************(**********************************************
      DO 500 I=1,M1
      DO 501 J=1,M
      B(J,I)=2*(CY(J+1)*AP(I,J+1)-CY(J)*AP(I,J))
  501 B(J+M1,I)=-2*ANUM(I,J)+2*(CY(J)*CP(I,J)-CY(J+1)*CP(I,J+1))
  500 B(M1,I)=SUF(I)
      DO 502 I=1,M
      DO 503 J=1,M
      K=2*I-1
      L=2*I-2
      IS=10*J+1
      II=10*(J-1)+1
      B(J,I+M1)=2*(SIN(K*TETA(IS))-SIN(K*TETA(II)))/K+2*(CY(1+1)*COS(L*
     STETA(IS))-CY(J)*COS(L*TETA(II)))
  503 B(J+M1,I+M1)=2*(CY(J)*SIN(L*TETA(II))-CY(J+1)*SIN(L*TETA(IS)))
  502 B(M1,I+M1)=0.
      WRITE(IMP,110)
  110 FORMAT(///)
C
C     RESOLUTION DU SYSTEME
C     *********************
      DO 600 I=1,M
      R(I)=-RX(I)
      R(M1+I)=-RY(I)
  600 CONTINUE
      R(M1)=0.
      L=M3
      N=1
      EPS=0.0000001
      CALL GELG(R,B,L,N,EPS,IER)
      IF(IER.NE.0)GO TO 15
      RETURN
   15 WRITE(IMP,160)IER
  160 FORMAT(1X,'ERREUR DANS LA RESOLUTION DU SYSTEME : IER=',I3)
      STOP
      END
```

(S)

```
      COMMON TETA(101),RPRO(101),STET(101),A(11,101),AP(11,11),CP(11,11)
      COMMON CX(11),CY(11),TSB1(12),TSB2(12),Y(11),Z(11),ANUM(11,10)
      COMMON RX(10),RY(10),R(21)
      COMMON B(21,21),X(11),SUP(11)
      COMMON PI,MM,M1,LC,IMP,NM,B22,B12,CON,CONS,B1,B2,M,GAMMA
      DATA TETA(1),STET(1),LC,IMP/0.,0.,7,8/
      DATA A(1,1),A(2,1),A(3,1),A(4,1),A(5,1),A(6,1)/0.,0.,0.,0.,0.,0./
      DATA A(7,1),A(8,1),A(9,1),A(10,1),A(11,1)/0.,0.,0.,0.,0./
      DATA CP(1,1),CP(2,1),CP(3,1),CP(4,1),CP(5,1)/0.,0.,0.,0.,0./
      DATA CP(6,1),CP(7,1),CP(8,1),CP(9,1),CP(10,1)/0.,0.,0.,0.,0./
      DATA CP(11,1)/0./
      DATA CX(1),CY(1)/1.,0./
      READ(LC,10)B2,B1,M
   10 FORMAT(2(F4.2),I2)
      WRITE(IMP,20)B2,B1,M
   20 FORMAT(1H ,30X,'B2=',F4.2,10X,'B1=',F4.2,10X,'M=',I2,///)
C
C     CALCUL DES PARAMETRES AUX BORNES DES ARCS D'INTEGRATION
C     ******************************************************
      B22=B2*B2
      B12=B1*B1
      PI=4*ATAN(1.)
      M1=M+1
      MM=10*M+1
      DO 100 I=1,MM
      IF(I.NE.1)GO TO 1
      RO1=1.+B2
      RO2=1.+B1
      RO3=1.-B1
      RO4=1.-B2
      RPRO(1)=SQRT(RO1*RO2*RO3*RO4)
      GO TO 100

    1 TETA(I)=TETA(I-1)+PI/(20*M)
      SI=SIN(TETA(I))
      CO=COS(TETA(I))
      TETA1=ATAN(SI/(CO+B2))
      TETA2=ATAN(SI/(CO+B1))
      TETA3=ATAN(SI/(CO-B1))
      IF(TETA3)2,3,4
    2 TETA3=PI+TETA3
    4 TETA4=ATAN(SI/(CO-B2))
      IF(TETA4)5,3,6
    5 TETA4=PI+TETA4
    6 STET(I)=(TETA1+TETA2+TETA3+TETA4)/2.
      RO1=SI/SIN(TETA1)
      RO2=SI/SIN(TETA2)
      RO3=SI/SIN(TETA3)
      RO4=SI/SIN(TETA4)
      RPRO(1)=SQRT(RO1*RO2*RO3*RO4)
      DO 101 J=1,M1
  101 A(J,1)=-SIN((2*J-1)*TETA(1)-STET(1))/RPRO(1)
  100 CONTINUE
C
C     CALCUL DES PARAMETRES AUX BORNES DES ARCS DE DIVISION
```

```
C     ********************************************************************
      AP(1,1)=1./RPRO(1)
      DO 102 I=2,M1
  102 AP(I,1)=AP(1,1)
      J=1
      DO 200 I=11,MM,10
      J=J+1
      CX(J)=COS(TETA(I))
      CY(J)=SIN(TETA(I))
      DO 201 N=1,M1
      AP(N,J)=COS((2*N-2)*TLTA(I)-STLT(I))/RPRO(I)
  201 CP(N,J)=SIN((2*N-2)*TLTA(I)-STLT(I))/RPRO(I)
  200 CONTINUE
      CALL LINK('B4')
      CALL LINK('B5')
      CALL LINK('B6')
C
C     CALCUL DES COEFFICIENTS D'INTENSITE DE CONTRAINTES
C     ********************************************************************
      TSB1(1)=0.
      TSB2(1)=0.
      DO 700 I=1,M1
      TSB1(I+1)=TSB1(I)+R(I)*B1**(2*I-3)
      TSB2(I+1)=TSB2(I)+R(I)*B2**(2*I-3)
  700 CONTINUE
      WRITE(IMP,180)
  180 FORMAT(///,36X,'COEFFICIENTS D''INTENSITE DE CONTRAINTES',//)
      P1B1=SQRT(P1*B1)
      P1B2=SQRT(P1*B2)
      DEN1=SQRT(B22-B12)
      VRK1B1=-(((B12-B22)/2.-GAMMA)/(DEN1*P1B1))-2*P1B1*TSB1(M1+1)/DEN1
      VRK1B2=+(((B22-B12)/2.-GAMMA)/(DEN1*P1B2))+2*P1B2*TSB2(M1+1)/DEN1
      YB1=VRK1B1/SQRT((B2-B1)/(2*P1))
      RO=VRK1B2/VRK1B1
      WRITE(IMP,190)VRK1B1,VRK1B2,YB1,RO
  190 FORMAT(10X,'K1B1=',F7.4,10X,'K1B2=',F7.4,10X,'YB1=',F7.4,10X,'RO='
     S,F7.4)
      STOP
    3 WRITE(IMP,210)
  210 FORMAT(1X,'ARCTANGENTE TLTA3 OU TLTA4 = 0')
      STOP
      END
```

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(S)
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ANNEXE A3

DISQUE COMPORTANT TROIS FISSURES SYMÉTRIQUES

MÉTHODE DE SUPERPOSITION

```
      SUBROUTINE TRUC
      COMMON TETA(101),RPRO(101),STET(101),A(11,101),CP(11,11),CX(11)
      COMMON CY(11),ANUM(11,10),Y(11),Z(11),B(21,21),TSB1(12),TSB2(12)
      COMMON RX(10),RY(10),R(21),TSA(12),AP(11,11),SUP(11),X(11)
      COMMON /SS/AF,B1,B2,B22,B12,AF2,PI,BETA,M,M1,M3,MM,LC,IMP
      DATA A(1,1),A(2,1),A(3,1),A(4,1),A(5,1)/0.,0.,0.,0.,0./
      DATA A(6,1),A(7,1),A(8,1),A(9,1),A(10,1)/0.,0.,0.,0.,0./
      DATA A(11,1)/0./
C
C     CALCUL NUMERIQUE DES INTEGRALES
C     ********************************************************************
      H=PI/(20*M)
      NDIM=11
      L=0
      NM=10*M-9
      DO 300 I=1,NM,10
      L=L+1
      DO 302 N=1,M1
      DO 301 J=1,11
  301 Y(J)=A(N,I+J-1)
      CALL QSF(H,Y,Z,NDIM)
  302 ANUM(N,L)=Z(11)
  300 CONTINUE
      UPS1=B1*1.E-03
      UPS2=B2*1.E-03
      X(1)=B1+UPS1
      H=(B2-B1-UPS1-UPS2)/10
      V=SQRT(B22-B12)
      DO 101 N=1,M1
      DO 102 I=1,11
      IF(I.GT.1)X(I)=X(I-1)+H
      X2=X(I)*X(I)
      PD=SQRT((X2-B12)*(X2-AF2)*(B22-X2))
  102 Y(I)=X(I)**(2*N-1)/PD
      CALL QSF(H,Y,Z,NDIM)
      S1=SQRT(2*UPS1)*(B1**(2*N-1))/(V*SQRT(B1))
      S2=SQRT(2*UPS2)*(B2**(2*N-1))/(V*SQRT(B2))
      SUP(N)=Z(11)+S1+S2
  101 CONTINUE
      RETURN
      END
```

(S)

```
      SUBROUTINE CHOSE
      COMMON TETA(101),RPRO(101),STET(101),A(11,101),CP(11,11),CX(11)
      COMMON CY(11),ANUM(11,10),Y(11),Z(11),B(21,21),TSB1(12),TSB2(12)
      COMMON RX(10),RY(10),R(21),TSA(12),AP(11,11),SUP(11),X(11)
      COMMON /S5/AF,B1,B2,B22,B12,AF2,PI,BETA,M,M1,M3,MM,LC,IMP
C
C     CALCUL DE BETA
C     ******************************************************************
      AK=SQRT((B22-B12)/(B22-AF2))
      CALL CEL1(RES,AK,IER)
      F=RES
      AZ=1
      BZ=1-AK*AK
      CALL CEL2(RES,AK,AZ,BZ,IER)
      E=RES
      CONS=-1/PI
      BETA=CONS*((AF2-B12-B22)/2.+(B22-AF2)*E/F)
      WRITE(IMP,240)
  240 FORMAT(////)
C
C     CALCUL DES RESULTANTES DE L'ETAT B
C     ******************************************************************
      CON=(AF2+B12+B22)/2.
      WRITE(IMP,50)
   50 FORMAT(1H ,30X,'ARC',20X,'RX',20X,'RY',//)
      DO 400 J=1,M
      RX(J)=CY(J+1)*(CONS*(1-AP(2,J+1)+CON*AP(1,J+1))+BETA*AP(1,J+1))-
     SCY(J)*(CONS*(1-AP(2,J)+CON*AP(1,J))+BETA*AP(1,J))
      RY(J)=-CONS*(CX(J+1)-CX(J)-ANUM(2,J)+CON*ANUM(1,J))-BETA*ANUM(1,J)
     S+CY(J+1)*(CONS*(CP(2,J+1)-CON*CP(1,J+1))-BETA*CP(1,J+1))-CY(J)*(1*
     SCONS*(CP(2,J)-CON*CP(1,J))-BETA*CP(1,J))
      WRITE(IMP,60)J,RX(J),RY(J)
   60 FORMAT(32X,I1,17X,F9.6,13X,F9.6,/)
  400 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE B3
      COMMON TETA(101),RPRO(101),STET(101),A(11,101),CP(11,11),CX(11)
      COMMON CY(11),ANUM(11,10),Y(11),Z(11),B(21,21),TSB1(12),TSB2(12)
      COMMON RX(10),RY(10),R(21),TSA(12),AP(11,11),SUP(11),X(11)
      COMMON /S5/AF,B1,B2,B22,B12,AF2,PI,BETA,M,M1,M3,MM,LC,IMP
C
C     CALCUL DES COEFFICIENTS DE LA MATRICE
C     *************************************************************
C
C     DEFINITION DE LA MATRICE  B
C     *************************************************************
      DO 500 I=1,M1
      DO 501 J=1,M
     .  B(J,I)=2*(CY(J+1)*AP(I,J+1)-CY(J)*AP(I,J))
  501 B(J+M1,I)=-2*(ANUM(I,J)+CY(J+1)*CP(I,J+1)-CY(J)*CP(I,J))
  500 B(M1,I)=SUP(I)
      DO 502 I=1,M
      DO 503 J=1,M
      K=2*I-1
      L=2*I-2
      IS=10*J+1
      IT=10*(J-1)+1
      B(J,I+M1)=2*((SIN(K*TETA(IS))-SIN(K*TETA(IT)))/K+CY(J+1)*COS(L*
     STETA(IS))-CY(J)*COS(L*TETA(IT)))
  503 B(J+M1,I+M1)=-2*(CY(J+1)*SIN(L*TETA(IS))-CY(J)*SIN(L*TETA(IT)))
  502 B(M1,I+M1)=0.
      WRITE(IMP,190)
  190 FORMAT(////)
C
C     RESOLUTION DU SYSTEME
C     *************************************************************
      DO 600 I=1,M
      R(I)=-RX(I)
      R(I+M1)=-RY(I)
  600 CONTINUE
      R(M1)=0.
      EPS=0.0000001
      CALL GELG(R,B,M3,1,EPS,IER)
      IF(IER.NE.0)GO TO 15
      RETURN
   15 WRITE(IMP,170)IER
  170 FORMAT(1H ,'ERREUR DANS LA RESOLUTION DU SYSTEME :IER=',I3)
      STOP
      END
```

```
      SUBROUTINE MACHIN
      COMMON TETA(101),RPRO(101),STET(101),A(11,101),CP(11,11),CX(11)
      COMMON CY(11),ANUM(11,10),Y(11),Z(11),B(21,21),TSB1(12),TSB2(12)
      COMMON RX(10),RY(10),R(21),TSA(12),AP(11,11),SUP(11),X(11)
      COMMON /S5/AF,B1,B2,B22,B12,AF2,PI,BETA,M,M1,M3,MM,LC,IMP
      DATA CX(1),CY(1),STET(1)/1.,0.,0./
      DATA CP(1,1),CP(2,1),CP(3,1),CP(4,1),CP(5,1)/0.,0.,0.,0.,0./
      DATA CP(6,1),CP(7,1),CP(8,1),CP(9,1),CP(10,1)/0.,0.,0.,0.,0./
      DATA CP(11,1)/0./
C
C     CALCUL DE X,Y,C1,C3,C5,C7,C9 POUR LES BORNES DES 10 INTERVALLES
C     ***************************************************************
      I=1
      DO 200 N=11,MM,10
      I=I+1
      CX(I)=COS(TETA(N))
      CY(I)=SIN(TETA(N))
      DO 900 J=1,M1
      AP(J,I)=COS((2*J-1)*TETA(N)-STET(N))/RPRO(N)
      CP(J,I)=SIN((2*J-1)*TETA(N)-STET(N))/RPRO(N)
  900 CONTINUE
  200 CONTINUE
      RETURN
      END
(S)
```

```
      SUBROUTINE BS
      COMMON TETA(101),RPRO(101),STET(101),A(11,101),CP(11,11),CX(11)
      COMMON CY(11),ANUM(11,10),Y(11),Z(11),B(21,21),TSB1(12),TSB2(12)
      COMMON RX(10),RY(10),R(21),TSA(12),AP(11,11),SUP(11),X(11)
      COMMON /S5/AF,B1,B2,B22,B12,AF2,PI,BETA,M,M1,M3,MM,LC,IMP
      REAL K1A,K1B1,K1B2
      DATA TSA(1),TSB1(1),TSB2(1)/0.,0.,0./
C
C     CALCUL DES COEFFICIENTS D'INTENSITE DE CONTRAINTES
C     ***************************************************************
      M2=M+2
      DO 700 I=1,M1
      TSA(I+1)=TSA(I)+R(I)*AF**(2*I-2)
      TSB1(I+1)=TSB1(I)+R(I)*B1**(2*I-2)
      TSB2(I+1)=TSB2(I)+R(I)*B2**(2*I-2)
  700 CONTINUE
      PIB=PI*BETA
      DEN1=SQRT((B12-AF2)*(B22-AF2))
      K1A=1/DEN1*((B22+B12-AF2)/2-PIB-2*PI*TSA(M2))
      DEN2=SQRT((B12-AF2)*(B22-B12))
      DEN3=SQRT((B22-AF2)*(B22-B12))
      VRK1A=SQRT(PI*AF)*((B12+B22-AF2)/(2*PI)-BETA-2*TSA(M2))/DEN1
      VRK1B1=SQRT(PI*B1)*((AF2+B22-B12)/(2*PI)-BETA-2*TSB1(M2))/DEN2
      VRK1B2=SQRT(PI*B2)*((B22-AF2-B12)/(2*PI)+BETA+2*TSB2(M2))/DEN3
      ROAB1=VRK1B1/VRK1A
      ROAB2=VRK1B2/VRK1A
      RO=VRK1B2/VRK1B1
      WRITE(IMP,150)
  150 FORMAT(1H ,35X,'COEFFICIENTS D''INTENSITE DE CONTRAINTES',//)
      WRITE(IMP,160)K1A,VRK1A,VRK1B1,VRK1B2
  160 FORMAT(10X,'YA=',F7.4,10X,'K1A=',F7.4,10X,'K1B1=',F7.4,10X,'K1B2='
     S,F7.4,//)
      WRITE(IMP,170)ROAB1,ROAB2,RO
  170 FORMAT(10X,'K1(B1/A)=',F7.4,10X,'K1(B2/A)=',F7.4,10X,'RO=',F7.4)
      RETURN
      END
```

```
      COMMON TETA(101),RPRO(101),STET(101),A(11,101),CP(11,11),CX(11)
      COMMON CY(11),ANUM(11,10),Y(11),Z(11),B(21,21),TSB1(12),TSB2(12)
      COMMON RX(10),RY(10),R(21),TSA(12),AP(11,11),SUP(11),X(11)
      COMMON /S5/AF,B1,B2,B22,B12,AF2,PI,BETA,M,M1,M3,MM,LC,IMP
      DATA CX(1),CY(1),STET(1)/1.,0.,0./
      DATA TETA(1)/0./
      LC=7
      IMP=8
C
C     LECTURE DES DONNEES ET INITIALISATION DES PARAMETRES
C     ****************************************************************
      READ(LC,10)B2,B1,AF,M
   10 FORMAT(3F4.2,I2)
      WRITE(IMP,20)B2,B1,AF,M
   20 FORMAT(1H ,30X,'B2=',F4.2,10X,'B1=',F4.2,10X,'A=',F4.2,10X,'M=',I2
     S,///)
      B22=B2*B2
      AF2=AF*AF
      B12=B1*B1
      PI=4.*ATAN(1.)
      M1=M+1
      M3=2*M+1
      R01=1-B2
      R02=1-B1
      R03=1-AF
      R04=1+AF
      R05=1+B1
      R06=1+B2
      RPRO(1)=SQRT(R01*R02*R03*R04*R05*R06)
      AP(1,1)=1./RPRO(1)
      DO 401 J=2,M1
      AP(J,1)=AP(1,1)
  401 CONTINUE
C
C     CALCUL DES PARAMETRES AU NIVEAU DES 100 COUPURES
C     ****************************************************************
      MM=10*M+1
      DO 100 N=2,MM
      TETA(N)=(N-1)*PI/(20*M)
      SI=SIN(TETA(N))
      CO=COS(TETA(N))
      IF(TETA(N).EQ.PI/2)CO=0.0000000
      TETA1=ATAN(SI/(CO-B2))
      TETA2=ATAN(SI/(CO-B1))
      TETA3=ATAN(SI/(CO-AF))
      IF(TETA1)2,3,4
    2 TETA1=PI+TETA1
    4 IF(TETA2)5,3,6
    5 TETA2=PI+TETA2
    6 IF(TETA3)7,3,8
    7 TETA3=PI+TETA3
    8 TETA4=ATAN(SI/(CO+AF))
      TETA5=ATAN(SI/(CO+B1))
      TETA6=ATAN(SI/(CO+B2))
```

```
      RO1=SI/SIN(TETA1)
      RO2=SI/SIN(TETA2)
      RO3=SI/SIN(TETA3)
      RO4=SI/SIN(TETA4)
      RO5=SI/SIN(TETA5)
      RO6=SI/SIN(TETA6)
      RPRO(N)=SQRT(RO1*RO2*RO3*RO4*RO5*RO6)
      STET(N)=(TETA1+TETA2+TETA3+TETA4+TETA5+TETA6)/2.
      DO 800 I=1,M1
      A(I,N)=-SIN(2*I*TETA(N)-STET(N))/RPRO(N)
  800 CONTINUE
  100 CONTINUE
      CALL LINK('B7')
      CALL LINK('B1')
      CALL LINK('B2')
      CALL LINK('B3')
      CALL LINK('B8')
      STOP
    3 WRITE(IMP,180)
  180 FORMAT(1H ,'ARCTANGENTE = 0')
      STOP
      END
```

R(S)

ANNEXE A4

DISQUE COMPORTANT UNE FISSURE CENTRALE

TRANSFORMATION CONFORME

```
      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
      DIMENSION TETA(42),TETZ(42),ROZ(42),A(42),C(42),D(42)
      DIMENSION FAC(42),FAS(42),TTZ(42),PON(82)
      DIMENSION B(82,82)
      DIMENSION P(82),F(84)
      REAL K1,KO
      DATA LC,IMP/105,108/
      DATA TETA(1)/0.D0/
      DATA TETZ(1),C(1),D(1)/0.D0,0.D0,0.D0/
C
C     LECTURE ET DETERMINATION DES PARAMETRES
C     ***************************************
      READ(LC,10)AF,N,L,NB
   10 FORMAT(F5.3,I2,I3,I3)
      WRITE(IMP,70)AF,L,L,LB
   70 FORMAT(20X,'AF=',F5.3,20X,'N=',I2,20X,'L=',I3,20X,'N=',I3,//)
      NP2=N+2
      NP1=N+1
      NN=-N
      NN=2*N+2
      AF2=AF*AF
      PI=4.D0*DATAN(1.D0)
      ROP=DSQRT(1.D0-AF2)
      ROZ(1)=(1.D0+ROP)/AF
C
      PAS=PI*(0.5-(1./L))/N
      DO 100 I=2,NP2
      IF(I-2)2,2,1
    1 TETA(I)=TETA(I-1)+PAS
      GO TO 3
    2 TETA(I)=PI/L
    3 CO=DCOS(TETA(I))
      SI=DSIN(TETA(I))
      T2=2*TETA(I)
      ROP=(1-2*AF2*DCOS(T2)+AF**4)**0.25
      PHI=DATAN2(DSIN(T2),DCOS(T2)-AF2)/2.
    9 ROZ(I)=DSQRT((CO+ROP*DCOS(PHI))**2+(SI+ROP*DSIN(PHI))**2)/AF
      TETZ(I)=DARCOS((CO+ROP*DCOS(PHI))/(AF*ROZ(I)))
      TPZ=2*TETZ(I)
      CONU=DSIN(TETZ(I))*ROZ(I)*(ROZ(I)*ROZ(I)-1.)
      CON=ROZ(I)*ROZ(I)-DCOS(TPZ)
      DEN=CON*CON+DSIN(TPZ)*DSIN(TPZ)
      C(I)=CONU*CON/DEN
      D(I)=CONU*DSIN(TPZ)/DEN
  100 CONTINUE
C
C     CALCUL DES COEFFICIENTS DE LA MATRICE
C     *************************************
C
C     FORMATION DE LA MATRICE DES COEFFICIENTS (2N+2,2N+2)
C     ****************************************************
```

```
      NBP=2*N+1+NB
      DO 200 J=2,NP2
      M=0
      DO 200 I=NB,NBP
      M=M+1
      JJ=IABS(I)
      PON(M)=(2.D0/AE)**(2*JJ)
      JJ=J-1
      DO 310 II=JJ,J
      ROZP=ROZ(II)**(2*I)
      ROZS=ROZP*ROZ(II)
      A(II)=(ROZS-(1.D0/ROZS))/PON(M)
      FF=2*(2*I+1)*ROZP
      TSZ=2*I*TETZ(II)
      TTZ(II)=(2*I+1)*TETZ(II)
      FAC(II)=FA*DCOS(TSZ)/PON(M)
      FAS(II)=FA*DSIN(TSZ)/PON(M)
  310 CONTINUE
C     B(J-1,M)=A(J)*DSIN(TTZ(J))-A(J-1)*DSIN(TTZ(J-1))+1*(FAC(J)*C(J)-
     SFAC(J-1)*C(J-1)+FAS(J)*D(J)-FAS(J-1)*D(J-1))
      B(J+N,M)=-1*(A(J)*DCOS(TTZ(J))-A(J-1)*DCOS(TTZ(J-1))-1*(FAC(J)*D(J)
     SJ)-FAC(J-1)*D(J-1)-FAS(J)*C(J)+FAS(J-1)*C(J-1)))
  200 CONTINUE
C
C     VECTEUR RESULTANTE DES ACTIONS SUR LE CONTOUR
C     *********************************************
      R(1)=-1*DCOS(PI/(2*L))/2.D0
      R(N+2)=-1*DSIN(PI/(2*L))/2.D0
      DO 400 J=2,NP1
      R(J)=0.D0
      R(J+N+1)=0.D0
  400 CONTINUE
C
C     RESOLUTION DU SYSTEME
C     *********************
      I=NN
      J=NN
      CALL DARRAY(2,I,J,B2,B2,B,B)
      M=NN
      EPS=1.D-16
      CALL DGELG(R,B,M,1,EPS,IER)
      IF(IER.NE.0)GO TO 15
      WRITE(IMP,20)
   20 FORMAT(36X,'COEFFICIENTS DES TERMES DE LA SERIE DE PHI',///)
      WRITE(IMP,30)(I,R(I),I=1,NN)
   30 FORMAT(51X,'ALPHA(',I2,')=',E11.4,/)
C
C     CALCUL DE K1
C     ************
      P(1)=0.D0
      DO 500 I=1,NN
```

```
      P(I+1)=P(I)+(2*(I+NB)-1)*R(I)/PON(I)
  500 CONTINUE
      K1=2*DSQRT(PI/AF)*P(2*I+3)
      K0=DSQRT(AF/PI)
      Y=K1/K0
      WRITE(IMP,40)
   40 FORMAT(///,30X,'FACTEUR D''INTENSITE DE CONTRAINTES',//)
      WRITE(IMP,50)K1
   50 FORMAT(31X,'K1=',E11.4)
      WRITE(IMP,90)Y
   90 FORMAT(//,32X,'Y=',F8.5)
      STOP
   15 CONTINUE
      WRITE(IMP,60)IER
   60 FORMAT(1HC,'ERREUR DANS LA RESOLUTION DU SYSTEME ; IER=',I2)
      STOP
      END
```

ANNEXE A5

ANNEAU COMPORTANT DEUX FISSURES SYMÉTRIQUES

TRANSFORMATION CONFORME

```
C                    TRANSFORMATION CONFORME ANNEAU
C                    ******************************
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      DIMENSION RZ(35),TZ(35),R(35),T(35),T3(25),RP(25),TP(25),R3(25)
      DIMENSION B(101,101),BBX(101),BB2(35),BOD(35),BOT(25)
      DIMENSION RZ1(2),RZ10(2),RZ21(2),RZ22(2),RZ23(2),S0TZ(2),S1TZ(2),
     S          S20TZ(2),S21TZ(2),S2TZ(2),S2T(2),C0TZ(2),C1TZ(2),C20TZ(2),
     S          C21TZ(2),C2TZ(2),C2T(2),RZZ(2),RZS(2),DE1256(2),DE34(2),
     S          DE73(2),DER(2),ACM7(2),ASM8(2),BCM7(2),BSM8(2),Z(2),ON(2),
     S          DN(2),OD(2),DD(2),YA1(2),YA2(2),YB1(2),YB2(2),XA1(2),
     S          XA2(2),XB1(2),XB2(2)
      DIMENSION RP3(2),RP2(2),RP1(2),S1TP(2),S2TP(2),C1TP(2),C2TP(2),
     S          T23Z(2),T22Z(2),S23(2),S22(2),C23(2),C22(2),P7(2)
      REAL NU,K1,K0
      DATA LC,IMP/105,108/
C
C
C       LE CHOIX DE LA DISCRETISATION EST TEL QUE  : NA+NB+ND  DOIT
C       ETRE IMPAIR
C
C
      READ(LC,10)NA,NB,NC,ND
   10 FORMAT(4I2)
      READ(LC,20)RE,RI,FL,T23
   20 FORMAT(3F5.2,F12.10)
      READ(LC,30)NU,P
   30 FORMAT(F3.2,I5)
      WRITE(IMP,11)NA
   11 FORMAT(1H1,'NOMBRE DE SEGMENTS DE DECOUPAGE DE LA FISSURE : ',I2)
      WRITE(IMP,12)NB
   12 FORMAT(//,'NOMBRE DE SEGMENTS DE DECCUPAGE DU CONTOUR EXTERIEUR DE
     S LA REGION 2 : ',I2)
      WRITE (IMP,13)NC
   13 FORMAT(//,'NOMBRE DE SEGMENTS DE DECOUPAGE DU CONTOUR EXTERIEUR DE
     S LA REGION 3 : ',I2)
      WRITE(IMP,14)ND
   14 FORMAT(//,'NOMBRE DE SEGMENTS DE DECOUPAGE DU CONTOUR COMMUN : ',
     S I2)
      WRITE(IMP,15)RE,RI,FL
   15 FORMAT(//,'RAYON EXTERIEUR = ',F5.2,10X,'RAYON INTERIEUR = ',F5.2,
     S10X,'LONGUEUR DE FISSURE = ',F5.2,//)
      WRITE(IMP,16)T23
   16 FORMAT(1X,'ANGLE DE PARTAGE : ',F12.10,//)
      WRITE(IMP,17)NU,P
   17 FORMAT(1X,'COEFFICIENT DE POISSON = ',F3.2,20X,'CHARGE APPLIQUEE : ',I5
     S ',I5,//)
      ETA=3.-4*NU
      ER1=ETA+1
      EM1=ETA-1
      PI=4.D0*DATAN(1.D0)
C
```

```
C                 CALCUL DES PARAMETRES DE FISSURE (REGION 2)
C                 ***********************************************
C
      RZ(1)=1.
      TZ(1)=0.
      T(1)=PI/2.
      R(1)=RI
      FLW=DLOG(1+FL/RI)
      DO 100 I=1,NA
      R(I+1)=RI+I*FL/NA
      RW=DLOG(R(I+1)/RI)
      R1=FLW-RW
      R2=FLW+RW
      R12=DSQRT(R1*R2)
      TZ(I+1)=DATAN(RW/R12)
      RZ(I+1)=1.
  100 T(I+1)=PI/2.
C
C           CALCUL DES PARAMETRES DE CONTOUR EXTERIEUR (REGION 2)
C           ****************************************************
C
      P1=DLOG(RE/RI)
      P2=P1+FLW
      P3=P1-FLW
      NE=NA+1
C
C        ARC DE CHARGEMENT
C        *****************
C
      T(NA+2)=PI/2.
      RW=P1
      R1=P3
      R2=P2
      R12=DSQRT(R1*R2)
      RZ(NA+2)=(RW+R12)/FLW
      TZ(NA+2)=T(NA+2)
      R(NA+2)=RE
      PSC=PI/100.
      PSC2=PSC*PSC
      NA2=NA+3
      T(NA3)=T(NA+2)-PSC
      RW=DSQRT(PSC2+P1*P1)
      TW=DATAN(P1/PSC)
      R1=DSQRT(PSC2+P3*P3)
      R2=DSQRT(PSC2+P2*P2)
      T1=DATAN(P3/PSC)
      T2=DATAN(P2/PSC)
      R12=DSQRT(R1*R2)
      T12=(T1+T2)/2.
      RZ(NA3)=DSQRT(RW*RW+R1*R2+2*R12*RW*DCOS(TW-T12))/FLW
      TZ(NA3)=DATAN2(RW*DSIN(TW)+R12*DSIN(T12),RW*DCOS(TW)+R12*DCOS(T12))
```

```
     S)
      R(NA3)=RE
C
C          RESTE DU CONTOUR EXTERIEUR
C          **************************
C
      DT=(T(NA3)-T23)/NB
      DO 150 I=1,NB
      T(NA3+I)=T(NA3)-DT*I
      PMT=PSC+DT*I
      PMT2=PMT*PMT
      RW=DSQRT(PMT2+P1*P1)
      R1=DSQRT(PMT2+P3*P3)
      R2=DSQRT(PMT2+P2*P2)
      R12=DSQRT(R1*R2)
      TW=DATAN(P1/PMT)
      T1=DATAN(P3/PMT)
      T2=DATAN(P2/PMT)
      T12=(T1+T2)/2.
      RZ(NA3+I)=DSQRT(RW*RW+R1*R2+2*R12*RW*DCOS(TW-T12))/FLW
      TZ(NA3+I)=DATAN2(RW*DSIN(TW)+R12*DSIN(T12),RW*DCOS(TW)+R12*DCOS(
     ST12))
  150 R(NA3+I)=RE
C
C          CALCUL DES PARAMETRES DE CONTOUR COMMUN
C          ***************************************
C
      NJ=NA3+NB
      PMT23=PI/2.-T23
      PC=PMT23*PMT23
      DR=(RE-RI)/ND
      DO 200 I=1,ND
      R(NJ+I)=RE-I*DR
      P4=DLOG(R(NJ+I)/RI)
      P5=P4-FLW
      P6=P4+FLW
      RW=DSQRT(PC+P4*P4)
      R1=DSQRT(PC+P5*P5)
      R2=DSQRT(PC+P6*P6)
      TW=DATAN(P4/PMT23)
      T1=DATAN(P5/PMT23)
      T2=DATAN(P6/PMT23)
      R12=DSQRT(R1*R2)
      T12=(T1+T2)/2.
      RZ(NJ+I)=DSQRT(RW*RW+R1*R2+2*R12*RW*DCOS(TW-T12))/FLW
      TZ(NJ+I)=DATAN2(RW*DSIN(TW)+R12*DSIN(T12),RW*DCOS(TW)+R12*DCOS(T12))
     S))
  200 T(NJ+I)=T23
C
C                    COEFFICIENTS REGION 2
C                    *********************
```

```
C
      WRITE(IMP,120)(RZ(I),I=1,35)
  120 FORMAT(10(4X,F7.3))
      NA=0
      NCT=2*(1+NA+NB+ND)
      N2=3+NA+NB+ND
      NTS=2*(NA+NB+NC+2*ND+2)+1
      JPD=NCT+2*(ND+2)
      CTC=FL*(2*RI+FL)/(2*FLW*(RI+FL)*(RI+FL))
      NCS=(1+NA+NB+ND)/2
      NCI=-NCS
      L=0
      DO 250 N=NCI,NCS
      NA=NA+1
      NB=NA+2*NCS
      NV=IABS(N)
      POD(NA)=1.D0
      B(1,NA)=(-1)**NV*(CTC*(0.5D0-2*N)-1)
      B(1,NB)=(-1)**NV*(CTC*(0.5D0+2*N)-1)
      IF(N.EQ.NCI)B(1,NB)=0.D0
      DO 300 I=1,N2
      IF(I.EQ.N2)GO TO 301
      IF(I.EQ.NF)GO TO 300
C
C        PARAMETRES DE BASE
C        ******************
C
      DO 350 J=1,2
      JJ=I+J-1
      RZ1(J)=RZ(JJ)**(2*N-1)
      RZ20(J)=RZ1(J)*RZ(JJ)
      RZ21(J)=RZ20(J)*RZ(JJ)
      RZ22(J)=RZ21(J)*RZ(JJ)
      RZ23(J)=RZ22(J)*RZ(JJ)
      S0TZ(J)=DSIN((2*N-2)*TZ(JJ))
      S1TZ(J)=DSIN((2*N-1)*TZ(JJ))
      S20TZ(J)=DSIN(2*N*TZ(JJ))
      S21TZ(J)=DSIN((2*N+1)*TZ(JJ))
      S2TZ(J)=DSIN(2*TZ(JJ))
      S2T(J)=DSIN(2*T(JJ))
      C0TZ(J)=DCOS((2*N-2)*TZ(JJ))
      C1TZ(J)=DCOS((2*N-1)*TZ(JJ))
      C20TZ(J)=DCOS(2*N*TZ(JJ))
      C21TZ(J)=DCOS((2*N+1)*TZ(JJ))
      C2TZ(J)=DCOS(2*TZ(JJ))
      C2T(J)=DCOS(2*T(JJ))
C
C        DENOMINATEURS
C        *************
C
      RZ2(J)=RZ(JJ)*RZ(JJ)
```

```
      RZS(J)=RZ(JJ)*DSIN(TZ(JJ))
      DE1256(J)=(RZ2(J)+2*RZS(J)+1)*POD(MA)
      DE34(J)=(RZ2(J)-2*RZS(J)+1)*POD(MA)
      DE78(J)=RZ2(J)*RZ2(J)+4*RZ2(J)*RZS(J)+2*RZ2(J)*(2-C2TZ(J))+4*RZS(J
     S)+1
      DER(J)=(FLW*FLW/(4*RZ2(J)*RZ2(J))*(RZ2(J)*RZ2(J)+2*RZ2(J)*C2TZ(J)+1
     S1))*POD(MA)
C
C          EXPRESSIONS DE BASE
C          *******************
C
      ACM7(J)=2*N/DE1256(J)*(RZ20(J)*C0TZ(J)+RZ1(J)*S1TZ(J))-1/DE78(J)*
     S(RZ22(J)*C0TZ(J)+2*RZ21(J)*S1TZ(J)-RZ20(J)*C20TZ(J))
      ASM8(J)=2*N/DE1256(J)*(RZ1(J)*C1TZ(J)-RZ20(J)*S0TZ(J))-1/DE78(J)*
     S(-RZ22(J)*S0TZ(J)+2*RZ21(J)*C1TZ(J)+RZ20(J)*S20TZ(J))
      BCM7(J)=(2*N+1)/DE1256(J)*(RZ20(J)*C20TZ(J)-RZ21(J)*S1TZ(J))-1/
     SDE78(J)*(RZ21(J)*S21TZ(J)+2*RZ22(J)*C20TZ(J)-RZ23(J)*S1TZ(J))
      BSM8(J)=-(2*N+1)/DE1256(J)*(RZ20(J)*S20TZ(J)+RZ21(J)*C1TZ(J))-1/
     SDE78(J)*(RZ21(J)*C21TZ(J)-2*RZ22(J)*S20TZ(J)-RZ23(J)*C1TZ(J))
      Z(J)=FLW/(2*RZ2(J))*((RI/R(JJ))**2-1)
      ON(J)=Z(J)*(RZ2(J)+C2TZ(J))*S2T(J)
      DN(J)=Z(J)*(RZ2(J)+C2TZ(J))*C2T(J)
      OD(J)=Z(J)*S2TZ(J)*S2T(J)
      DD(J)=Z(J)*S2TZ(J)*C2T(J)
      YA1(J)=RZ21(J)*C1TZ(J)
      YA2(J)=RZ20(J)*S20TZ(J)
      YB1(J)=RZ21(J)*C21TZ(J)
      YB2(J)=RZ22(J)*S20TZ(J)
      XA1(J)=RZ21(J)*S1TZ(J)
      XA2(J)=RZ20(J)*C20TZ(J)
      XB1(J)=RZ21(J)*S21TZ(J)
      XB2(J)=RZ22(J)*C20TZ(J)
  350 CONTINUE
C
C                          RESULTANTES REGION 2
C                          ********************
C
      L=I+1
      IF(I.NE.NA)GO TO 302
C
C          RESULTANTES SUR DERNIER SEGMENT DE FISSURE
C          ******************************************
C
C                    VERTICALES
C                    **********
C
      B(NF,MA)=-(((YA1(1)+YA2(1))/DE1256(1))-((YA1(1)-YA2(1))/DE34(1))*
     S          (ACM7(1)*(ON(1)-DD(1))-ASM8(1)*(OD(1)+DN(1)))/DER(1))
      B(NF,MB)=-(((YB1(1)-YB2(1))/DE1256(1))-((YB1(1)+YB2(1))/DE34(1))*
     S          (BCM7(1)*(ON(1)-DD(1))-BSM8(1)*(OD(1)+DN(1)))/DER(1))
C
```

```
C                    HORIZONTALES
C                    ************
C
      NF2=NF+1+NA+NB+ND
      B(NF2,MA)=(-1)**NV*(CTC*(-4*N*N+N+0.25)-0.5-2*N)-
     S          (((XA1(1)-XA2(1))/DE1256(1))+((XA1(1)+XA2(1))/DE34(1))*(
     S          ACM7(1)*(DN(1)+OD(1))+ASM8(1)*(DD(1)-ON(1)))/DER(1))
      B(NF2,MB)=(-1)**NV*(CTC*(4*N*N+3*N+0.25)-2*N-0.5)-
     S          (((XB1(1)+XB2(1))/DE1256(1))-((XB2(1)-XB1(1))/DE34(1))*
     S          (BCM7(1)*(DN(1)+OD(1))+BSM8(1)*(DD(1)-ON(1)))/DER(1))
      GO TO 300
C
C                         RESULTANTES VERTICALES REGION 2
C                         ******************************
C
  302 IF(I.GT.NF)L=I
      B(L,MA)=(((YA1(2)+YA2(2))/DE1256(2))-((YA1(2)-YA2(2))/DE34(2))+
     S          (ACM7(2)*(ON(2)-DD(2))-ASM8(2)*(OD(2)+DN(2)))/DER(2))-
     S          (((YA1(1)+YA2(1))/DE1256(1))-((YA1(1)-YA2(1))/DE34(1))+
     S          (ACM7(1)*(ON(1)-DD(1))-ASM8(1)*(OD(1)+DN(1)))/DER(1))
      B(L,MB)=(((YB1(2)-YB2(2))/DE1256(2))-((YB1(2)+YB2(2))/DE34(2))+   VB(I,MA
     S          (BCM7(2)*(ON(2)-DD(2))-BSM8(2)*(OD(2)+DN(2)))/DER(2))-
     S          (((YB1(1)-YB2(1))/DE1256(1))-((YB1(1)+YB2(1))/DE34(1))+
     S          (BCM7(1)*(ON(1)-DD(1))-BSM8(1)*(OD(1)+DN(1)))/DER(1))
C
C                         RESULTANTES HORIZONTALES REGION 2
C                         *********************************
C
      IHR=L+1+NA+NB+ND
      B(IHR,MA)=(((XA1(2)-XA2(2))/DE1256(2))+((XA1(2)+XA2(2))/DE34(2))+ HA(IHR
     S          (ACM7(2)*(DN(2)+OD(2))+ASM8(2)*(DD(2)-ON(2)))/DER(2))-
     S          (((XA1(1)-XA2(1))/DE1256(1))+((XA1(1)+XA2(1))/DE34(1))+
     S          (ACM7(1)*(DN(1)+OD(1))+ASM8(1)*(DD(1)-ON(1)))/DER(1))
      B(IHR,MB)=(((XB1(2)+XB2(2))/DE1256(2))-((XB2(2)-XB1(2))/DE34(2))+ HB(IHR
     S          (BCM7(2)*(DN(2)+OD(2))+BSM8(2)*(DD(2)-ON(2)))/DER(2))-
     S          (((XB1(1)+XB2(1))/DE1256(1))-((XB2(1)-XB1(1))/DE34(1))+
     S          (BCM7(1)*(DN(1)+OD(1))+BSM8(1)*(DD(1)-ON(1)))/DER(1))
      IF(I.LT.NJ)GO TO 300
C
C                         CONTOUR COMMUN IJ
C                         *****************
C
C                    DEPLACEMENTS HORIZONTAUX REGION 2
C                    *********************************
C
      J2=1
  301 IF(I.EQ.N2)J2=2
      IHD=I+NCT-NJ+2
      IVD=IHD+ND+1
      B(IHD,MA)=(ETA*(YA1(J2)+YA2(J2))/DE1256(J2))+((YA1(J2)-YA2(J2))/
     S          DE34(J2))-(ACM7(J2)*(ON(J2)-DD(J2))-ASM8(J2)*(OD(J2)+DN(J
```

```
     S          J2)))/DER(J2)
      B(IHD,MB)=(ETA*(YB1(J2)-YB2(J2))/DE1256(J2))+((YB1(J2)+YB2(J2))/
     S          DE34(J2))-(BCM7(J2)*(DN(J2)-DD(J2))-BSM8(J2)*(DD(J2)+DN(
     S          J2)))/DER(J2)
C
C                  DEPLACEMENTS VERTICAUX REGION 2
C                  *******************************
C
      B(IVD,MA)=(ETA*(XA1(J2)-XA2(J2))/DE1256(J2))-((XA1(J2)+XA2(J2))/
     S          DE34(J2))-(BCM7(J2)*(DN(J2)+CD(J2))+ASM8(J2)*(DD(J2)-
     S          DN(J2)))/DER(J2)
      B(IVD,MB)=(ETA*(XB1(J2)+XB2(J2))/DE1256(J2))+((XB2(J2)-XB1(J2))/
     S          DE34(J2))-(BCM7(J2)*(DN(J2)+DD(J2))+BSM8(J2)*(DD(J2)-
     S          DN(J2)))/DER(J2)
      DO 400 J=JRD,NTS
      B(J,MA)=0.D0
  400 B(J,MB)=0.D0
      IF(N.NE.NCI)GO TO 300
      B(NF,MB)=0.D0
      B(NF2,MB)=0.D0
      B(L,MB)=0.D0
      B(IHR,MB)=0.D0
      B(IHD,MB)=0.D0
      B(IVD,MB)=0.D0
  300 CONTINUE
  250 CONTINUE
      WRITE(IMP,130)(RZ(I),I=1,35)
  130 FORMAT(10(4X,F7.3))
C
C                        COEFFICIENTS REGION 3
C                        *********************
C
C                     PARAMETRES DE POSITION
C                     **********************
C
C              CONTOUR EXTERIEUR
C              *****************
C
      DT3=T23/NC
      P2=1-RI/RE*RI/RE
      T3(1)=0.D0
      R3(1)=RE
      NSJ=1+NA+NB
      NC1=NC+1
      NP3=NC1+ND
      NP1=NP3-1
      RP(1)=P1
      TP(1)=P1/2.
      DO 450 I=2,NC1
      T3(I)=(I-1)*DT3
      R3(I)=RE
```

```
      RP(I)=DSQRT(T3(I)*T3(I)+P1*P1)
  450 TP(I)=DATAN2(P1,-T3(I))
C
C                CONTOUR COMMUN
C                **************
C
      DO 500 I=1,ND
      LL=I+NC1
      T3(LL)=T23
      R3(LL)=RE-I*DR
      P9=DLOG(R3(LL)/RI)
      RP(LL)=DSQRT(T23*T23+P9*P9)
  500 TP(LL)=DATAN2(P9,-T23)
      TP(ND+NC1)=PI
C
C                COEFFICIENTS REGION 3
C                *********************
C
      DO 550 M=1,NP3
      MG=M+NCT+1
      MD=MG+NP3
      POT(M)=1.D0
      DO 600 I=1,NP1
      DO 650 J=1,2
      JJ=I+J-1
      RP3(J)=RP(JJ)**(2*M-3)/POT(M)
      RP2(J)=RP3(J)*RP(JJ)/POT(M)
      RP1(J)=RP2(J)*RP(JJ)/POT(M)
      S1TP(J)=DSIN((2*M-1)*TP(JJ))
      S2TP(J)=DSIN((2*M-2)*TP(JJ))
      C1TP(J)=DCOS((2*M-1)*TP(JJ))
      C2TP(J)=DCOS((2*M-2)*TP(JJ))
      T23Z(J)=(2*M-3)*TP(JJ)+2*T(JJ)
      T22Z(J)=2*T(JJ)-(2*M-2)*TP(JJ)
      S23(J)=DSIN(T23Z(J))
      C23(J)=DCOS(T23Z(J))
      S22(J)=DSIN(T22Z(J))
      C22(J)=DCOS(T22Z(J))
      P7(J)=1.D0-RI/R3(JJ)*RI/R3(JJ)
  650 CONTINUE
C
C                          CONTOUR EXTERIEUR
C                          *****************
C
      IF(I.GT.NC)GO TO 601
C
C                   RESULTANTES VERTICALES
C                   **********************
C
      IRV=JRD+I-1
      B(IRV,MG)=(2*M-2)*(P7(2)*RP3(2)*S23(2)-P7(1)*RP3(1)*S23(1))
```

```
      B(IRV,MD)=-((2*RP1(2)*S1TP(2)+P7(2)*(2*M-1)*RP2(2)*C22(2))-(2*RP1
     S            (1)*S1TP(1)+P7(1)*(2*M-1)*RP2(1)*C22(1)))
C
C                    RESULTANTES HORIZONTALES
C                    ************************
C
      IRH=IRV+NC
      B(IRH,MG)=-((2*RP2(2)*S2TP(2)-P7(2)*(2*M-2)*RP3(2)*C23(2))-(2*RP2
     S            (1)*S2TP(1)-P7(1)*(2*M-2)*RP3(1)*C23(1)))
      B(IRH,MD)=(2*M-1)*(P7(2)*RP2(2)*S22(2)-P7(1)*RP2(1)*S22(1))
      GO TO 600
C
C                              CONTOUR COMMUN
C                              **************
C
C                    RESULTANTES VERTICALES
C                    **********************
C
  601 IRV=NSJ+2-NC1+I
      B(IRV,MG)=-((2*M-2)*(P7(2)*RP3(2)*S23(2)-P7(1)*RP3(1)*S23(1)))
      B(IRV,MD)= ((2*RP1(2)*S1TP(2)+P7(2)*(2*M-1)*RP2(2)*C22(2))-(2*RP1
     S            (1)*S1TP(1)+P7(1)*(2*M-1)*RP2(1)*C22(1)))
C
C                    RESULTANTES HORIZONTALES
C                    *******R*****************
C
      IRH=IRV+2*NCS
      B(IRH,MG)= ((2*RP2(2)*S2TP(2)-P7(2)*(2*M-2)*RP3(2)*C23(2))-(2*RP2
     S            (1)*S2TP(1)-P7(1)*(2*M-2)*RP3(1)*C23(1)))
      B(IRH,MD)=-(2*M-1)*(P7(2)*RP2(2)*S22(2)-P7(1)*RP2(1)*S22(1))
C
C                    DEPLACEMENTS HORIZONTAUX
C                    ************************
C
      J3=1
      IDH=NCT+2-NC1+I
      B(IDH,MG)=-((RP2(J3)*C2TP(J3)*EP1+P7(J3)*(2*M-2)*RP3(J3)*S23(J3)))
      B(IDH,MD)=(RP1(J3)*S1TP(J3)*EM1+P7(J3)*(2*M-1)*RP2(J3)*C22(J3))
      IF(I.NE.NP1)GO TO 602
      IH1=IDH+1
      J3=2
      B(IH1,MG)=-((RP2(J3)*C2TP(J3)*EP1+P7(J3)*(2*M-2)*RP3(J3)*S23(J3)))
      B(IH1,MD)=(RP1(J3)*S1TP(J3)*EM1+P7(J3)*(2*M-1)*RP2(J3)*C22(J3))
C
C                    DEPLACEMENTS VERTICAUX
C                    **********************
C
  602 J3=1
      IDV=IDH+ND+1
      B(IDV,MG)=-((RP2(J3)*S2TP(J3)*EM1-P7(J3)*(2*M-2)*RP3(J3)*C23(J3)))
      B(IDV,MD)=-((RP1(J3)*C1TP(J3)*EP1-P7(J3)*(2*M-1)*RP2(J3)*S22(J3)))
```

```
      IF(I.NE.NP1)GO TO 603
      IV1=IH1+ND+1
      J3=2
      B(IV1,MG)=-((RP2(J3)*S2TP(J3)*EM1-P7(J3)*(2*M-2)*RP3(J3)*C23(J3))
      B(IV1,MD)=-((RP1(J3)*C1TP(J3)*EP1-P7(J3)*(2*M-1)*RP2(J3)*S22(J3)))
  603 DO 700 II=1,NSJ
      III=II+NSJ+ND+1
      B(II,MG)=0.D0
      B(II,MD)=0.D0
      B(III,MG)=0.D0
  700 B(III,MD)=0.D0
      B(NSJ+1,MG)=0.D0
      B(NSJ+1,MD)=0.D0
  600 CONTINUE
  550 CONTINUE
      WRITE(IMP,140)((B(I,J),J=1,NTS),I=1,NTS)
  140 FORMAT(///,10(3X,E10.4))
C
C                          RESULTANTES EXTERIEURES APPLIQUEES
C                          **********************************
C
      DO 750 I=1,NTS
  750 REX(I)=0.D0
      REX(NA+2)=-P/2.D0
C
C                               RESOLUTION DU SYSTEME
C                               *********************
C
      I=NTS
      J=NTS
      CALL DARRAY(2,I,J,101,101,B,B)
      EPS=1.D-30
      CALL DGELG(REX,B,NTS,1,EPS,IER)
      IF(IER.NE.0)GO TO 1000
      WRITE(IMP,40)
   40 FORMAT(///,20X,'COEFFICIENTS DE LA SERIE ZETA REGION 2',//)
      NC2=NCT/2+1
      WRITE(IMP,50)((I,REX(I),I,REX(I+NC2)),I=1,NC2)
   50 FORMAT(10X,'ALPHA(',I2,')='E11.5,18X,'BETA(',I2,')=',E11.5,/)
      WRITE(IMP,60)
   60 FORMAT(///,20X,'COEFFICIENTS DE LA SERIE W REGION 3',//)
      NP4=NCT+NP3+1
      WRITE(IMP,70)((I,REX(I+NCT),I,REX(I+NP4)),I=1,NP3)
   70 FORMAT(10X,'GAMMA(',I2,')=',E11.5,18X,'DELTA(',I2,')=',E11.5,/)
C
C                               FACTEUR D''INTENSITE DE CONTRAINTES
C                               ***********************************
C
      FAC=2*DSQRT(PI)/DSQRT(FLW*RI*DEXP(FLW))
      PH2(1)=0.D0
      DO 800 I=1,NC2
```

```
      J=NCI+I-1
      JV=IABS(J-1)
      OM1=(-1)**JV
      PH2(I+1)=PH2(I)+OM1*(REX(I)*(J-0.25)+0.25*REX(I+NC2-1)*
     S           (1-2*(2*J+1)))/POD(I)
      IF(I.EQ.1)PH2(I+1)=PH2(I)+OM1*REX(I)*(J-0.25)
  800 CONTINUE
      K1=FAC*PH2(NC2+1)
      K0=P*DSQRT(FL/PT)/RE
      Y=K1/K0
      WRITE(IMP,80)
   80 FORMAT(//,20X,'FACTEUR D''INTENSITE DE CONTRAINTES ET FACTEUR DE
     S FORME',//)
      WRITE(IMP,90)K1,K0
   90 FORMAT(20X,'K1=',F8.5,20X,'Y=',F8.5)
      STOP
 1000 WRITE(IMP,110)IER
  110 FORMAT(///,'PROBLEME DE RESOLUTION : IER=',I3)
      STOP
      END
```

ANNEXE A6

MÉTHODE DES DISCONTINUITÉS DE DÉPLACEMENTS

```
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      COMMON DN(100),DT(100),A(100),X(100),Z(100),DCN(100),DCL(100),
     1       PN(100),PT(100),KOD(100),BN(100),BT(100),B(200,200),R(200),
     S WF(101)
      COMMON/S1/FSB (6),FDB(8)
      COMMON/S2/TXZN,TXZT,TXXN,TXXT,TZZN,TZZT,DXN,DXT,DZN,DZT
      COMMON/S3/DR,EPOD,NINF
      DATA IMP,LC/108,105/
C
   60 READ (LC,3,END=66)NUMBS,NUMBC,NUMBCR,NUMOS,NINF,NSYM
      NUMBD=0
      FAC=1.D0
      IF (NUMBCR.EQ.0)GO TO 56
      DO 55 I=1,NUMBCR
      READ  6,NUM,RAY,TETAD,TETAF,KODE
      TETA=(TETAF-TETAD)/NUM
      IF(TETA.LT.0.D0)FAC=-1.D0
      SW=RAY*DSQRT(2-2*DCOS(TETA))
      DO 55 N=1,NUM
      NUMBD=NUMBD+1
      TETAM=TETAD+(2*N-1)*TETA/2.D0
      TED=(N-1)*TETA
      TEF=N*TETA
      X(NUMBD)=RAY*DCOS(TETAM)
      Z(NUMBD)=RAY*DSIN(TETAM)
      A(NUMBD)=SW/2
      DCL(NUMBD)=FAC*DCOS(TETAM)
      DCN(NUMBD)=FAC*DSIN(TETAM)
      BN(NUMBD)=-100*(((DCOS(TED)-DCOS(TEF))*DSIN((TED+TEF)/2.D0))
     S/(2.D0*DSIN((TEF-TED)/2.D0)))
      BT(NUMBD)= 100*(((DCOS(TED)-DCOS(TEF))*DCOS((TED+TEF)/2.D0))
     S/(2.D0*DSIN((TEF-TED)/2.D0)))
   55 KOD(NUMBD)=KODE
   56 IF(NUMBC.LE.0)GO TO 61
      PRINT 1,NUMBC
      DO 57 I=1,NUMBC
      READ 2,NUM,RAY,TETAD,TETAF,KODE,TN,TT
      TETA=(TETAF-TETAD)/NUM
      IF(TETA.LT.0.D0)FAC=-1.D0
      SW=RAY*DSQRT(2-2*DCOS(TETA))
      DO 57 N=1,NUM
      NUMBD=NUMBD+1
      TETAM=TETAD+(2*N-1)*TETA/2
      X(NUMBD)=RAY*DCOS(TETAM)
      Z(NUMBD)=RAY*DSIN(TETAM)
      A(NUMBD)=SW/2
      DCL(NUMBD)=FAC*DCOS(TETAM)
      DCN(NUMBD)=FAC*DSIN(TETAM)
      BN(NUMBD)=TN
      BT(NUMBD)=TT
      KOD(NUMBD)=KODE
```

```
   57 CONTINUE
   61 READ 4,PR,EMOD,CDIS
      READ 5,AXX,AZZ,AXZ,BXX,BZZ,BXZ
      PRINT 10,NUMBS
      PRINT 11,NUMOS
      IF (NINF)70,65,70
   65 PRINT 13
      GOTO 75
   66 STOP
   70 PRINT 14
   75 GOTO (80,85,90,95),NSYM
   80 PRINT 15
      GOTO 110
   85 PRINT 16
      GOTO110
   90 PRINT 17,CDIS
      GOTO100
   95 PRINT 18,CDIS
  100 IF(NINF) 110,105,110
  105 PRINT 19
      STOP
  110 CONTINUE
      PRINT 20,PR
      PRINT 21,EMOD
      PRINT 23,AXX,BXX
      PRINT 24,AZZ,BZZ
      PRINT 25,AXZ,BXZ
C
C     EMPLACEMENT,DIMENSION ET ORIENTATION DES DISCONTINUITES DE DEPLACEMENT
C     DU CONTOUR
C
      PRINT 39
      PRINT 40
      DO 115N=1,NUMBS
      READ 41,NUM,XB,ZB,XE,ZE,KODE,TN,TT
      XD=(XE-XB)/NUM
      ZD=(ZF-ZB)/NUM
      SW=DSQRT(XD**2+ZD**2)
      DO 115 NI=1,NUM
      NUMBD=NUMBD+1
      X(NUMBD)=XB+(2*NI-1)*XD/2
      Z(NUMBD)=ZB+(2*NI-1)*ZD/2
      DCL(NUMBD)=ZD/SW
      DCN(NUMBD)=-XD/SW
      A(NUMBD)=SW/2
      BN(NUMBD)=TN
      BT(NUMBD)=TT
      KOD(NUMBD)=KODE
  115 CONTINUE
  116 PRINT 42,(I,KOD(I),X(I),Z(I),A(I),DCN(I),DCL(I),BN(I),BT(I),I=1,
     SNUMBD)
```

```
C
C       INCLURE LES COMPOSANTES DE TRACTION AU TRAVERS DES BORNES DE DISCONTINUIT
C       DE DEPLACEMENT ET INITIALISER LES VALEURS DES DISCONTINUITES
C
        DO 120 N=1,NUMBD
        DT(N)=0.
        DN(N)=0.
        PXX=BXX+AXX*Z(N)
        PZZ=BZZ+AZZ*Z(N)
        PXZ=BXZ+AXZ*Z(N)
        PN(N)=DCL(N)**2*PXX+DCN(N)**2*PZZ+2*DCN(N)*DCL(N)*PXZ
  120   PT(N)=DCN(N)*DCL(N)*(PXX-PZZ)+(DCN(N)**2-DCL(N)**2)*PXZ
        DO150 I=1,NUMBD
        KODE=KOD(I)
        GO TO (125,130,135,140),KODE
  125   BN(I)=PN(I)-BN(I)
        BT(I)=PT(I)-BT(I)
        GO TO 150
  130   BN(I)=-BN(I)
        BT(I)=-BT(I)
        GO TO 150
  135   BN(I)=PN(I)-BN(I)
        BT(I)=-BT(I)
        GO TO 150
  140   BN(I)=-BN(I)
        BT(I)=PT(I)-BT(I)
  150   CONTINUE
C
C       CALCUL DES COEFFICIENTS D'INFLUENCE
C
        DO 200 J=1,NUMBD
        DCLJ=DCL(J)
        DCNJ=DCN(J)
        ZJ=Z(J)
        AH=A(J)
        DO 200 I=1,NUMBD
        CALL INITIA
        XDIS=X(I)-X(J)
        ZI=Z(I)
        CALL COEFF(XDIS,ZI,AH,ZJ,DCLJ,DCNJ,1)
        GO TO (170,155,160,165),NSYM
  155   XDIS=X(I)+X(J)
        CALL  COEFF(XDIS,ZI,AH,ZJ,-DCLJ,DCNJ,-1)
        GOTO 170
  160   ZDIS=2*CDIS-ZJ
        CALL COEFF(XDIS,ZI,AH,ZDIS,DCLJ,-DCNJ,-1)
        GO TO 170
  165   ZDIS=2*CDIS-ZJ
        CALL COEFF (XDIS,ZI,AH,ZDIS,DCLJ,-DCNJ,-1)
        XDIS=X(I)+X(J)
        CALL COEFF (XDIS,ZI,AH,ZJ,-DCLJ,DCNJ,-1)
```

```
      CALL COEFF (XDIS,ZI,AH,ZDIS,-DCLJ,-DCNJ,1)
  170 CONTINUE
      KODE=KOD(I)
      JN=I+NUMBD
      JD=J+NUMBD
      GO TO (175,180,185,190),KODE
  175   B(I,JD)=DCN(I)*DCL(I)*(TXXN-TZZN)+(DCN(I)**2-DCL(I)**2)*TXZN
        B(I,J)=DCN(I)*DCL(I)*(TXXT-TZZT)+(DCN(I)**2-DCL(I)**2)*TXZT
       B(JN,J)=DCL(I)**2*TXXT+DCN(I)**2*TZZT+2*DCN(I)*DCL(I)*TXZT
      B(JN,JD)=DCL(I)**2*TXXN+DCN(I)**2*TZZN+2*DCN(I)*DCL(I)*TXZN
      GO TO 200
  180   B(I,JD)=DCN(I)*DXN-DCL(I)*DZN
        B(I,J)=DCN(I)*DXT-DCL(I)*DZT
       B(JN,J)=DCL(I)*DXT+DCN(I)*DZT
      B(JN,JD)=DCL(I)*DXN+DCN(I)*DZN
      GO TO 200
  185   B(I,JD)=DCN(I)*DXN-DCL(I)*DZN
        B(I,J)=DCN(I)*DXT-DCL(I)*DZT
       B(JN,J)=DCL(I)**2*TXXT+DCN(I)**2*TZZT+2*DCN(I)*DCL(I)*TXZT
      B(JN,JD)=DCL(I)**2*TXXN+DCN(I)**2*TZZN+2*DCN(I)*DCL(I)*TXZN
      GO TO 200
  190   B(I,JD)=DCN(I)*DCL(I)*(TXXN-TZZN)+(DCN(I)**2-DCL(I)**2)*TXZN
        B(I,J)=DCN(I)*DCL(I)*(TXXT-TZZT)+(DCN(I)**2-DCL(I)**2)*TXZT
       B(JN,J)=DCL(I)*DXT+DCN(I)*DZT
      B(JN,JD)=DCL(I)*DXN+DCN(I)*DZN
  200 CONTINUE
      M1=2*NUMBD
C
C     RESOLUTION DES EQUATIONS
C
      EPS=1.D-20
      DO 400 I=1,NUMBD
      R(I)=-BT(I)
  400 R(I+NUMBD)=-BN(I)
      CALL DARRAY(2,M1,M1,200,200,B,B)
      CALL DGELG(R,B,M1,1,EPS,IER)
      IF(IER.NE.0)GO TO 380
      DO 401 I=1,NUMBD
      DT(I)=R(I)
  401 DN(I)=R(I+NUMBD)
C
C
C     INCLURE LES DEPLACEMENTS SUR LES COTES POSITIF ET NEGATIF DES DISCONTINU
C     (ET LES COMPOSANTES DE TRACTION) ET ECRIRE LES RESULTATS
C
      PRINT 51
      WF(1)=0.D0
      DO 600 I=1,NUMBD
      ZI=Z(I)
      SIGXZ=0.
      SIGXX=0.
```

```
      SIGZZ=0.
      UXPOS=0.
      UZPOS=0.
      UXNEG=0.
      UZNEG=0.
      DO 570 J=1,NUMBD
      CALL INITIA
      DCLJ=DCL(J)
      DCNJ=DCN(J)
      ZJ=Z(J)
      AH=A(J)
      XDIS=X(I)-X(J)
      CALL COEFF (XDIS,ZI,AH,ZJ,DCLJ,DCNJ,1)
      IF (I-J) 480,470,480
  470 CON=DCNJ
      COL=DCLJ
      GO TO 490
  480 CON=0.
      COL=0.
  490 CONTINUE
      GO TO (560,500,510,520),NSYM
  500 XDIS=X(I)+X(J)
      CALL COEFF (XDIS,ZI,AH,ZJ,-DCLJ,DCNJ,-1)
      GO TO 560
  510 ZDIS=2*CDIS-ZJ
      CALL COEFF (XDIS,ZI,AH,ZDIS,DCLJ,-DCNJ,-1)
      GO TO 560
  520 ZDIS=2*CDIS-ZJ
      CALL COEFF(XDIS,ZI,AH,ZDIS,DCLJ,-DCNJ,-1)
      XDIS=X(I)+X(J)
      CALL COEFF(XDIS,ZI,AH,ZJ,-DCLJ,DCNJ,-1)
      CALL COEFF(XDIS,ZI,AH,ZDIS,-DCLJ,-DCNJ,1)
  560 SIGXX=SIGXX+TXXT*DT(J)+TXXN*DN(J)
      SIGZZ=SIGZZ+TZZT*DT(J)+TZZN*DN(J)
      SIGXZ=SIGXZ+TXZT*DT(J)+TXZN*DN(J)
      UXPOS=UXPOS+DXT*DT(J)+DXN*DN(J)
      UZPOS=UZPOS+DZT*DT(J)+DZN*DN(J)
      UXNEG=UXNEG+(DXT-CON)*DT(J)+(DXN-COL)*DN(J)
      UZNEG=UZNEG+(DZT+COL)*DT(J)+(DZN-CON)*DN(J)
  570 CONTINUE
      UNNEG=DCL(I)*UXNEG+DCN(I)*UZNEG
      UNPOS=DCL(I)*UXPOS+DCN(I)*UZPOS
      UTNEG=DCN(I)*UXNEG-DCL(I)*UZNEG
      UTPOS=DCN(I)*UXPOS-DCL(I)*UZPOS
      WF(I+1)=WF(I)+(A(I)*(UNPOS*BN(I)+UTPOS*BT(I)))-
      SN=PN(I)*DCL(I)**2*SIGXX+DCN(I)**2*SIGZZ+2*DCL(I)*DCN(I)*SIGXZ
      ST=PT(I)+DCL(I)*DCN(I)*(SIGXX-SIGZZ)+(DCN(I)**2-DCL(I)**2)*SIGXZ
      PRINT 52,I,DN(I),UNPOS,UNNEG,DT(I),UTPOS,UTNEG,UXPOS,UZPOS,UXNEG,
     SUZNEG,SN,ST
  600 CONTINUE
      PRINT 58,WF(NUMBD+1)
```

```
C
C       INTRODUCTION DES CONTRAINTES OU DES DEPLACEMENTS AUX ENDROITS OU L'ON
C        VEUT FAIRE UN CALCUL
C
        IF (NUMOS) 900,900,700
  700   PRINT 53
        NUMP=0
        DO 850 N=1,NUMOS
        READ 43,NUM,XB,ZB,XE,ZE
        XD=(XE-XB)/NUM
        ZD=(ZE-ZB)/NUM
        DO 850 NI=1,NUM
        NUMP=NUMP+1
        XOL=XB+(2*NI-1)*XD/2
        ZOL=ZB+(2*NI-1)*ZD/2
        SIGXX=BXX+AXX*ZOL
        SIGZZ=BZZ+AZZ*ZOL
        SIGXZ=BXZ+AXZ*ZOL
        UX=0.
        UZ=0.
C
        DO 830 J=1,NUMBD
        CALL INITIA
        DCLJ=DCL(J)
        DCNJ=DCN(J)
        ZJ=Z(J)
        AH=A(J)
        XDIS=XOL-X(J)
        CALL COEFF(XDIS,ZOL,AH,ZJ,DCLJ,DCNJ,1)
        GOTO (825,800,810,820),NSYM
  800   XDIS=XOL+X(J)
        CALL COEFF(XDIS,ZOL,AH,ZJ,-DCLJ,DCNJ,-1)
        GO TO 825
  810   ZDIS=2*CDIS-ZJ
        CALL COEFF(XDIS,ZOL,AH,ZDIS,DCLJ,-DCNJ,-1)
        GO TO 825
  820   ZDIS=2*CDIS-ZJ
        CALL COEFF(XDIS,ZOL,AH,ZDIS,DCLJ,-DCNJ,-1)
        XDIS=XOL+X(J)
        CALL COEFF(XDIS,ZOL,AH,ZJ,-DCLJ,DCNJ,-1)
        CALL COEFF(XDIS,ZOL,AH,ZDIS,-DCLJ,-DCNJ,1)
  825   SIGXX=SIGXX+TXXT*DT(J)+TXXN*DN(J)
        SIGZZ=SIGZZ+TZZT*DT(J)+TZZN*DN(J)
        SIGXZ=SIGXZ+TXZT*DT(J)+TYZN*DN(J)
        UX=UX+DXT*DT(J)+DXN*DN(J)
        UZ=UZ+DZT*DT(J)+DZN*DN(J)
C
  830   CONTINUE
        PRINT 54 ,NUMP,XOL,ZOL,SIGXX,SIGZZ,SIGXZ,UX,UZ
  850   CONTINUE
C
```

```
900 CONTINUE
    GO TO 60

  1 FORMAT(1X,'NOMBRE DE SEGMENTS DE CONTOUR CALCULES : ',I4,//)
  2 FORMAT(I4,F8.4,2F10.7,I4,2F10.3)
  3 FORMAT(6I4)
  4 FORMAT(F6.2,E11.4,F8.2)
  5 FORMAT (6F8.2)
  6 FORMAT(I4,F8.4,2F10.7,I4)
 10 FORMAT (//'NOMBRE DE SEGMENTS DE DROITES (CONTENANT AU MOINS UNE
   1DISCONTINUITE) UTILISES POUR DETERMINER LES CONTOURS='I4)
 11 FORMAT (//'NOMBRE DE SEGMENTS DE DROITES UTILISES POUR DETERMINER
   1LES AUTRES ENDROITS OU L ON VEUT OBTENIR DES RESULTATS='I4)
 12 FORMAT (//'NOMBRE MAXIMUM D ITERATIONS POUR RESOUDRE LES EQUATIONS
   1='I4)
 13 FORMAT (//'MILIEU SEMI-INFINI.')
 14 FORMAT (//'SOLUTION EN MILIEU INFINI.')
 15 FORMAT (//'AUCUNE CONDITION DE SYMETRIE N EST IMPOSEE.')
 16 FORMAT (//'X=0.00 EST AXE DE SYMETRIE.')
 17 FORMAT (//'Z='F8.2' EST AXE DE SYMETRIE.')
 18 FORMAT (//'X=0.00 ET Z='F8.2' SONT AXES DE SYMETRIE.')
 19 FORMAT (////'LA DROITE Z=CONST NE PEUT ETRE UN AXE DE SYMETRIE DAN
   1S  UN MILIEU SEMI-INFINI.')
 20 FORMAT (//'COEFFICIENT DE POISSON DU MILIEU ='F6.2)
 21 FORMAT (//'MODULE D ELASTICITE DU MILIEU ='E11.4)
 22 FORMAT (//' FACTEUR DE RELAXATION ='F6.2)
 23 FORMAT (//'COMPOSANTE XX DU CHAMP DE CONTRAINTES='F8.2' Z+'F8.2)
 24 FORMAT (//'COMPOSANTE ZZ DU CHAMP DE CONTRAINTES ='F8.2' Z+'F8.2)
 25 FORMAT (//'COMPOSANTE XZ DU CHAMP DE CONTRAINTES ='F8.2' Z+'F8.2)
 39 FORMAT (////'    DANS LA LISTE SUIVANTE,LES DIFFERENTES VALEURS DE
   1KODE SONT'/'          -TRACTION NORMALE ET TANGENTIELLE SONT INDUI
   2TES (KODE=1)'/'          -DEPLACEMENTS NORMAUX ET TANGENTIELS INDU
   3ITS (KODE=2)'/'          -TRACTION NORMALE ET DEPLACEMENT TANGENTI
   4EL INDUITS (KODE=3)'/'          -TRACTION  TANGENTIELLE ET DEPLACE
   5MENT NORMAL INDUITS (KODE=4)'/'    LES DEPLACEMENTS INDUITS SONT
   6APPLIQUES SUR LA FACE POSITIVE D UNE DISCONTINUITE')
 40 FORMAT (////'     SEGMENT      KODE      X-COORD      Z-COORD  HALF
   SIDTH   DIR COS N  DIR COS L  N. TRACT. (OU DEPL.)  T. TRACT. (OU
   SDEPL.)'/)
 41 FORMAT (I4,4F12.4,I4,2F12.4)
 42 FORMAT (I12,I9,3F12.4,2F12.6,2F22.6)
 43 FORMAT (I4,4F12.4)
 49 FORMAT (////' NOMBRE D"ITERATIONS='I4/'DIFFERENCE MAXIMALE ENTRE
   SDEUX ITERATIONS SUCCESSIVES='E10.3////)
 50 FORMAT (////' LE PROCESSUS D"ITERATIONS N"ARRIVE PAS A CONVERGER
   SPOUR 'I4' ITERATIONS-DIFFERENCE MAXIMALE ENTRE DEUX ITERATIONS
   SSUCCESSIVES ='E10.3///)
 51 FORMAT(/,'SEG    UN(TOTAL)     UN(POS)     UN(NEG)     UT(TOTAL)',4X,
   1'UT(POS)     UT(NEG)     UX(POS)     UZ(POS)     UX(NEG)     UZ(NEG)'5X
   2'SIG-N    SIG-T',//)
 52 FORMAT(I3,F14.7,F12.6,F10.4,F14.7,F12.6,F9.4,2F11.6,2F10.5,2F8.1)
```

```
 53 FORMAT (/'     POINT     X-COORD      Z-COORD      SIGXX      SIGZZ
   S  SIGXZ          UX          UZ'/)
 54 FORMAT (I8,5F12.4,2F12.8)
 58 FORMAT(//,'  U  =  'E21.15)
380 WRITE(IMP,381)IER
381 FORMAT(20X,'PROBLEME D''INVERSION;IER=',I4)
    STOP
    END
```

```
      SUBROUTINE INITIA
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      COMMON/S2/TXZN,TXZT,TXXN,TXXT,TZZN,TZZT,DXN,DXT,DZN,DZT
      TXZN=0.
      TXZT=0.
      TXXN=0.
      TXXT=0.
      TZZN=0.
      TZZT=0.
      DXN=0.
      DXT=0.
      DZN=0.
      DZT=0.
      RETURN
      END
```

```
      SUBROUTINE COEFF (X,Z,A,C,DCL,DCN,MULT)
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      COMMON/S1/FSB(6),FDB(8)
      COMMON/S2/TX4N,TXZT,TXXN,TXXT,TZZN,TZZT,DXN,DXT,DZN,DZT
      COMMON /S3/PR,EMOD,NINF
      CON=EMOD/(16*DATAN(1.0)*(1-PR*PR))
      CON=1./(16*DATAN(1.)*(1-PR))
      XI=DCN*X-DCL*(Z-C)
      ZETA=DCL*X+DCN*(Z-C)
      CALL TERMSB(XI,ZETA,A,DCL,DCN)
C
      SXZSBN=CON*ZETA*(DCL*FSB(6)-DCN*FSB(5))
      SXZSBT=CON*(FSB(4)+ZETA*(DCN*FSB(6)+DCL*FSB(5)))
      SXXSBN=CON*((DCN**2-DCL**2)*FSB(4)+2*DCN*DCL*FSB(3)+ZETA*
     S(DCL*FSB(5)+DCN*FSB(6)))
      SXXSBT=CON*(2*DCN**2*FSB(3)-2*DCN*DCL*FSB(4)+ZETA*(DCN*FSB(5)-
     SDCL*FSB(6)))
      SZZSBN=CON*((DCN**2-DCL**2)*FSB(4)+2*DCN*DCL*FSB(3)-ZETA*(DCL*
     SFSB(5)+DCN*FSB(6)))
      SZZSBT=-CON*(2*DCN*DCL*FSB(4)+2*DCL**2*FSB(3)+ZETA*(DCN*FSB(5)-
     S  DCL*FSB(6)))
C
      DXSBN=CON*((DCL**2+(DCL**2-DCN**2)*(1-2*PR))*FSB(1)+DCN*DCL*(3-4*
     S  PR)*FSB(2)+ZETA*(DCL*FSB(4)-DCN*FSB(3)))
      DXSBT=CON*(DCN*DCL*(3-4*PR)*FSB(1)+(DCN**2+(DCN**2-DCL**2)*(1-2*
     S  PR))*FSB(2)+ZETA*(DCN*FSB(4)+DCL*FSB(3)))
      DZSBN=CON*(DCL*DCL*(3-4*PR)*FSB(1)+(DCN**2+(DCN**2-DCL**2)*(1-2*
     S  PR))*FSB(2)-ZETA*(DCL*FSB(3)+DCN*FSB(4)))
      DZSBT=CON*(-(DCL**2+(DCL**2-DCN**2)*(1-2*PR))*FSB(1)-DCN*DCL*(3-4*
     S  PR)*FSB(2)+ZETA*(DCL*FSB(4)-DCN*FSB(3)))
C
      IF  (NINF) 150,100,150
  100 XIP=DCN*X+DCL*(Z+C)
      ZETAP=-DCL*X+DCN*(Z+C)
C
      CALL TERMDB(XIP,ZETAP,A,DCL,DCN)
C
      SXZDBN=CON*((-(1-4*DCL**2)*Z+DCL*XI-C)*FDB(5)+DCL*(ZETA+4*DCN*Z)*
     S  FDB(6)+2*Z*((DCL*XI-C)*FDB(7)+DCL*ZETA*FDB(8)))
      SXZDBT=-CON*(FDB(4)+DCL*(ZETA+4*DCN*Z)*FDB(5)+((1+4*DCL**2)*Z-
     S  (DCL*XI-C))*FDB(6)+2*Z*(DCL*ZETA*FDB(7)-(DCL*XI-C)*FDB(8)))
      SXXDBN=CON*(-(DCN**2-DCL**2)*FDB(4)+2*DCN*DCL*FDB(3)+DCL*(3*ZETA+
     S  4*DCN*Z)*FDB(5)-((1-4*DCL**2)*Z+3*(DCL*XI-C))*FDB(6)+2*Z*
     S    (DCL*ZETA*FDB(7)-(DCL*XI-C)*FDB(8)))
      SXXDBT=-CON*(2*(1+DCL**2)*FDB(3)-2*DCN*DCL*FDB(4)+((1+4*DCL**2)*Z-
     S  3*(DCL*XI-C))*FDB(5)-DCL*(3*ZETA+4*DCN*Z)*FDB(6)-2*Z*((DCL*
     S  XI-C)*FDB(7)+DCL*ZETA*FDB(8)))
      SZZDBN=CON*(2*DCN*DCL*FDB(3)-(DCN**2-DCL**2)*FDB(4)+DCL*(ZETA-4*Z*
     S  DCN)*FDB(5)+((1-4*DCL**2)*Z-DCL*XI+C)*FDB(6)-2*Z*(DCL*
     S  ZETA*FDB(7)-(DCL*XI-C)*FDB(8)))
      SZZDBT=-CON*(2*DCL**2*FDB(3)-2*DCN*DCL*FDB(4)-((1+4*DCL**2)*Z+DCL*
```

```
     S   XI-C)*FDB(5)-DCL*(ZETA-4*DCN*Z)*FDB(6)+2*Z*((DCL*XI-C)*
     S   FDB(7)+DCL*ZETA*FDB(8)))
C
      DXDBN=COM*((DCL**2+1-2*PR)*FDB(1)-DCN*DCL*FDB(2)+((3-4*PR)*(DCL*
     S   XI-C)+(1-2*DCL**2)*Z)*FDB(3)+DCL*((3-4*PR)*ZETA+2*DCN*Z)*
     S   FDB(4)+2*Z*((DCL*XI-C)*FDB(5)+DCL*ZETA*FDB(6)))
      DXDBT=-COM*(-DCN*DCL*FDB(1)+(DCN**2+1-2*PR)*FDB(2)+DCL*((3-4*PR)*
     S   ZETA+2*DCN*Z)*FDB(3)-((3-4*PR)*(DCL*XI-C)-(1+2*DCL**2)*Z)*
     S   FDB(4)+2*Z*(DCL*ZETA*FDB(5)-(DCL*XI-C)*FDB(6)))
      DZDBN=COM*(DCN*DCL*FDB(1)+(DCN**2-(1+2*DCN**2)*(1-2*PR))*FDB(2)+
     S   DCL*((3-4*PR)*ZETA-2*DCN*Z)*FDB(3)+((1-2*DCL**2)*Z-(3-4*PR)*
     S   (DCL*XI-C))*FDB(4)-2*Z*(DCL*ZETA*FDB(5)-(DCL*XI-C)*FDB(6)))
      DZDBT=-COM*((DCL**2+1-2*PR)*FDB(1)-DCN*DCL*FDB(2)-((1+2*DCL**2)*4+
     S   (3-4*PR)*(DCL*XI-C))*FDB(3)-DCL*((3-4*PR)*ZETA-2*DCN*Z)*
     S   FDB(4)+2*Z*((DCL*XI-C)*FDB(5)+DCL*ZETA*FDB(6)))
      GO TO 200
  150 SXZDBN=0.
      SXZDBT=0.
      SXXDBN=0.
      SXXDBT=0.
      SZZDBN=0.
      SZZDBT=0.
      DXDBN=0.
      DXDBT=0.
      DZDBN=0.
      DZDBT=0.
C
  200 TXZN=TXZN+SXZSBN+SXZDBN
      TXZT=TXZT+MULT*(SXZSBT+SXZDBT)
      TXXN=TXXN+SXXSBN+SXXDBN
      TXXT=TXXT+MULT*(SXXSBT+SXXDBT)
      TZZN=TZZN+SZZSBN+SZZDBN
      TZZT=TZZT+MULT*(SZZSBT+SZZDBT)
      DXN=DXN+DXSBN+DXDBN
      DXT=DXT+MULT*(DXSBT+DXDBT)
      DZN=DZN+DZSBN+DZDBN
      DZT=DZT+MULT*(DZSBT+DZDBT)
C
      RETURN
      END
```

```
      SUBROUTINE TERMSB(XI,ZETA,A,DCL,DCN)
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      COMMON /S1/FSB(6),FDB(8)
C
      IF (ZETA) 20,5,20
    5 ARG=DSQRT((XI+A)**2/(XI-A)**2)
      IF (DABS(XI)-A) 10,10,15
   10 FSB(1)=4*DCL*DATAN(1.0)+DCN*DLOG(ARG)
      FSB(2)=4*DCN*DATAN(1.0)-DCL*DLOG(ARG)
      GO TO 30
   15 FSB(1)=DCN*DLOG(ARG)
      FSB(2)=-DCL*DLOG(ARG)
      GO TO 30
   20 FSB(1)=F1(XI,ZETA,A,DCL,DCN)
      FSB(2)=F2(XI,ZETA,A,DCL,DCN)
   30 FSB(3)=F3(XI,ZETA,A,DCL,DCN)
      FSB(4)=F4(XI,ZETA,A,DCL,DCN)
      FSB(5)=F5(XI,ZETA,A,DCL,DCN)
      FSB(6)=F6(XI,ZETA,A,DCL,DCN)
C
      RETURN
      END
```

```
      SUBROUTINE TERMDB(XIP,ZETAP,A,DCL,DCN)
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      COMMON/S1/FSE(6),FDE(8)
C
      IF (ZETAP) 50,40,50
   40 ARG=DSQRT((XIP+A)**2/(XIP-A)**2)
      FDE(1)=DCL*DLOG(ARG)
      FDE(2)=DCL*DLOG(ARG)
      GO TO 60
   50 FDE(1)=F1(XIP,ZETAP,A,-DCL,DCN)
      FDE(2)=F2(XIP,ZETAP,A,-DCL,DCN)
   60 FDE(3)=F3(XIP,ZETAP,A,-DCL,DCN)
      FDE(4)=F4(XIP,ZETAP,A,-DCL,DCN)
      FDE(5)=F5(XIP,ZETAP,A,-DCL,DCN)
      FDE(6)=F6(XIP,ZETAP,A,-DCL,DCN)
      FDE(7)=F7(XIP,ZETAP,A,-DCL,DCN)
      FDE(8)=F8(XIP,ZETAP,A,-DCL,DCN)
C
      RETURN
      END
```

```
      FUNCTION F1(X,Z,A,DCL,DCN)
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      F1=DCL*(DATAN((X+A)/Z)-DATAN((X-A)/Z))+DCN*(DLOG((X+A)**2+Z*Z)-
     SDLOG((X-A)**2+Z*Z))/2
      RETURN
      END
```

```
      FUNCTION F2(X,Z,A,DCL,DCN)
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      F2=DCN*(DATAN((X+A)/Z)-DATAN((X-A)/Z))-DCL*(DLOG((X+A)**2+Z*Z)-
     $DLOG((X-A)**2+Z*Z))/2
      RETURN
      END
```

```
      FUNCTION F3(X,Z,A,DCL,DCN)
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      F3=((DCN**2-DCL**2)*Z-2*DCN*DCL*(X+A))/((X+A)**2+Z*Z)-
     S((DCN**2-DCL**2)*Z-2*DCN*DCL*(X-A))/((X-A)**2+Z*Z)
      RETURN
      END
```

```
      FUNCTION F4(X,Z,A,DCL,DCN)
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      F4=-(2*DCN*DCL*Z+(DCN**2-DCL**2)*(X+A))/((X+A)**2+Z*Z)+
     S(2*DCN*DCL*Z+(DCN**2-DCL**2)*(X-A))/((X-A)**2+Z*Z)
      RETURN
      END
```

```
      FUNCTION F5(X,Z,A,DCL,DCN)
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      F5=(DCN*(DCN**2-3*DCL**2)*((X+A)**2-Z*Z)+2*DCL*(3*DCN**2-DCL**2)*
     S(X+A)*Z)/((X+A)**2+Z*Z)**2-
     S(DCN*(DCN**2-3*DCL**2)*((X-A)**2-Z*Z)+2*DCL*(3*DCN**2-DCL**2)*
     S(X-A)*Z)/((X-A)**2+Z*Z)**2
      RETURN
      END
```

```
      FUNCTION F6(X,Z,A,DCL,DCN)
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      F6=(2*DCN*(DCN**2-3*DCL**2)*(X+A)*Z-DCL*(3*DCN**2-DCL**2)*
     S((X+A)**2-7*Z))/((X+A)**2+Z*Z)**2-
     S(2*DCN*(DCN**2-3*DCL**2)*(X-A)*Z-DCL*(3*DCN**2-DCL**2)*
     S((X-A)**2-Z*Z))/((X-A)**2+Z*Z)**2
      RETURN
      END
```

```
      FUNCTION F7(X,Z,A,DCL,DCN)
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      F7=(8*DCN*DCL*(DCN**2-DCL**2)*(X+A)*((X+A)**2-3*Z*Z)+2*(DCN**4-
     S   6*(DCN*DCL)**2+DCL**4)*Z*(Z*Z-3*(X+A)**2))/ ((X+A)**2+Z*Z)**3-
     S   (8*DCN*DCL*(DCN**2-DCL**2)*(X-A)*((X-A)**2-3*Z*Z)+2*(DCN**4-
     S   6*(DCN*DCL)**2+DCL**4)*Z*(Z*Z-3*(X-A)**2))/((X-A)**2+Z*Z)**3
      RETURN
      END
```

```
      FUNCTION FB(X,Z,A,DCL,DCN)
      IMPLICIT DOUBLE PRECISION(A-H,O-Z)
      FB=(2*(DCN**4-6*(DCN*DCL)**2+DCL**4)*(X+A)*((X+A)**2-3*Z*Z)-8*DCN*
     S   DCL*(DCN**2-DCL**2)*Z*(Z*Z-3*(X+A)**2))/((X+A)**2+Z*Z)**3-
     S   (2*(DCN**4-6*(DCN*DCL)**2+DCL**4)*(X-A)*((X-A)**2-3*Z*Z)-8*DCN*
     S   DCL*(DCN**2-DCL**2)*Z*(Z*Z-3*(X-A)**2))/((X-A)**2+Z*Z)**3
      RETURN
      END
```

SOUS - PROGRAMMES DE RÉSOLUTIONS DES SYSTÈMES D'ÉQUATIONS LINÉAIRES

```
      SUBROUTINE DARRAY(MODE,I,J,N,M,S,D)
      DOUBLE PRECISION S,D
      DIMENSION S(68000),D(68000)
      NJ=N-I
      IF(MODE-1)100,100,120
  100 IJ=I*J+1
      NN=N*J+1
      DO 110 K=1,J
      NN=NN-NI
      DO 110 L=1,I
      IJ=IJ-1
      NN=NN-1
  110 D(NN)=S(IJ)
      GO TO 140
  120 IJ=0.D0
      NN=0.D0
      DO 130 K=1,J
      DO 125 L=1,I
      IJ=IJ+1
      NN=NN+1
  125 S(IJ)=D(NN)
  130 NN=NN+NJ
  140 RETURN
      END
```

```
      SUBROUTINE DGELG(R,A,M,N,EPS,IER)
      DOUBLE PRECISION R,A,PIV,TB,TOL,PIVI
      DIMENSION A(62000),R(200)
      IF(N)23,23,1
    1 IER=0
      PIV=0.D0
      MM=M*M
      NM=N*M
      DO 3 L=1,MM
      TB=DABS(A(L))
      IF(TB-PIV)3,3,2
    2 PIV=TB
      I=L
    3 CONTINUE
      TOL=EPS*PIV
      LST=1
      DO 17 K=1,M
      IF(PIV)23,23,4
    4 IF(IER)7,5,7
    5 IF(PIV-TOL)6,6,7
    6 IER=K-1
    7 PIVI=1.D0/A(I)
      J=(I-1)/M
      I=I-J*M-K
      J=J+1-K
      DO 8 L=K,MM,M
      LL=L+I
      TB=PIVI*R(LL)
      R(LL)=R(L)
    8 R(L)=TB
      IF(K-M)9,18,18
    9 LEND=LST+M-K
      IF(J)12,12,10
   10 II=J*M
      DO 11 L=LST,LEND
      TB=A(L)
      LL=L+II
      A(L)=A(LL)
   11 A(LL)=TB
   12 DO 13 L=LST,MM,M
      LL=L+I
      TB=PIVI*A(LL)
      A(LL)=A(L)
   13 A(L)=TB
      A(LST)=J
      PIV=0.D0
      LST=LST+1
      J=0
      DO 16 II=LST,LEND
      PIVI=-A(II)
      IST=II+M
```

```
      J=J+1
      DO 15 L=IST,NN,M
      LL=L-J
      A(L)=A(L)+PIVI*A(LL)
      TB=DABS(A(L))
      IF(TB-PIV)15,15,14
   14 PIV=TB
      I=L
   15 CONTINUE
      DO 16 L=K,NN,M
      LL=L+J
   16 R(LL)=R(LL)+PIVI*R(L)
   17 LST=LST+M
   18 IF(M-1)23,22,19
   19 IST=NN+M
      LST=L+1
      DO 21 I=2,M
      II=LST-I
      IST=IST-LST
      L=IST-M
      L=A(L)+.500
      DO 21 J=II,NN,M
      TB=R(J)
      LL=J
      DO 20  K=IST,NN,M
      LL=LL+1
   20 TB=TB-A(K)*R(LL)
      K=J+L
      R(J)=R(K)
   21 R(K)=TB
   22 RETURN
   23 IER=-1
      RETURN
      END
```