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C     ================================================================
C     SUBROUTINE CMM            :
C     1. calculate fatigue crack-initiation life using Coffin-Manson-Morrow method.
C     2. Inelastic stress strain :  Ramber-Osgood law.
C     3. Neuber's rule for inelastic stress concentration.
C
C     ================================================================
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      SUBROUTINE CMM(MAX_PRIN, E, R_NF, GDR)
c     1 IFLAG_DIST)
C      SUBROUTINE CMM(X, A, XT)


      USE UMACH_INT
      USE ZBREN_INT
      INCLUDE "link_fnl_shared.h"
C      IMPLICIT NONE
      REAL*8 MAX_PRIN, E(3), S1_1, S1_2, DS1, E1_1, E1_2, DE1, E1_I,
     1   S1_I, DE1_I, DS1_I, R_K, R_N, SF, B, EF, C, EY, SM, R_NF, R_KF,
     2   C1, TMP1, TMP2, TMP3


      INTEGER    NOUT
      REAL A1, B1, F1, F2, F3
      EXTERNAL   F1, F2, F3
      CHARACTER(320) GDR,FNF

      COMMON /CMM01/ DE1_I, SM, SF, EF, B, C, EY, R_K, R_N, S1_1, DS1,
     1 E1_1, DE1, C1, R_KF

      SF = 1332.0
      B = -0.1085
      EF = 0.375
      C = -0.6354
      EY = 203.0*10.0**3
      C1 = 0.0
      R_KF = 1.0


      R_K = SF/(EF**(B/C))
      R_N = B/C

      S1_1 = MAX_PRIN
      S1_2 = 0.0
      DS1 = S1_1 - S1_2
      E1_1 = E(1)
      E1_2 = 0.0
      DE1 = E1_1 - E1_2

      FNF =  TRIM(GDR)//'\'//'FATIGUE_LIFE.DAT'
      OPEN(801,FILE=trim(FNF),STATUS='NEW')



      A1      = 0.0
      B1      = R_KF**2.0*EY
      ERRABS = 0.0
      ERRREL = 0.000001
      MAXFN  = 1000
      CALL ZBREN (F1, A1, B1, ERRABS=ERRABS, ERRREL=ERRREL, MAXFN=MAXFN)

      S1_I = B1
      E1_I = R_KF**2.0*S1_1*E1_1/S1_I

      PRINT*, '-----------------------------S1_I --------------'
      PRINT*, S1_I
      PRINT*, '-----------------------------E1_I --------------'
      PRINT*, E1_I
      PRINT*, '-----------------------------MAXFN --------------'
      PRINT*, MAXFN

      WRITE(801, '(A40)') '-------------------------S1_I -----------'
      WRITE(801,'(E20.10)')  S1_I

      WRITE(801, '(A40)') '-------------------------E1_I -----------'
      WRITE(801,'(E20.10)')  E1_I

      WRITE(801, '(A40)') '-------------------------MAXFN -----------'
      WRITE(801,'(I8)')  MAXFN



      A1      = 0.0
      B1      = R_KF**2.0*EY
      ERRABS = 0.0
      ERRREL = 0.000001
      MAXFN  = 1000
      CALL ZBREN (F2, A1, B1, ERRABS=ERRABS, ERRREL=ERRREL, MAXFN=MAXFN)

      DS1_I = B1
      DE1_I = R_KF**2.0*DS1*DE1/DS1_I
      PRINT*, '-----------------------------DS1_I --------------'
      PRINT*, DS1_I
      PRINT*, '-----------------------------DE1_I --------------'
      PRINT*, DE1_I
      PRINT*, '-----------------------------MAXFN --------------'
      PRINT*, MAXFN

      WRITE(801, '(A40)') '-------------------------DS1_I -----------'
      WRITE(801,'(E20.10)')  DS1_I

      WRITE(801, '(A40)') '-------------------------DE1_I -----------'
      WRITE(801,'(E20.10)')  DE1_I

      WRITE(801, '(A40)') '-------------------------MAXFN -----------'
      WRITE(801,'(I8)')  MAXFN

      SM = S1_I - DS1_I/2.0


      C1 = (SF - SM)/EY

C     ---------------F3(A1)<0, F3(B1)>0  IF B C CHANGE, NEED CHECK WHICH ONE IS BIGGER IN TWO TERM OF cmm EQUATION      ----
      TMP1  = 0.5 * (2.0*C1/DE1_I)**(-1.0/B)
      TMP2  = 0.5 * (2.0*EF/DE1_I)**(-1.0/C)
      IF (TMP1 .GE. TMP2) THEN
        TMP3 = -1.0/B
      ELSE
        TMP3 = -1.0/C
      ENDIF
      A1      = MIN(TMP1, TMP2)
      B1      = 2.0**TMP3*MAX(TMP1, TMP2)
c      A1      = 1.0
c      B1      = 10.0**14.0
      ERRABS = 0.0
      ERRREL = 0.000001
      MAXFN  = 1000
      CALL ZBREN (F3, A1, B1, ERRABS=ERRABS, ERRREL=ERRREL, MAXFN=MAXFN)

      R_NF = B1

      PRINT*, '-----------------------------R_NF --------------'
      PRINT*, R_NF
      PRINT*, '-----------------------------A1 --------------'
      PRINT*, A1
      PRINT*, '-----------------------------MAXFN --------------'
      PRINT*, MAXFN


      WRITE(801, '(A40)') '-------------------------R_NF -----------'
      WRITE(801,'(E20.10)')  R_NF

      WRITE(801, '(A40)') '-------------------------A1 -----------'
      WRITE(801,'(E20.10)')  A1

      WRITE(801, '(A40)') '-------------------------MAXFN -----------'
      WRITE(801,'(I8)')  MAXFN




      CLOSE(801)



      RETURN
      END


      REAL FUNCTION F1 (X)
      REAL       X
      REAL*8 MAX_PRIN, E(3), S1_1, S1_2, DS1, E1_1, E1_2, DE1, E1_I,
     1   S1_I, DE1_I, DS1_I, R_K, R_N, SF, B, EF, C, EY, SM, R_NF, R_KF,
     2   C1

      COMMON /CMM01/ DE1_I, SM, SF, EF, B, C, EY, R_K, R_N, S1_1, DS1,
     1 E1_1, DE1, C1, R_KF



      F1 = R_KF**2.0*S1_1*E1_1 - X**2.0/EY - (X/R_K)**(1/R_N)*X

      RETURN
      END

      REAL FUNCTION F2 (X)
      REAL       X
      REAL*8 MAX_PRIN, E(3), S1_1, S1_2, DS1, E1_1, E1_2, DE1, E1_I,
     1   S1_I, DE1_I, DS1_I, R_K, R_N, SF, B, EF, C, EY, SM, R_NF, R_KF,
     2   C1

      COMMON /CMM01/ DE1_I, SM, SF, EF, B, C, EY, R_K, R_N, S1_1, DS1,
     1 E1_1, DE1, C1, R_KF


      F2 = R_KF**2.0*DS1*DE1 - X**2.0/EY - 2.0*(0.5*X/R_K)**(1/R_N)*X

      RETURN
      END

      REAL FUNCTION F3 (X)
      REAL       X
      REAL*8 MAX_PRIN, E(3), S1_1, S1_2, DS1, E1_1, E1_2, DE1, E1_I,
     1   S1_I, DE1_I, DS1_I, R_K, R_N, SF, B, EF, C, EY, SM, R_NF, R_KF,
     2   C1

      COMMON /CMM01/ DE1_I, SM, SF, EF, B, C, EY, R_K, R_N, S1_1, DS1,
     1 E1_1, DE1, C1, R_KF


      F3 = (0.5*DE1_I - C1*(2.0*X)**B - EF*(2.0*X)**C)/(DE1_I**2.0)

      RETURN
      END
```