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OF THE FORMA SYSTEM FOR RESPONSE AND LOAD
ANALYSIS, VOLUME 2G: LISTINGS, FINITE
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EXPANSION AND IMPROVEMENT OF THE FORMA
SYSTEM FOR RESPONSE AND LOAD ANALYSIS

Volume IIC - Listings, Finite Element FORMA Subroutines

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FOREWORD

This report presents results of the expansion and improvement of the FORMA system for response and load analysis. The acronym FORMA stands for FORTRAN Matrix Analysis. The study, performed from 16 May 1975 through 17 May 1976 was conducted by the Analytical Mechanics Department, Martin Marietta Corporation, Denver Division, under the contract NAS8-31379. The program was administered by the National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Alabama under the direction of Dr. John R. Admire, Structural Dynamics Division, Systems Dynamics Laboratory.

This report is published in seven volumes:

Volume I - Programming Manual,
Volume IIA - Listings, Dense FORMA Subroutines,
Volume IIB - Listings, Sparse FORMA Subroutines,
Volume IIC - Listings, Finite Element FORMA Subroutines,
Volume IIIA - Explanations, Dense FORMA Subroutines,
Volume IIIB - Explanations, Sparse FORMA Subroutines, and
Volume IIIC - Explanations, Finite Element FORMA Subroutines.
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ABSTRACT

This report presents techniques for the solution of structural dynamic systems on a digital computer using FORMA (FORTRAN Matrix Analysis).

FORMA is a library of subroutines coded in FORTRAN IV for the efficient solution of structural dynamics problems. These subroutines are in the form of building blocks that can be put together to solve a large variety of structural dynamics problems. The obvious advantage of the building block approach is that programming and checkout time are limited to that required for putting the blocks together in the proper order.

The FORMA method has advantageous features such as:

1. subroutines in the library have been used extensively for many years and as a result are well checked out and debugged;

2. method will work on any computer with a FORTRAN IV compiler;

3. incorporation of new subroutines is no problem;

4. basic FORTRAN statements may be used to give extreme flexibility in writing a program.

Two programming techniques are used in FORMA: dense and sparse.
ACKNOWLEDGMENTS

The editor expresses his appreciation to those individuals whose assistance was necessary for the successful completion of this report. Dr. John R. Admire was instrumental in the definition of the program scope and contributed many valuable suggestions. Messrs. Carl Bodley, Wilcomb Benfield, Darrell Devers, Richard Hruda, Roger Philippus, and Herbert Wiikening, all of the Analytical Mechanics Department, Denver Division of Martin Mariett Corporation, have contributed ideas, as well as subroutines, in the formulation of the FORMA library.

The editor also expresses his appreciation to those persons who developed FORTRAN, particularly the subroutine concept of that programming tool.
I. INTRODUCTION

A listing of the source deck of each finite element FORMA subroutine is given in this volume to remove the "black box" aura of the subroutines so that the analyst may better understand the detailed operations of each subroutine.

The FORTRAN IV programming language is used in all finite element FORMA subroutines.
II. SUBROUTINE LISTINGS

The subroutines are given in alphabetical order with numbers coming before letters.
SUBROUTINE AXIAL (XYZ, JD0F, EUL, NUTEL, NJ, 
* NUTMX, NUTKX, NUTLT, NUTST, 
* W, T, S, KX, KJ, KE, KW)
DIMENSION XYZ(KX,1), JD0F(KJ,1), EUL(KF,1), W(KW,1), T(KW,1), S(KW,1)
DIMENSION C1(3,2), E1(3,2), IVI(6)
DATA NAMEL/6A-XIA/L, NRW, NRLT/6,2/, IBLNK/6H, /* KCJ/3, */  
DATA NIT, NCT/5, 6/  
C 
C SUBROUTINE TO CALCULATE (ON OPTION) FINITE ELEMENT ...  
C MASS MATRICES AND IVECS (ON NUTMX),  
C STIFFNESS MATRICES (SAME AS GLOBAL LOAD TRANSFORMATION MATRICES)  
C AND IVECS (ON NUTKX),  
C LOCAL LOAD TRANSFORMATION MATRICES AND IVECS (ON NUTLT),  
C STRESS TRANSFORMATION MATRICES AND IVECS (ON NUTST)  
C FOR AXIAL ROD ELEMENTS.  
C MASS, STIFFNESS MATRICES ARE IN GLOBAL COORDINATE DIRECTIONS.  
C GLOBAL COORDINATE ORDER FOR EACH ELEMENT IS 
C (U, V, W) JOINT 1, THEN JOINT 2.  
C WHERE U, V, W ARE TRANSLATIONS.  
C IVEC GIVES ELEMENT DOF INTO GLOBAL DOF. EXAMPLES...  
C IVEC(6)=834 PLACES ELEMENT DOF 6 INTO GLOBAL DOF 834.  
C IVEC(3)=0 OMQTS ELEMENT DOF 3 FROM GLOBAL DOF. THIS CONSTRAINS 
C ELEMENT DOF 3 TO ZERO MOTION.  
C GLOBAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT ROD ENDS IN GLOBAL 
C COORDINATE DIRECTIONS TO DEFLECTIONS IN THE GLOBAL COORDINATE 
C DIRECTIONS.  
C ROW ORDER IN GLOBAL LOAD TRANSFORMATION MATRIX IS 
C (PU, PV, PW) JOINT 1, THEN JOINT 2.  
C WHERE P IS FORCE.  
C LOCAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT ROD ENDS IN LOCAL 
C COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE 
C DIRECTIONS.  
C ROW ORDER IN LOCAL LOAD TRANSFORMATION MATRIX IS 
C PX1, PX2  
C WHERE PX IS AXIAL FORCE.  
C PX1(+), PX2(+) IS TENSION. PX1(-), PX2(-) IS COMPRESSION. 
C STRESS TRANSFORMATION MATRIX RELATES STRESS AT ROD ENDS IN LOCAL 
C COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE DIRECTIONS.  
C ROW ORDER IN STRESS TRANSFORMATION MATRIX IS 
C SIGMA-X1, SIGMA-X2  
C WHERE SIGMA IS NORMAL STRESS.  
C SX1(-), SX2(+) IS TENSION. SX1(+), SX2(-) IS COMPRESSION.  
C DATA ARRANGEMENT ON NUTMX, NUTKX, NUTLT, NUTST FOR EACH FINITE 
C ELEMENT IS (W=M,K,LT,ST)  
C WRITE (NUTWX) NAMEL,NEL,NR,NC,NAMEL,(IBLNNK,I=1,5), 
C (W[I,J],I=1,NR),J=1,NC,(IVEC[I],I=1,NC) 
C CALLS FORMA SUBROUTINES MASIA, PAGEHD, STFIA, ZZBOMB.  
C LAST REVISION BY WA EENFIELD. MARCH 1976.  
C
C **********************************************************************************************************  
C INPUT DATA READ IN THIS SUBROUTINE FROM NUTEL. IF NUTEL = 5, DATA IS  
C READ FROM CARDS.  
C NAMEM,NAMEK,NAMELT,NAMEST FORMAT (4(A6,4X)  
C RO,E FORMAT (2(5X,E10))
C 20 NEL, J1, J2, A1, A2
C IF (J1 .EQ. 0) RETURN
C GO TO 20
C
C DEFINITION OF INPUT VARIABLES.
C NAMEM = TYPE OF MASS MATRIX WANTED.
C   = M1, DIAGONAL LUMPED.
C   = M2, CONSISTENT.
C   = 6H OR 6HNUMASS, NO MASS MATRIX CALCULATED.
C NAMEK = TYPE OF STIFFNESS MATRIX WANTED.
C   = K1, CONSTANT AXIAL FORCE ASSUMED.
C   = 6H OR 6HNOSTIF, NO STIFFNESS MATRIX CALCULATED.
C NAMELT = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES.
C   = 6H OR 6HLOAD, NO LOAD TRANSFORMATIONS CALCULATED.
C NAMEST = IDENTIFICATION NAME FOR STRESS TRANSFORMATION MATRICES.
C   = 6H OR 6HSTRES, NO STRESS TRANSFORMATIONS CALCULATED.
C RD = MASS DENSITY.
C E = YOUNGS MODULUS OF ELASTICITY.
C NEL = FINITE ELEMENT NUMBER. FOR REFERENCE ONLY, NOT USED IN
C   CALCULATIONS. WRITTEN ON NUTMX, ETC.
C J1 = JOINT NUMBER AT ROD END 1.
C J2 = JOINT NUMBER AT ROD END 2.
C A1 = CROSS-SECTION AREA AT ROD END 1.
C A2 = CROSS-SECTION AREA AT ROD END 2.
C
C EXPLANATION OF INPUT FORMATS. NUMBER INDICATES CARD COLUMNS USED.
C I = INTEGER DATA, RIGHT ADJUSTED.
C F = DECIMAL POINT DATA, ANYWHERE IN FIELD. Exponent Right Adjusted.
C X = CARD COLUMNS SKIPPED.
C
C SUBROUTINE ARGUMENTS (ALL INPUT)
C XYZ = MATRIX OF JOINT GLOBAL X, Y, Z LOCATIONS. ROWS CORRESPOND
C TO JOINT NUMBERS. COLUMNS 1, 2, 3 CORRESPOND TO THE JOINT
C X, Y, Z LOCATIONS RESPECTIVELY. SIZE(NJ, 3).
C JDOF = MATRIX OF JOINT GLOBAL DEGREES OF FREEDOM. ROWS CORRESPOND
C TO JOINT NUMBERS. COLUMNS 1, 2, 3 CORRESPOND TO THE JOINT
C TRANSLATION DOFS AND COLUMNS 4, 5, 6 CORRESPOND TO THE JOINT
C ROTATION DOFS. SIZE(NJ, 6).
C EUL = MATRIX OF JOINT EULER ANGLES (DEGREES). ROWS CORRESPOND
C TO JOINT NUMBERS. COLUMNS 1, 2, 3 CORRESPOND TO THE
C GLOBAL X, Y, Z PERMUTATION. SIZE(NJ, 3).
C NUTEL = LOGICAL NUMBER OF TAPE CONTAINING ELEMENT INPUT DATA FOR
C THIS SUBROUTINE. IF NUTEL = 5, DATA IS READ FROM CARDS.
C NJ = NUMBER OF JOINTS OR ROWS IN MATRICES (XYZ), (JDOF), (EUL).
C NUTMX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
C MASS MATRICES AND IVFCS ARE OUTPUT.
C NUTMX MAY BE ZERO IF MASS MATRIX IS NOT FORMED.
C USES FORTRAN READ, WRITE.
C NUTKX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
C STIFFNESS MATRICES (SAME AS GLOBAL LOADS TRANSFORMATION
C MATRICES) AND IVFCS ARE OUTPUT.
C NUTKX MAY BE ZERO IF STIFFNESS MATRIX IS NOT FORMED.
C USES FORTRAN READ, WRITE.
C NUTLT = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT LOCAL
C LOAD TRANSFORMATION MATRICES AND IVECS ARE OUTPUT.
C NUTLT MAY BE ZERO IF LOAD TRANSFORMATIONS ARE NOT FORMED.
C USES FORTRAN READ, WRITE.
C NUTST = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
C STRESS TRANSFORMATION MATRICES AND IVECS ARE OUTPUT.
C NUTST MAY BE ZERO IF STRESS TRANSFORMATIONS ARE NOT FORMED.
C USES FORTRAN READ, WRITE.
C W = MATRIX WORK SPACE. MIN SIZE(6,6).
C T = MATRIX WORK SPACE. MIN SIZE(6,6).
C S = MATRIX WORK SPACE. MIN SIZE(6,6).
C KK = ROW DIMENSION OF XYZ IN CALLING PROGRAM.
C KJ = ROW DIMENSION OF JDOF IN CALLING PROGRAM.
C KE = ROW DIMENSION OF FUL IN CALLING PROGRAM.
C
C NERROR EXPLANATION
C 1 = JOINT NUMBER GREATER THAN NUMBER OF JOINTS.
C 2 = MASS MATRIX FORMED, NUTMX .LE. ZERO.
C 3 = STIFFNESS MATRIX FORMED, NUTKX .LE. ZERO.
C 4 = LT MATRIX FORMED, NUTLT .LE. ZERO.
C 5 = ST MATRIX FORMED, NUTST .LE. ZERO.
C
1001 FORMAT (4(A6,4X))
1002 FORMAT (2(5X,E10.6))
1003 FORMAT (3(5F,4E10.0))
2001 FORMAT (///46X 29HINPUT DATA FOR AXIAL ELEMENTS)
2002 FORMAT (///40X 41HINPUT DATA FOR AXIAL ELEMENTS (CONTINUED))
2003 FORMAT (/ 16X7MASS = A6, 9X7HSTIF = A6, 9X13HLOAD TRANS = A6,
* 6X15HSTRESS TRANS = A6,
* / 18X4HRO = E10.3, 9X3HE = E10.3,
* //16X7HELELEMENT 13X7HJOINT 1 13X7HJOINT 2 15X4HAREA
* 16X4HAREA / 16X6HNUMEER 55X7HJOINT 1 13X7HJOINT 2 /)
2004 FORMAT (1X 3120, 14X E10.3, 10X E10.3)
C
C READ AND WRITE FINITE ELEMENT DATA.
NLINE = 0
CALL PAGEBD
WRITE (NCT'800) NAM,NAMEK,NAMELT,NAMET
READ (NUTEL,1001) NAM,NAMEK,NAMELT,NAMET
READ (NUTEL,1002) RO,E
WRITE (NCT'800) NAM,NAMEK,NAMELT,NAMET,RO,E
20 READ (NUTEL,1003) NEI,J1,J2,A1,A2
IF (J1 .LE. 0) RETURN
NLINE = NLINE + 1
IF (NLINE .LE. 42) GO TO 30
CALL PAGEBD
WRITE (NCT,2002)
WRITE (NCT,2003) NAM,NAMEK,NAMELT,NAMET,RO,E
NLINE = 0
30 WRITE (NCT,2004) NEI,J1,J2,A1,A2
C IF (J1 .GT. NJ .OR. J2 .GT. NJ ) GO TO 999
C
C FORM FINITE ELEMENT COORDINATE LOCATIONS, EULER ANGLES! REVADD IVEC.
DO 42 I=1,3
C AXIAL -- 4/4

C FORM MASS MATRIX (W).
    IF (NAMEM .EQ. 6H .OR. NAMEM .EQ. 6HNO MASS) GO TO 110
    CALL MAS1A (CJ, EJ, A1, A2, R0, NAMEM, W, KCJ, KCJ, KW)
    NERROR=2
    IF (NUTMX .LE. 0) GO TO 999
    WRITE (NUTMX) NAMEM, NEL, NW, NW, NAMEL, (I=1,5),
       (*)
        ((WR(I,J), I=1, NRW), J=1, NRW), (IV1(I), I=1, NRW)
C
C FORM STIFFNESS MATRIX (W), LOCAL LOAD TRANSFORMATION MATRIX (T),
C STRESS TRANSFORMATION MATRIX (S).
110 IF (NAMEK .EQ. 6H .OR. NAMEK .EQ. 6HNO STIF) GO TO 20
    CALL STF1A (CJ, EJ, A1, A2, E, NAMEK, NAMEST, W, T, S, NRST,
       *)
       KCJ, KCJ, KW, KW, KW)
    NERROR=3
    IF (NUTMX .LE. 0) GO TO 999
    WRITE (NUTMX) NAMEK, NEL, NW, NW, NAMEL, (I=1,5),
       (*)
        ((WI(I,J), I=1, NRW), J=1, NRW), (IV1(I), I=1, NRW)
    IF (NAMELT .EQ. 6H .OR. NAMELT .EQ. 6HNO LOAD) GO TO 115
       NERROR=4
    IF (NULT .LE. 0) GO TO 999
    WRITE (NULT) NAMELT, NEL, NRLT, NRW, NAMEL, (I=1,5),
       (*)
        ((T(I,J), I=1, NRTL), J=1, NRW), (IV1(I), I=1, NRW)
115 IF (NAMEST .EQ. 6H .OR. NAMEST .EQ. 6HNO STRS) GO TO 20
       NERROR=5
    IF (NUST .LE. 0) GO TO 999
    WRITE (NUST) NAMEST, NEL, NRST, NRW, NAMEL, (I=1,5),
       (*)
        ((S(I,J), I=1, NRST), J=1, NRW), (IV1(I), I=1, NRW)
    GO TO 20

C 999 CALL ZZBOME (6HAXIAL, NERROR)
END
SUBROUTINE R1A1 (RL, Z, KZ)
DIMENSION Z(KZ,2)

C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C BUCKLING MATRIX
C FOR AN AXIAL ROD ELEMENT WITH UNRESTRAINED BOUNDARIES.
C BUCKLING MATRIX IS BASED ON UNIT AXIAL LOAD.
C BUCKLING MATRIX IS IN LOCAL COORDINATE SYSTEM.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE ROD TO LIE IN THE X-Z PLANE
C WITH JOINT 1 AT THE ORIGIN, JOINT 2 ALONG THE POSITIVE X AXIS.
C LOCAL COORDINATE ORDER IS
C DZ1, DZ2
C WHERE DZ IS TRANSLATION.
C DEVELOPED BY RL WOHLLEN, AUGUST 1973.
C
C SUBROUTINE ARGUMENTS
C RL = INPUT ROD LENGTH.
C Z = OUTPUT BUCKLING MATRIX. SIZE(2,2).
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=2.
C
C C = 1./RL
Z(1,1) = C
Z(1,2) = -C
Z(2,1) = -C
Z(2,2) = C

RETURN
END
SUBROUTINE B1A2 (RL, Z, K2)
DIMENSION Z(K2,1)

SUBROUTINE TO CALCULATE FINITE ELEMENT...
BUCKLING MATRIX
FOR A BEAM ELEMENT WITH UNRESTRAINED BOUNDARIES.
BUCKLING MATRIX IS BASED ON UNIT AXIAL LOAD.
BUCKLING MATRIX IS IN LOCAL COORDINATE SYSTEM.
THE LOCAL COORDINATE SYSTEM ASSUMES THE BEAM TO LIE IN THE X-Z PLANE.
WITH JOINT 1 AT THE ORIGIN, JOINT 2 ALONG THE POSITIVE X AXIS.
LOCAL COORDINATE ORDER IS
DZ1, DZ2, TY1, TY2
WHERE DZ IS TRANSLATION AND TY IS ROTATION.

SUBROUTINE ARGUMENTS
RL = INPUT ROD LENGTH.
Z = OUTPUT BUCKLING MATRIX SIZE(4,4).
K2 = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM MIN=4.

C1 = 6./(5.*RL)
C2 = 0.1
C3 = (2.*RL)/15.
Z(1,1) = C1
Z(1,2) = -C1
Z(1,3) = -C2
Z(1,4) = -C2
Z(2,2) = C1
Z(2,3) = C2
Z(2,4) = C2
Z(3,3) = C3
Z(3,4) = -RL/30.
Z(4,4) = C3
DO 10 I=1,4
  DO 10 J=1,4
  10 Z(J,I) = Z(I,J)

RETURN
END
SUEROUTINE BAR  (XYZ,JDCF,EUL,NUTFL,NJ, *
  )
NUTMX,NUTKX,NUTRXX,NUTLT,NUTST, *
W,T,S,KK,KJ,KE,KW)
DIMENSION XYZ(KX,1),JDCF(KJ,1),EUL(KE,1),W(KW,1),T(KW,1),S(KW,1)
DIMENSION CJ(3,3), EJ(3,2), IV1(12), TR(12,12), TD(24,24)
DIMENSION KODEK(4), KODEB(2), IFPN(4), IV2(4)
DATA NAMEL / 6HEAP /
DATA NROW,NRLT/12,12/, IBLNK/6H  /, KCI/3/, KTR/12/, KTD/24/
DATA NIT,NCT/5,6 /
  C
  C SUBROUTINE TO CALCULATE (ON OPTION) FINITE ELEMENT ...
  C
  C MASS MATRICES AND IVECS (ON NUTMX),
  C STIFFNESS MATRICES (SAME AS GLOBAL LOAD TRANSFORMATION MATRICES)
  C AND IVECS (ON NUTMX),
  C UNIT LOAD BUCKLING MATRICES AND IVECS (ON NUTBX),
  C LOCAL LOAD TRANSFORMATION MATRICES AND IVECS (ON NUTLT),
  C STRESS TRANSFORMATION MATRICES AND IVECS (ON NUTST)
  C FOR COMBINED AXIAL-TORSION-ENDING BAR ELEMENTS.
  C MASS, STIFFNESS, BUCKLING MATRICES ARE IN GLOBAL COORDINATE
  C DIRECTIONS.
  C GLOBAL COORDINATE ORDER FOR EACH ELEMENT IS
  C (U,V,W,P,Q,R) JOINT 1, THEN JOINT 2
  C WHERE U,V,W ARE TRANSLATIONS AND P,Q,R ARE ROTATIONS.
  C IVEC GIVES ELEMENT DOF INTO GLOBAL DOF. EXAMPLES ... 
  C IVEC(6)=834 PLACES ELEMENT DOF 6 INTO GLOBAL DOF 834.
  C IVEC(3)=0 OMQTS ELEMENT DOF 3 FROM GLOBAL DOF. THIS CONSTRAINTS
  C ELEMENT DOF 3 TO ZERO MOTION.
  C GLOBAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT BAR ENDS IN GLOBAL
  C COORDINATE TO DEFLECTIONS IN THE GLOBAL COORDINATE
  C DIRECTIONS.
  C ROW ORDER IN GLOBAL LOAD TRANSFORMATION MATRIX IS
  C (PU,PV,PW,MP,MO,MR) JOINT 1, THEN JOINT 2.
  C WHERE P IS FORCE AND M IS MOMENT.
  C LOCAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT BAR ENDS IN LOCAL
  C COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE DIRECTIONS.
  C ROW ORDER IN LOCAL LOAD TRANSFORMATION MATRIX IS
  C PX1, PX2, MX1, MX2, FY1, PY2, MZ1, MZ2, PZ1, PZ2, MY1, MY2
  C WHERE P IS FORCE AND M IS MOMENT.
  C STRESS TRANSFORMATION MATRIX RELATES STRESS AT BAR ENDS IN LOCAL
  C COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE DIRECTIONS.
  C ROW ORDER IN STRESS TRANSFORMATION MATRIX IS
  C PX1/A1, PX2/A2, MX1/R1/TJ1, MX2/R2/TJ2,
  C PY1/A1, PY2/A2, MZ1/CY1/B121, MZ2/CY2/B122,
  C PZ1/A1, PZ2/A2, MY1/C1/E111, MY2/C2/E122
  C WHERE P IS FORCE AND M IS MOMENT.
  C DATA ARRANGEMENT ON NUTMX, NUTKX, NUTRXX, NUTLT, NUTST FOR EACH
  C FINITE ELEMENT IS (W=M,K,B,L,T,ST)
  C WRITE (NUTMX) NAME,NFL,NR,NC,NAMEL,(IBLNK,1=1,5),
  C (((W,I,J),1=1,NR),J=1,NC),(IVEC(1),I=1,NC)
  C CALLS FORM SUPROUTINES EUCLE, MASIE, PAGEHD, STF18, ZZBOMO.
  C DEVELOPED BY WA EENEFIELD, CS BOOLEY, RL WOHLEN. FEBRUARY 1973.
  C LAST REVISION BY RL WOHLEN. APRIL 1976.
  C
  C******************************************************************************
  C INPUT DATA READ IN THIS SUBROUTINE FROM NUTEL. IF NUTEL = 5, DATA IS
READ FROM CARDS.
C
NAME, NAMEK, NAME1, NAMEST, NAME2,
T C
KODEK(1), I=1, 4), (KODEB(1), I=1, 2)
C
20 NEL, J1, J2, JREF, A1, P11, TJ1, 61Z1, 81Y1, SF;
C
1FPY1, 1FPZ1, 1FPY2, 1FPZ2, 1FTAPR
C
IF (J1 = FC, 0) RETURN
C
IF (IFTAPR .EQ. 1HT) A2, PI2, TJ2, 61Z2, 81Y2
C
30 IF (NAMEST .EQ. 6H) .OR. NAMEST .EQ. 6HSTRES) GO TO 20
C
R1, CY1, CZ, R2, CY2, CZ, 2Z
C
GO TO 20
C
INPUT DATA REQUIREMENTS
C
AXIAL TORSION BENDING BENDING
C
ALONG ABOUT ABOUT ABOUT
LOCAL X LOCAL X LOCAL Z LOCAL Y
C
MASS A, RC PI, RC A, RO A, RO
C
STIFF, LOAD TRANS A, SF TJ, G F12, 1, SF, 0, SF, 0
C
BUCKLING NONE NONE NONE NONE
C
STRESS TRANS SEE STIF - STIF + R STIF - CY STIF + C2
C
FOR NO SHEAR DEFORMATION IN BENDING, SET ANY OF A (NOT IF AXIAL USED),
C
SF, OR GINTY IF TORSION IS USED) TO ZERO. IF BENDING STRESS
C
TRANSFORMATION IS WANTED, A MUST NOT BE ZERO.
C
DEFINITION OF INPUT VARIABLES.
C
NAME = TYPE OF MASS MATRIX WANTED
C
= M1, DIAGONAL LUMPED.
C
= M2, CONSISTENT.
C
= 6H, CR 6H=NMMASS, NO MASS MATRIX CALCULATED.
C
NAMEK = TYPE OF STIFFNESS MATRIX WANTED.
C
= K1, CONSTANT FORCE FOR AXIAL, CONSTANT TORQUE FOR TORSION,
C
CONSTANT SHEAR AND LINEAR MOMENT FOR BENDING.
C
= 6H, CR 6H=NMSTIF, NO STIFFNESS MATRIX CALCULATED.
C
NAMEST = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES.
C
= 6H, CR 6H=NLOAD, NO LOAD TRANSFORMATIONS CALCULATED.
C
NAMEST = IDENTIFICATION NAME FOR STRESS TRANSFORMATION MATRICES.
C
= 6H, CR 6H=NSTRES, NO STRESS TRANSFORMATIONS CALCULATED.
C
NAMEB = TYPE OF BUCKLING MATRIX WANTED.
C
= E1, AXIAL RCD.
C
= E2, BEAM.
C
= 6H, CR 6H=NPUCK, NO BUCKLING MATRIX CALCULATED.
C
KODEK = OPTION CODE FOR AXIAL, TORSION, BENDING Z, BENDING Y LOCAL
C
STIFFNESS. IF BLANK, ALL FOUR ARE CALCULATED. SIZE(4).
C
KODEK(1) = A, LOCAL STIF MATRIX IS CALCULATED FOR AXIAL
C
ALONG LOCAL X-AXIS.
C
KODEK(2) = T, LOCAL STIF MATRIX IS CALCULATED FOR TORSION
C
ABOUT LOCAL X-AXIS.
C
KODEK(3) = E2, LOCAL STIF MATRIX IS CALCULATED FOR BENDING
C
ABOUT LOCAL Z-AXIS.
C
KODEK(4) = EY, LOCAL STIF MATRIX IS CALCULATED FOR BENDING
C
ABOUT LOCAL Y-AXIS.
C
KODEB = OPTION CODE FOR BUCKLING IN LOCAL Y CO 2 DIRECTION.
C
IF BLANK, BOTH ARE CALCULATED. SIZE(2).
C
KODEB(1) = EY, LOCAL BUCKLING MATRIX IS CALCULATED FOR
DEFLECTION IN LOCAL Y DIRECTION.

KODEE(2)=62, LOCAL BUCKLING MATRIX IS CALCULATED FOR
DEFLECTION IN LOCAL Z DIRECTION.

R0 = MASS DENSITY.
E = YOUNG'S MODULUS OF ELASTICITY.
G = SHEAR MODULUS OF ELASTICITY.
NEL = FINITE ELEMENT NUMBER, FOR REFERENCE ONLY, NOT USED IN
CALCULATIONS, WRITTEN ON NUTMX, ETC.
J1 = JOINT NUMBER AT BAR END 1. LOCAL X-AXIS ORIGINATES AT J1.
J2 = JOINT NUMBER AT BAR END 2. LOCAL X-AXIS GOES FROM J1 TO J2.
JREF = REFERENCE POINT. LOCAL Z-AXIS IS DEFINED BY VECTOR (J1,J2)
CROSSED INTO VECTOR (J1,JREF). LOCAL Y-AXIS LIES IN XY PLANE
DEFINED BY J1,J2,JREF.
A1 = CROSS-SECTION AREA AT BAR END 1.
A2 = SAME AS A1 AT BAR END 2.
PI1 = CROSS-SECTION POLAR AREA MOMENT OF INERTIA FOR MASS
CALCULATIONS AT BAR END 1.
PI2 = SAME AS PI1 AT BAR END 2.
TJ1 = CROSS-SECTION PRINCIPAL VENANTS TORSION CONSTANT (J) IN JG FOR
TORSION STIFFNESS AT BAR END 1.
TJ2 = SAME AS TJ1 AT BAR END 2.
BIZ1 = CROSS-SECTION AREA MOMENT OF INERTIA ABOUT LOCAL Z-AXIS
(FOR BENDING) AT BAR END 1.
BIZ2 = SAME AS BIZ1 AT BAR END 2.
BIY1 = CROSS-SECTION AREA MOMENT OF INERTIA ABOUT LOCAL Y-AXIS
( FOR BENDING) AT BAR END 1.
BIY2 = SAME AS BIY1 AT BAR END 2.
SF = SHAPE FACTOR (K) FOR SHEAR IN KAG.
USE SF=0.0 FOR NO SHEAR DEFORMATION IN BENDING.
SF=1.0 FOR A SOLID CIRCULAR CYLINDER.
SF=.5 FOR A THIN WALLED CIRCULAR CYLINDER.
IFPY1 = PIN JOINT OPTION FOR LOCAL COORDINATE THETA Y AT BAR END 1.
= 1H, MOMENT JOINT.
= 1HP, PIN JOINT.
IFPY2 = SAME AS IFPY1 AT BAR END 2.
IFPZ1 = PIN JOINT OPTION FOR LOCAL COORDINATE THETA Z AT BAR END 1.
= 1H, MOMENT JOINT.
= 1HP, PIN JOINT.
IFPZ2 = SAME AS IFPZ1 AT BAR END 2.
IFTAPR = OPTION FOR TAPERED EAR.
= 1H, CONSTANT SECTION PROPERTIES.
= 1HT, LINEAR TAPER SECTION PROPERTIES.
R1 = DISTANCE FROM LOCAL X-AXIS TO OUTER FIBER FOR TORSION
STIFFNESS CALCULATION AT BAR END 1.
R2 = SAME AS R1 AT BAR END 2.
CY1 = DISTANCE FROM LOCAL XZ PLANE TO OUTER FIBER FOR BENDING
STRESS CALCULATION AT BAR END 1. LOCAL Y DIRECTION.
CY2 = SAME AS CY1 AT BAR END 2.
CZ1 = DISTANCE FROM LOCAL XY PLANE TO OUTER FIBER FOR BENDING
STRESS CALCULATION AT BAR END 1. LOCAL Z DIRECTION.
CZ2 = SAME AS CZ1 AT BAR END 2.

EXPLANATION OF INPUT FORMATS. NUMBER INDICATES CARD COLUMNS USED.
I = INTEGRAL DATA, RIGHT ADJUSTED.
E = DECIMAL POINT DATA, ANYWHERE IN FIELD. EXPONENT RIGHT ADJUSTED.
**SUBROUTINE ARGUMENTS (ALL INPUT)**

- **XYZ** = MATRIX OF JOINT GLOBAL X, Y, Z locations. Rows correspond to joint numbers. Columns 1, 2, 3 correspond to the joint X, Y, Z locations respectively. Size(NJ,3).
- **JDOF** = MATRIX OF JOINT GLOBAL DEGREES OF FREEDOM. Rows correspond to joint number. Columns 1, 2, 3 correspond to the joint translation DOFs and columns 4, 5, 6 correspond to the joint rotation DOFs. Size(NJ,6).
- **EUL** = MATRIX OF JOINT EULER ANGLES (DEGREES). Rows correspond to joint numbers. Columns 1, 2, 3 correspond to the joint global X, Y, Z permutation. Size(NJ,3).
- **NUTEL** = LOGICAL NUMBER OF TAPE CONTAINING ELEMENT INPUT DATA FOR THIS SUBROUTINE. If NUTEL = 5, data is read from cards.
- **NJ** = NUMBER OF JOINTS = ROWS IN MATRICES (XYZ), (JDOF), (EUL).
- **NUTMX** = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT MASS MATRICES AND IVCS ARE OUTPUT. NUTMX MAY BE ZERO IF MASS MATRIX IS NOT FORMED. USES FORTRAN READ, WRITE.
- **NUTKX** = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT STIFFNESS MATRICES (SAME AS GLOBAL LOADS TRANSFORMATION MATRICES) AND IVCS ARE OUTPUT. NUTKX MAY BE ZERO IF STIFFNESS MATRIX IS NOT FORMED. USES FORTRAN READ, WRITE.
- **NUTBX** = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT UNIT LOAD PUCKLING MATRICES AND IVCS ARE OUTPUT. NUTBX MAY BE ZERO IF PUCKLING MATRIX IS NOT FORMED. USES FORTRAN READ, WRITE.
- **NUTLT** = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT LOCAL LOAD TRANSFORMATION MATRICES AND IVCS ARE OUTPUT. NUTLT MAY BE ZERO IF LOCAL LOAD TRANSFORMATIONS ARE NOT FORMED. USES FORTRAN READ, WRITE.
- **NUTST** = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT STRESS TRANSFORMATION MATRICES AND IVCS ARE OUTPUT. NUTST MAY BE ZERO IF STRESS TRANSFORMATIONS ARE NOT FORMED. USES FORTRAN READ, WRITE.
- **W** = MATRIX WORK SPACE. MIN SIZE(12,12).
- **T** = MATRIX WORK SPACE. MIN SIZE(12,12).
- **S** = MATRIX WORK SPACE. MIN SIZE(17,12).
- **KX** = ROW DIMENSION OF XYZ IN CALLING PROGRAM.
- **KJ** = ROW DIMENSION OF JDOF IN CALLING PROGRAM.
- **KE** = ROW DIMENSION OF EUL IN CALLING PROGRAM.
- **KW** = ROW DIMENSION OF W, T, AND S IN CALLING PROGRAM. MIN=12.

**NEPROF EXPLANATION**

1. JOINT NUMBER GREATER THAN NUMBER OF JOINTS.
2. STIFFNESS MATRIX FORMED, NUTKX LE. ZERO.
3. LOAD TRANSFORMATION MATRIX FORMED, NUTLT LE. ZERO.
4. STRESS TRANSFORMATION MATRIX FORMED, NUTST LE. ZERO.
5. MASS MATRIX FORMED, NUTMX LE. ZERO.
6. BUCKLING MATRIX FORMED, NUTBX LE. ZERO.

1001 FORMAT (5(A6,4X),A1,A1 ,2A2, 4X A2,A2)
1002 FORMAT (3(5X, E10.0))
1003 FORMAT (4(5X, E10.0), E5.0, 5A1)
1004 FORMAT (20X, 6E10.0)
2001 FORMAT (/46X 27H INPUT DATA FOR BAR ELEMENTS)  
2002 FORMAT (/46X 39H INPUT DATA FOR BAR ELEMENTS (CONTINUED))
2003 FORMAT (45X, 6HKODE = A1, A1, A2, A2, 4X 6HKODEB = A2, A2,  
* 10X7HMASS = A6, 6X7HSTIF = A6, 6X13HLOAD TRANS = A6,  
* 3X15HSTRESS TRANS = A6, 3X11HEUCKLING = A6,  
* 12X4HRC = E10.3, 6X3HE = E10.3, 80X7H1 I I I I,  
* 32X3PH = E10.3, 80X7HF F F F,  
* 125X7HP P P P,  
* 1X7HELEMENT 2X5HJOINT 2X5HJOINT 3X3HREF 5X4HAREA  
* 7X5HPOLAR 5XHTORSION 3X9H2 BENDING 2X9HY BENDING  
* 2X5HSHEAP 5X6HSTRESS 5X6HSTRESS 5X6HSTRESS 3X7HV Z Y Z  
* 1X6HNUMBER 5X1H1 6X1H2 4X5HPPOINT  
* 14X 7HINEPTIA 5X5HCONST 5X7HINERTIA  
* 4X7HINERTIA 3X6HFACTOR 5X1HR 9X2HCY 9X2HCZ 5X7H1 I I 2 2 /)
2004 FORMAT (1X I5, I8, I27, I1, 5E11.3, F7.3, 3E11.3, 4(I5A1))
2005 FORMAT (29X, 5E11.3, 7X, 3E11.3)

C READ AND WRITE FINITE ELEMENT DATA.
R1 = 0.0
CY1 = 0.0
CZ1 = 0.0
NLINE = 0
CALL PAGEHD
WRITE (NOT, 2001)
READ (NUTEL, 1001) NAMEK, NAMEK, NAMELT, NAMEST, NAMEB,
* (KODEK(I), I=1,4), (KODEB(I), I=1,2)
READ (NUTEL, 1002) RU, E, G
WRITE (NOT, 2003) (KODEK(I), I=1,4), (KODEB(I), I=1,2),
* NAMEK, NAMEK, NAMELT, NAMEST, NAMEB, RU, E, G
20 READ (NUTEL, 104) NEL, J1, J2, JREF, A1, PI1, TJ1, B1Z1, BIY1, SF,
* IFP IN, IFTAPR
IF (J1 .LE. 0) RETURN
IF (IFTAPR .EQ. 1HT) READ (NUTEL, 1004) A2, PI2, TJ2, B1Z2, BIY2
IF (NAMEST .EQ. 6HR) OR. NAMEST .EQ. 6HNOST (GO TO 25)
READ (NUTEL, 1004) R1, CY1, CZ1, R2, CY2, CZ2
25 NLINES = NLINES + 1
IF (IFTAPR .EQ. 1HT) NLINES = NLINES + 1
IF (NLINES .LE. 42) GO TO 30
CALL PAGEHD
WRITE (NOT, 2002)
WRITE (NOT, 2003) (KODEK(I), I=1,4), (KODEB(I), I=1,2),
* NAMEK, NAMEK, NAMELT, NAMEST, NAMEB, RU, E, G
NLINES = C
30 WRITE (NOT, 2004) NEL, J1, J2, JREF, A1, PI1, TJ1, B1Z1, BIY1, SF,
* R1, CY1, CZ1, IFP IN
NERROR = 1
IF (J1 .GT. NJ .CR. J2 .GT. NJ .CR. JREF .GT. NJ) GO TO 999
IF (IFTAPR .EQ. 1HT) WRITE (NOT, 2005) A2, PI2, TJ2, B1Z2, BIY2, R2,
* CY2, CZ2
C FORM FINITE ELEMENT COORDINATE LOCATIONS, EULER ANGLES, REVADD IVEC.
DC 42 I=1,3
C FORM DATA FOR UNIFORM ELEMENT.
IF (IFTAPR .EQ. 1HT) GO TO 50
A2 = A1
PI2 = PI1
TJ2 = TJ1
RI2 = RI1
BI2 = BI1
BI2 = BI1
RI2 = R1
CY2 = CY1
CZ2 = CZ1
C FORM PINING IVEC.
50 NPIN = 0
DO 55 I=1,N
IF (IFPIN(I) .NE. 1HP) GO TO 55
NPIN = NPIN + 1
IF (I .EQ. 1) IV2(NPIN) = 11
IF (I .EQ. 2) IV2(NPIN) = 7
IF (I .EQ. 3) IV2(NPIN) = 12
IF (I .EQ. 4) IV2(NPIN) = 8
55 CONTINUE
C FORM STIFFNESS MATRIX (W), LOCAL LOAD TRANSFORMATION MATRIX (T),
C STRESS TRANSFORMATION MATRIX (S).
100 IF (NAMEK .EQ. 6H .OR. NAMEK .EQ. 6HINSTIF) GO TO 110
   CALL STF1B (CJ,EJ,KODEK,A1,A2,TJ1,TJ2,BI1,BI2,BI1,BIV2,R1,R2,
      *   CY1,CY2,CZ1,CZ2,ST,E,G,NAMEK,NAMES,T,W,S,NRST,
      *   KCJ,KCJ,KW,KW,KW)
C C PIN STIFFNESS MATRIX.
IF (NPIN .EQ. 0) GO TO 105
CALL DQ1B (CJ,EJ,W,KCJ,KCJ,KW)
CALL TRANS (W,TR,NRW,NRW,KW,KTR)
CALL MULTA (TM,TR,NRTL,NRW,NRW,KW,KTR)
CALL SED3 (TM,IV2,TD,NRW,NPIN,I,KW)
CALL MULTA (TD,W,NRW,NRW,KRW,KTD,KW)
CALL MULTA (TR,TD,NRW,NRW,KR,KTR,KTD)
CALL MULTA (TR,W,NRTL,NRW,NRW,KW,KW)
CALL MUXPA (W,T,NRW,NRW,KW,KW)
IF (NAMEK .EQ. 6H .OR. NAMEK .EQ. 6HINSTRS) GO TO 105
   CALL MULTA (S,TR,NRST,NRW,NRW,KW,KTR)
105 NERROR=2
IF (NUTKX .LE. 0) GO TO 999
WRITE (NUTKX) NAMEK,NEL,NRW,NRW,NAMEL,(IRLNK,I=1,5),
      *,((W1,I,J,I=1,NRW),J=1,NRW),(IV1(I),I=1,NRW)
IF (NAMEL .EQ. 6H .OR. NAMEL .EQ. 6HINSTAD) GO TO 115
IF (NUTLT .LE. 0) GO TO 999
WRITE (NUTLT) NAMELT, NELT, NRTL, NRWT, NAMEL, (IBLNK, I=1, 5),
*  
115 IF (NAMEST .EQ. 6H .OR. NAMEST .EQ. 6HNOSTRS) GO TO 110
   NERROR=4

IF (NUTST .LE. C) GO TO 999
WRITE (NUTST) NAMEST, NELT, NRTL, NRWT, NAMEL, (IBLNK, I=1, 5),
*  
110 IF (NAMEM .EQ. 6H .OR. NAMEM .EQ. 6HNOASS) GO TO 140
   CALL MAS18 (CJ, EJ, A1, A2, PI1, PI2, RO, NAMEM, W, T, KCJ, KCJ, KW, KW)

C FORM MASS MATRIX (W).
140 IF (NAMEB .EQ. 6H .OR. NAMEB .EQ. 6HNOBUCK) GO TO 20
   CALL BUC1B (CJ, EJ, KODEF, NAMEB, W, S, KCJ, KCJ, KW, KW)

   IF (NUTMX .LE. 0) GO TO 999
   WRITE (NUTMX) NAMEB, NELT, NRWT, NRWT, NAMEL, (IBLNK, I=1, 5),
   *  
C FORM UNIT LOAD BUCKLING MATRIX (W).
140 IF (NAMEB .EQ. 6H .OR. NAMEB .EQ. 6HNOBUCK) GO TO 20
   CALL BUC1B (CJ, EJ, KODEF, NAMEB, W, S, KCJ, KCJ, KW, KW)

   IF (NUTFX .LE. 0) GO TO 999
   WRITE (NUTFX) NAMEB, NELT, NRWT, NRWT, NAMEL, (IBLNK, I=1, 5),
   *  
   GO TO 20

C 999 CALL ZZBOMB (6HEAR ,NERROR)
   END
SUBROUTINE RUCIB (CJ, EJ, KODEB, NAMEB, Z, W, KCJ, KEJ, KZ, KW)
DIMENSION CJ(KCJ,1), EJ(KEJ,1), KODEB(1), Z(KZ,1), W(KW,1)

C
C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C
C BUCKLING MATRIX
C FOR A COMBINED AXIAL-TORSION-BENDING BAR ELEMENT WITH UNRESTRAINED
C BOUNDARIES.
C BUCKLING MATRIX IS BASED ON UNIT AXIAL LOAD.
C BUCKLING MATRIX IS IN GLOBAL COORDINATE DIRECTIONS.
C GLOBAL COORDINATE ORDER IS
C (U,V,W,P,Q,R) JOINT 1, THEN JOINT 2
C WHERE U,V,W ARE TRANSLATIONS AND P,Q,R ARE ROTATIONS.
C EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
C CALLS FORMA SUBROUTINES B1A1, B1A2, BTAB, DCOS1B, Z2BOMB.
C LAST REVISION BY WA BENFIELD. MARCH 1976.
C
C SUBROUTINE ARGUMENTS
C CJ = INPUT MATRIX OF GLOBAL X,Y,Z COORDINATES AT BAR JOINTS.
C ROWS 1,2,3 CORRESPOND TO X,Y,Z COORDINATES.
C COLS 1,2 CORRESPOND TO JOINTS 1,2. COL 3 CORRESPONDS
C TO REFERENCE POINT TO DEFINE LOCAL XY PLANE. SIZE(3,3).
C EJ = INPUT MATRIX OF EULER ANGLES (DEGREES) AT BAR JOINTS.
C ROWS 1,2,3 CORRESPOND TO GLOBAL X,Y,Z PERMUTATION.
C COLS 1,2 CORRESPOND TO JOINTS 1,2. SIZE(3,2).
C KODEB = INPUT OPTION CODE FOR LOCAL Y, LOCAL Z BUCKLING.
C IF BLANK, BOTH ARE CALCULATED. SIZE(2).
C KODEB(1)=BY, LOCAL BUCKLING MATRIX IS CALCULATED
C FOR LOCAL Y DIRECTION.
C KODEB(2)=EZ, LOCAL BUCKLING MATRIX IS CALCULATED
C FOR LOCAL Z DIRECTION.
C NAMEB = INPUT TYPE OF BUCKLING MATRIX WANTED.
C =P1, AXIAL RC.
C =B1, BEAM.
C Z = OUTPUT BUCKLING MATRIX. SIZE(12,12).
C W = INPUT WORK SPACE MATRIX. SIZE(12,12).
C KCJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM.
C KEJ = INPUT ROW DIMENSION OF EJ IN CALLING PROGRAM.
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=12.
C KW = INPUT ROW DIMENSION OF W IN CALLING PROGRAM. MIN=12.
C
C NERROR EXPLANATION
C 1 = DIMENSION SIZE EXCEEDED.
C 2 = IMPROPERLY DEFINED NAMEB.
C
IF (KZ.LT.12) OR. KW.LT.12) GO TO 999
DO 5 J=1,12
DO 5 I=1,12
5 Z(I,J) = 0.0
RL = SQRT(CJ(1,2)-CJ(1,1)**2 + (CJ(2,2)-CJ(2,1))**2
     + (CJ(3,2)-CJ(3,1))**2)
KODEB1 = 1
KODEB2 = 1
IF (KODEB(1).EQ.2) AND. KODEB(2).EQ.2) GO TO 10
IF (KODEP(1) .NE. 2HBY) KODEBY = 0
IF (KODEB(2) .NE. 2HBZ) KODEBZ = 0
10 IF (NAMEB .EQ. 6HB1) GO TO 110
IF (NAMEB .EQ. 6HB2) GO TO 120
GO TO 999

C
110 IF (KODERY .EQ. 1) CALL B1A1 (RL,Z(5,5),KZ)
IF (KODEBZ .EQ. 1) CALL B1A1 (RL,Z(9,9),KZ)
GO TO 300

C
120 IF (KODERY .EQ. 1) CALL B1A2 (RL,Z(5,5),KZ)
DO 125 J=7,8
DO 125 I=5,6
Z(I,J) = Z(I,J)
125 Z(J,I) = -Z(J,I)
IF (KODEBZ .EQ. 1) CALL B1A2 (RL,Z(9,9),KZ)

C
300 CALL DCOS1B (CJ,EJ,W,KCJ,KEJ,KW)
CALL PTABA (Z,W, 12,12, KZ,KW)
RETURN

C
999 CALL ZZBOMB (6HBUCLB,NERROR)
END
SUBROUTINE DCOSIA (CJ,EJ,Z,KCJ,KEJ,KZ)
DIMENSION CJ(KCJ,1), EJ(KEJ,1), Z(KZ,1)
DIMENSION P(3), T(3,3)

SUBROUTINE TO CALCULATE FINITE ELEMENT...
DIRECTION COSINE MATRIX
FOR AN AXIAL ROD ELEMENT.
The direction cosine matrix relates local coordinate displacements to global coordinate displacements.
The local coordinate system assumes the rod to lie along the x axis with joint 1 at the origin, joint 2 along the positive x axis.
Row order (local coordinate order) of direction cosine matrix is

\[ DX_1, DX_2 \]

Where \( DX \) is translation.
Column order (global coordinate order) of direction cosine matrix is

\[ (U,V,W) \] joint 1, then joint 2.
Where \( U,V,W \) are translations.
Euler angle convention is global \( x,y,z \) permutation.
Calls forma subroutines EULER, MULT, ZIBOMB.

SUBROUTINE ARGUMENTS
CJ = input
Matrix of global \( x,y,z \) coordinates at rod joints.
Rows 1, 2, 3 correspond to \( x,y,z \) coordinates.
Cols 1, 2 correspond to joints 1, 2. Size(3,2).

EJ = input
Matrix of euler angles (degrees) at rod joints.
Rows 1, 2, 3 correspond to global \( x,y,z \) permutation.
Cols 1, 2 correspond to joints 1, 2. Size(3,2).

Z = output
Direction cosine matrix. Size(2,6).

KCJ = input
Row dimension of CJ in calling program.

KEJ = input
Row dimension of EJ in calling program.

KZ = input
Row dimension of Z in calling program. Min=2.

ERROR EXPLANATION
1 = Dimension size less than 2.

IF (KZ.LT.2) GO TO 999
PX = CJ(1,1)-CJ(1,1)
PY = CJ(2,1)-CJ(2,1)
PZ = CJ(3,1)-CJ(3,1)
PL = SQRT(PX**2 + PY**2 + PZ**2)
P(1) = PX/PL
P(2) = PY/PL
P(3) = PZ/PL
DO 10 I=1,2
DO 10 J=1,6
10 Z(I,J) = 0.0
CALL EULEP (EJ(1,1),T,3)
CALL MULTR (P,T,1,3,3,1,3)
DO 22 J=1,3
22 Z(I,J) = T(I,J)
CALL EULEP (EJ(1,1),T,3)
CALL MULTR (P,T,1,3,3,1,3)
DO 24 J = 1, 3
24 Z(2, J + 3) = T(1, J)
RETURN

C 999 CALL ZZBOMB (6HDCOS1A, NERROR)
END
SUBROUTINE DCOS1B (CJ,EJ,Z,KCJ,KEJ,KZ)
DIMENSION CJ(KCJ,1), EJ(KEJ,1), Z(KZ,1)
DIMENSION W(3,3), T(3,3)

C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C DIRECTION COSINE MATRIX
C FOR A COMBINED AXIAL-TORSION-BENDING BAR ELEMENT.
C THE DIRECTION COSINE MATRIX RELATES LOCAL COORDINATE DISPLACEMENTS
C TO GLOBAL COORDINATE DISPLACEMENTS.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE BAR TO LIE IN THE X-Y PLANE
C WITH JOINT 1 AT THE ORIGIN, JOINT 2 ALONG THE POSITIVE X AXIS,
C REFERENCE POINT 3 (TO DEFINE THE LOCAL X-Y PLANE) IS IN THE
C POSITIVE Y DIRECTION.
C ROW ORDER (LOCAL COORDINATE ORDER) OF DIRECTION COSINE MATRIX IS
C DX1,DX2, TX1,TX2, DY1,DY2, TZ1,TZ2, DZ1,DZ2, TY1,TY2
C WHERE DX,Y,Z ARE TRANSLATIONS AND TX,TY,TZ ARE ROTATIONS.
C COLUMN ORDER (GLOBAL COORDINATE ORDER) OF DIRECTION COSINE MATRIX IS
C (U,V,W,P,Q,R) JOINT 1, THEN JOINT 2
C WHERE U,V,W ARE TRANSLATIONS AND P,Q,R ARE ROTATIONS.
C EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
C CALLS FORMA SUBROUTINES EULEP,MULTB,ZZBOMB.
C LAST REVISION BY WA BENFIELD. MARCH 1976.

C SUBROUTINE ARGUMENTS
C CJ = INPUT MATRIX OF GLOBAL X,Y,Z COORDINATES AT BAR JOINTS.
C ROWS 1,2,3 CORRESPOND TO X,Y,Z COORDINATES.
C COLS 1,2 CORRESPOND TO JOINTS 1,2. COL 3 CORRESPONDS
C TO REFERENCE POINT TO DEFINE LOCAL XY PLANE. SIZE(3,3).
C EJ = INPUT MATRIX OF EULER ANGLES (DEGREES) AT BAR JOINTS.
C ROWS 1,2,3 CORRESPOND TO GLOBAL X,Y,Z PERMUTATION.
C COLS 1,2 CORRESPOND TO JOINTS 1,2. SIZE(3,2).
C Z = OUTPUT DIRECTION COSINE MATRIX. SIZE(12,12).
C KCJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM.
C KEJ = INPUT ROW DIMENSION OF EJ IN CALLING PROGRAM.
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=12.
C
C NERROR EXPLANATION
C 1 = DIMENSION SIZE LESS THAN 12.
C
IF (KZ .LT. 12) GO TO 999
PX = CJ(1,2)-CJ(1,1)
PY = CJ(2,2)-CJ(2,1)
PZ = CJ(3,2)-CJ(3,1)
PL = SQRT(PX**2 + PY**2 + PZ**2)
RX = PY*(CJ(3,3)-CJ(3,1)) - PZ*(CJ(2,3)-CJ(2,1))
RY = PZ*(CJ(1,3)-CJ(1,1)) - PX*(CJ(3,3)-CJ(3,1))
RZ = PX*(CJ(2,3)-CJ(2,1)) - PY*(CJ(1,3)-CJ(1,1))
RL = SQRT(RX**2 + RY**2 + RZ**2)
OX = RY*RZ - RZ*PY
OY = RZ*PX - RX*PZ
OZ = RX*PY - RY*PX
QL = SQRT(OX**2 + OY**2 + OZ**2)
W(1,1) = PX/PL
DCOSIB-- 2/2

W(1,2) = PY/PL
W(1,3) = PZ/PL
W(2,1) = GX/OL
W(2,2) = GY/OL
W(2,3) = CZ/OL
W(3,1) = RX/RL
W(3,2) = PY/RL
W(3,3) = RZ/RL
DO 10 J=1,12
  DO 10 I=1,12
10  Z(I,J) = 0.0
     CALL EULEP (EJ(I,1), T, 3)
     CALL MULTB (W, T, 3, 3, 3, 3)
   DC 22 J=1,3
     Z(I,J) = T(1,J)
     Z(5,J) = T(2,J)
     Z(9,J) = T(3,J)
     JP3 = J+3
     Z(3,JP3) = T(1,J)
     Z(7,JP3) = T(2,J)
   22  Z(11,JP3) = T(2,J)
     CALL EULER (EJ(I,2), T, 3)
     CALL MULTB (W, T, 3, 3, 3, 3)
   DO 24 J=1,3
     JP6 = J+6
     Z(2,JP6) = T(1,J)
     Z(6,JP6) = T(2,J)
     Z(10,JP6) = T(3,J)
     JP9 = J+9
     Z(4,JP9) = T(1,J)
     Z(8,JP9) = T(2,J)
   24  Z(12,JP9) = T(2,J)
     R' TURN
  999  CALL ZZBOMB (6DCOSIB, NERROR)
END
SUBROUTINE DCS2 (C, EJ, Z, KCJ, KEJ, KZ)
DIMENSION C(JCJ), EJ(KEJ), Z(KZ)
DIMENSION W(3,3), T(3,3)

SUBROUTINE TO CALCULATE FINITE ELEMENT...

DIRECTION COSINE MATRIX

FOR A COMBINED MEMBRANE-PENDING TRIANGLE PLATE ELEMENT.

THE DIRECTION COSINE MATRIX RELATES LOCAL COORDINATE DISPLACEMENTS
TO GLOBAL COORDINATE DISPLACEMENTS.

THE LOCAL COORDINATE SYSTEM ASSUMES THE PLATE TO LIE IN AN X-Y PLANE
WITH JOINT 1 AT THE ORIGIN. JOINT 2 LIES ALONG THE POSITIVE
X AXIS, AND JOINT 3 IS IN THE POSITIVE Y DIRECTION.

ROW ORDER (LOCAL COORDINATE ORDER) OF DIRECTION COSINE MATRIX IS

(PX, PY, PZ) JOINT 1, THEN JOINT 2, 3, NEXT

(OZ, TX, TY) JOINT 1, THEN JOINT 2, 3

WHERE DX, DY, DZ ARE TRANSLATIONS AND TX, TY, TZ ARE ROTATIONS.

COLUMN ORDER (GLOBAL COORDINATE ORDER) OF DIRECTION COSINE MATRIX IS

(UV, W, CP, EF) JOINT 1. THEN JOINT 2, 3.

WHERE U, V, W ARE TRANSLATIONS AND P, C, R ARE ROTATIONS.

EULER ANGLE CONVENTION IS GLOBAL X, Y, Z PERMUTATION.

CALLS FORM SUBROUTINES EULER, MULTP, ZCBOMB


LAST REVISION BY WA BENFIELD. MARCH 1976.

SUBROUTINE ARGUMENTS

CJ = INPUT MATRIX OF GLOBAL X, Y, Z COORDINATES AT TRIANGLE JOINTS.
    ROWS 1,2,3 CORRESPOND TO X, Y, Z COORDINATES.
    COLUMNS 1,2,3 CORRESPOND TO JOINTS 1,2,3. SIZE(3,3).

EJ = INPUT MATRIX OF EULER ANGLES (DEGREES) AT TRIANGLE JOINTS.
    ROWS 1,2,3 CORRESPOND TO GLOBAL X, Y, Z PERMUTATION.
    COLUMNS 1,2,3 CORRESPOND TO JOINTS 1,2,3. SIZE(3,3).

Z = OUTPUT DIRECTION COSINE MATRIX. SIZE(18,18).

KCJ = INPUT #FD DIMENSION OF CJ IN CALLING PROGRAM.

KEJ = INPUT ROW DIMENSION OF EJ IN CALLING PROGRAM.

KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=18.

NEQRCR EXPLANATION

1 = DIMENSION SIZE LESS THAN 18.

IF (KZ.LT.18) GO TO 999

PX = C(J1,2)-C(J1,1)
PY = C(J2,2)-C(J2,1)
PZ = C(J3,2)-C(J3,1)
PL = SQRT(PX**2 + PY**2 + PZ**2)
FX = PY*(C(J3,3)-C(J3,1)) - PZ*(C(J3,2)-C(J3,1))
RY = PZ*(C(J3,1)-C(J1,1)) - PX*(C(J3,3)-C(J3,1))
RZ = PX*(C(J3,2)-C(J1,1)) - PY*(C(J3,1)-C(J3,1))
RL = SQRT(RX**2 + RY**2 + RZ**2)
QX = QY*PZ - RZ*PY
LY = RZ*PX - RX*PZ
QZ = RX*PY - RY*PX
CL = SQRT(C1.*QX**2 + QY**2 + QZ**2)
W(1,1) = PX/PL
W(1,2) = PY/PL
W(1,3) = PZ/PL
W(2,1) = QX/QL
W(3,2) = QY/QL
W(3,3) = QZ/QL
W(3,1) = PX/RL
W(3,2) = PY/RL
DO 10 J=1,18
DO 10 I=1,18
10 Z(I,J) = 0.0
DO 50 NW=1,3
   CALL EULER (EJ(I,NW),T,3)
   CALL MULTF (W,T,3,3,3,3)
   IZZ = 3*(NW-1)
   JZZ = 6*(NW-1)
   DO 50 JW=1,3
   JZ = JZZ+JW
   Z(IZZ+1,JZ) = T(I,JW)
   Z(IZZ+2,JZ) = T(2,JW)
   Z(IZZ+3,JZ) = T(3,JW)
   JZ = JZ+2
   Z(IZZ+3,JZ) = T(3,JW)
   Z(IZZ+11,JZ) = T(1,JW)
50   Z(IZZ+12,JZ) = T(2,JW)
RETURN
C
999 CALL ZZSCORE (6,DCOS2 ,NERROR)
END
SUBROUTINE DCOS3C (CJ,EJ,Z,KCJ,KEJ,KZ)
DIMENSION CJ(KCJ,1), EJ(KEJ,1), Z(KZ,1)
DIMENSION W(2,3), T(3,3)

C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C DIRECTION COSINE MATRIX
C FOR A RECTANGULAR SHEAR PANEL ELEMENT.
C THE DIRECTION COSINE MATRIX RELATES LOCAL COORDINATE DISPLACEMENTS
C TO GLOBAL COORDINATE DISPLACEMENTS.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE PANEL TO LIE IN AN X-Y PLANE.
C WITH JOINT 1 AT THE X-Y ORIGIN, JOINT 2 LIES ALONG THE POSITIVE
C X AXIS, JOINT 3 IS IN THE POSITIVE X, Y DIRECTION, AND JOINT 4 LIES
C ALONG THE POSITIVE Y AXIS.
C ROW ORDER (LOCAL COORDINATE ORDER) OF DIRECTION COSINE MATRIX IS
C DX1,DX2,DX3,DX4, DY1, DY2, DY3, DY4
C WHERE DX,DY ARE TRANSLATIONS.
C COLUMN ORDER (GLOBAL COORDINATE ORDER) OF DIRECTION COSINE MATRIX IS
C (U,V,W) JOINT 1, THEN JOINT 2, 3, 4.
C WHERE U,V,W ARE TRANSLATIONS.
C EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
C CALLS FORMA SUBROUTINES EULER,MULT,ZZBOMB.
C DEVELOPED BY RL WOHLEN APRIL 1974.
C LAST REVISION BY WA BENFIELD MARCH 1976.

C SUBROUTINE: ARGUMENTS
C CJ = INPUT MATRIX OF GLOBAL X,Y,Z COORDINATES AT PANEL JOINTS.
C ROWS 1,2,3 CORRESPOND TO X,Y,Z COORDINATES.
C COLS 1,2,3,4 CORRESPOND TO JOINTS 1,2,3,4. SIZE(3,4).
C EJ = INPUT MATRIX OF EULER ANGLES (DEGREES) AT PANEL JOINTS.
C ROWS 1,2,3 CORRESPOND TO GLOBAL X,Y,Z PERMUTATION.
C COLS 1,2,3,4 CORRESPOND TO JOINTS 1,2,3,4. SIZE(3,4).
C Z = OUTPUT DIRECTION COSINE MATRIX. SIZE(3,3).
C KCJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM.
C KEJ = INPUT ROW DIMENSION OF EJ IN CALLING PROGRAM.
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=8.
C
C NEQRO: EXPLANATION
C 1 = DIMENSION SIZE TOO SMALL.
C
 IF (KZ .LT. E) CC TO 999
PX = CJ(1,1) - CJ(1,1)
PY = CJ(2,1) - CJ(2,1)
PZ = CJ(3,1) - CJ(3,1)
PL = SQRT(PX**2 + PY**2 + PZ**2)
CY = CJ(1,4) - CJ(1,1)
CY = CJ(2,4) - CJ(2,1)
CZ = CJ(3,4) - CJ(3,1)
CL = SQRT(CY**2 + CZ**2 + CL**2)
W(1,1) = PX/PL
W(1,2) = PY/PL
W(1,3) = PZ/PL
W(2,1) = CX/CL
W(2,2) = CY/CL
W(2,3) = CZ/CL
DO 10 J=1,12
DO 10 I=1,8
10 Z(I,J) = 0.0
DO 50 IJNT=1,4
   CALL EULEF (EJ(1,IJNT),T,3)
   CALL MULTF (W,T,2,3,3,2,3)
   JZZ = 2*(IJNT-1)
   DO 50 JW=1,3
   JZ = JZZ+JW
   Z(IJNT+JZ) = T(1,JW)
50    Z(IJNT+4,JZ) = T(2,JW)
RETURN

999 CALL ZZ60MB (6,H,DOS5C,MERROR)
END
SUBROUTINE EULER (E,R,KR)
DIMENSION E(1,R(KR,1))

C C CALCULATE EULER ANGLE ROTATION TRANSFORMATION MATRIX.
C C EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.

C SUBROUTINE ARGUMENTS
C R = INPUT VECTOR OF JOINT EULER ANGLES (DEGREES).
C LOCATIONS 1,2,3 CORRESPOND TO THE GLOBAL X,Y,Z
C PERMUTATION. SIZE(3).
C E = OUTPUT EULER ROTATION TRANSFORMATION MATRIX. SIZE(3,3).
C 
C KR = INPUT ROW DIMENSION OF R IN CALLING PROGRAM.

D10 = ATAN2(1.,1.)/45.

C C1 = COS(E(1)*D10)
C C2 = COS(E(2)*D10)
C C3 = COS(E(3)*D10)
C S1 = SIN(E(1)*D10)
C S2 = SIN(E(2)*D10)
C S3 = SIN(E(3)*D10)

C F(1,1) = C2*C3
C F(1,2) = -C2*S3
C R(1,3) = S2
C R(2,1) = C1*S3 + S1*S2*C3
C R(2,2) = C1*C3 - S1*S2*S3
C F(2,3) = -S1*C2
C R(3,1) = S1*S3 - C1*S2*C3
C R(3,2) = S1*C3 + C1*S2*S3
C R(3,3) = C1*C2

RETURN
END
SUBROUTINE FINEL (XYZ, JDOF, EUL, NUTEL, NJ, 
          MUTM, NUTK, NUTLT, NUTST, NUTP, V, LV, KV, 
          KRX, KRE, NUTMX, NUTKY, NUT1, NUT2, NUT3) 
DIMENSION XYZ(KRX,1), JDOF(KRE,1), EUL(KRE,1), V(1), LV(1) 
DIMENSION W1(24,24), W2(24,24), W3(24,24) 
DATA KW/24/, IFLANK/L6H/, II, II/1/ 
DATA NIT, NOT/5,6/ 
C 
SUBROUTINE TO CALCULATE (ON OPTION) FINITE ELEMENT... 
C ASSEMBLED MASS MATRIX (ON NUTH). 
C ASSEMBLED STIFFNESS MATRIX (ON NUTK). 
C ELEMENT LOCAL LOAD TRANSFORMATION MATRICES, IVECS (ON NUTLT), 
C ELEMENT GLOBAL LOAD TRANSFORMATION MATRICES, IVECS (ON NUTKX), 
C ELEMENT STRESS TRANSFORMATION MATRICES, IVECS (ON NUTST), 
C ELEMENT UNIT LOAD BUCKLING MATRICES, IVECS (ON NUTO). 
C IVEC GIVES ELEMENT DOF INTO GLOBAL DOF. EXAMPLES... 
C IVEC(6)=834 PLACES ELEMENT DOF 6 INTO GLOBAL DOF 834. 
C IVEC(3)=6 OMITS ELEMENT DOF 2 FROM GLOBAL DOF. THIS CONSTRAINTS 
C ELEMENT DOF 3 TO ZERO MOTION. 
C DATA ARRANGEMENT ON NUTH, NUTK FOR THE ASSEMBLED MATRICES IS IN 
C SPARSE (Y) FORMA SUBROUTINE FORMAT. 
C DATA ARRANGEMENT ON NUTLT, NUTKX, NUTST, NUTP FOR EACH FINITE 
C ELEMENT (WRITTEN IN SUBROUTINE AXIAL, BAR, ETC) IS 
C WRITE (NUTH) NAMEW,NEL,INF,NC,NAMEL (ILANK#,I=I,5), 
C (W(I,J),I=1,NC,J=1,NC),(IVEC(I),I=1,NC) 
C NAMEW = NAMELT,NAMEKX,NAMETST, OR NAMEB. 
C NAMEL = AXIAL,PAP,ETC. 
C LAST RECORD TO DENOTE TERMINATION IS, 
C WRITE (NUTH) IFLANK,(II,I=1,36) 
C THE FOLLOWING UTILITY TAPES USE RASIC FORTRAN READ, WRITE. DO NOT 
C USE THESE TAPES IN SPARSE (Y) FORMA SUBROUTINES WHICH USE FORMA 
C SUBROUTINES YIN, YOUT (BECAUSE THEY USE BUFFER IN, BUFFER OUT). 
C NUTH, NUTLT, NUTKX, NUTKX, NUTP. 
C THE FOLLOWING UTILITY TAPES USE FORMA YIN, YOUT. 
C NUTH, NUTK, NUT1, NUT2, NUT3. 
C CALLS FORMA SUBROUTINES AXIAL, BAR, FLUID, GRAVITY, PAGEHD, QUAD, 
C RECTSP, TANGL, YRVAD2, Z16CMB. 
C LAST REVISION BY RL WOHLER. MAY 1976. 
C 
C********************************************************************** 
C INPUT DATA READ IN THIS SUBROUTINE FROM NUTEL. IF NUTEL = 5, DATA IS 
C READ FROM CARDS. 
C 50 NAMEL FORMAT (A6) 
C IF (NAMEL ..EQ. 6) RETURN 
C IF (NAMEL ..EQ. 6) CALL AXISL (SEE SUPRT FOR INPUT) 
C IF (NAMEL ..EQ. 6) CALL BAR (SEE SUPRT FOR INPUT) 
C IF (NAMEL ..EQ. 6) CALL FLUID (SEE SUPRT FOR INPUT) 
C IF (NAMEL ..EQ. 6) CALL GRAVITY (SEE SUPRT FOR INPUT) 
C IF (NAMEL ..EQ. 6) CALL QUAD (SEE SUPRT FOR INPUT) 
C IF (NAMEL ..EQ. 6) CALL RECTSP (SEE SUPRT FOR INPUT) 
C IF (NAMEL ..EQ. 6) CALL TRNGL (SEE SUPRT FOR INPUT) 
C GO TO 50 
C 
C DEFINITION OF INPUT VARIABLES.
NAMEL = AXIAL, BAR, ETC AS SHOWN ABOVE. GIVES SUBROUTINE CALLED.

EXPLANATION OF INPUT FORMATS. NUMBER INDICATES CARD COLUMNS USED.
A = ANY KEYPUNCH SYMBOL.
X = CARD COLUMNS SKIPPED.

SUBROUTINE ARGUMENTS (ALL INPUT)
XYZ = MATRIX OF JOINT GLOBAL X, Y, Z LOCATIONS. ROWS CORRESPOND
      TO JOINT NUMBERS. COLUMNS 1, 2, 3 CORRESPOND TO THE JOINT
      X, Y, Z LOCATIONS RESPECTIVELY. SIZE(NJ,3).
C MAY BE EQUIVALED TO VN(1) IN CALLING PROGRAM.

JDOF = MATRIX OF JOINT GLOBAL DEGREES OF FREEDOM. ROWS CORRESPOND
      TO JOINT NUMBERS. COLUMNS 1, 2, 3 CORRESPOND TO THE JOINT
      TRANSLATION DOFS AND COLUMNS 4, 5, 6 CORRESPOND TO THE JOINT
      ROTATION DOFS. SIZE(NJ,6).
C MAY BE EQUIVALED TO LV(1) IN CALLING PROGRAM.

EUL = MATRIX OF JOINT EULER ANGLES (DEGREES). ROWS CORRESPOND
      TO JOINT NUMBERS. COLUMNS 1, 2, 3 CORRESPOND TO THE
      LOCAL X, Y, Z PERMUTATION. SIZE(NJ,3). MAY BE
      EQUIVALED TO VKRX*(XYZ COL DIM)+1 IN CALLING PROGRAM.

NUTEL = LOGICAL NUMBER OF TAPE CONTAINING ELEMENT INPUT DATA FOR
      THIS SUBROUTINE AND SUBRoutines AXIAL, ETC GIVEN BY NAMEL.
C IF NUTEL = 5, DATA WILL BE READ FROM CARDS.

NJ = NUMBER OF JOINTS OR ROWS IN MATRICES (XYZ), (JDOF), (EUL).

NUTM = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ASSEMBLED
      MASS MATRIX IS OUTPUT IN SPARSE NOTATION.
C NUTM MAY BE ZERO IF MASS MATRIX IS NOT FORMED.
C USES FORTRAN YIN, YOUT.

NUTK = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ASSEMBLED
      STIFFNESS MATRIX IS OUTPUT IN SPARSE NOTATION.
C NUTK MAY BE ZERO IF STIFFNESS MATRIX IS NOT FORMED.
C USES FORTRAN YIN, YOUT.

NULTL = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT LOAD
      TRANSFORMATION MATRICES AND IVECS ARE OUTPUT.
C NULTL MAY BE ZERO IF LOAD TRANSFORMATIONS ARE NOT FORMED.
C USES FORTRAN READ, WRITE.

NUTST = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
      STRESS TRANSFORMATION MATRICES AND IVECS ARE OUTPUT.
C NUTST MAY BE ZERO IF STRESS TRANSFORMATIONS ARE NOT FORMED.
C USES FORTRAN READ, WRITE.

NUTB = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT UNIT LOAD
      BUCKLING MATRICES AND IVECS ARE OUTPUT.
C NUTB MAY BE ZERO IF BUCKLING MATRICES ARE NOT FORMED.
C USES FORTRAN READ, WRITE.

V = VECTOR WORK SPACE.
LV = VECTOR WORK SPACE.
KV = DIMENSION SIZE OF V, LV IN CALLING PROGRAM.

KRX = ROW DIMENSION OF XYZ IN CALLING PROGRAM.
KRE = ROW DIMENSION OF JDOF IN CALLING PROGRAM.

NUTMX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
      MASS MATRICES AND IVECS ARE STORED.
C NUTMX MAY BE ZERO IF MASS MATRIX IS NOT FORMED.
C USES FORTRAN READ, WRITE.
FINEL -- 3/5

C NUTKX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
C STIFFNESS MATRICES (SAME AS GLOBAL LOADS TRANSFORMATION
C MATRICES) AND INECS ARE STORED.
C NUTKX MAY BE ZERO IF STIFFNESS MATRIX IS NOT FORMED.
C USES FORTRAN READ, WRITE.
C NUT1 = LOGICAL NUMBER OF UTILITY TAPE. USES FORMA YIN, YOUT.
C NUT2 = LOGICAL NUMBER OF UTILITY TAPE. USES FORMA YIN, YOUT.
C NUT3 = LOGICAL NUMBER OF UTILITY TAPE. USES FORMA YIN, YOUT.
C
C NERROR EXPLANATION
C 1 = NAMEL IMPROPERLY DEFINED.
C
1001 FORMAT (A6)
2001 FORMAT (/41X 35HJOINT DATA USED IN SUBROUTINE FINEL)
2002 FORMAT (/35X 47HJOINT DATA USED IN SUBROUTINE FINEL (CONTINUED))
2003 FORMAT (/16X .8HDEGREES OF FREEDOM
  * 1PX 2HGLOBAL CARTESIAN COORDINATES
  * 12X 22HEULER ANGLES (DEGREES)
  * /14X 11HTRANSLATION 8X 8ROTATION
  * / 2X5HJOINT 6XIHU 5XIHV 5XIHW 5X1HP 5XIHQ 5X1HR
  * I1XIHX I1XHY I1XHZ I4XIHX 10XIHY 10XIHZ /)
2004 FORMAT (1X IS, 3X 6I6, 3X 3F12.4, 4X 3F11.4)
C
IF (NUTMX .GT. 0) REWIND NUTMX
IF (NUTKX .GT. 0) REWIND NUTKX
IF (NUTE .GT. 0) REWIND NUTE
IF (NULT .GT. 0) REWIND NULT
IF (NUTST .GT. 0) REWIND NUTST
C
C DETERMINE SIZE OF FINAL MASS-STIFFNESS MATRIX FROM THE MAXIMUM DOF
C NUMBER IN JDOF.
C NDOF = JDOF(I,1)
  DO 35 I=1,NJ
  DO 35 J=1,6
    IF (JDOF(I,J) .GT. NDOF) NDOF=JDOF(I,J)
 35 CONTINUE
C
C PRINT JOINT DOF, XYZ COORDINATES, EULER ANGLES.
C CALL PAGEHD
WRITE (NCT,2001)
WRITE (NCT,2003)
NLINE = 0
DO 40 IJ=1,NJ
NLINE = NLINE+1
IF (NLINE .LE. 42) GO TO 40
CALL PAGEHD
WRITE (NCT,2002)
WRITE (NCT,2003)
NLINE = 1
40 WRITE (NCT,2004) IJ, (JDOF(IJ,J), J=1,6), (XYZ(IJ,J), J=1,3),
  * (EUL(IJ,J), J=1,3)
C
C READ FINITE ELEMENT TYPE.
50 READ (NUTEL,1001) NAMEL
IF (NAMEL .EQ. 6HRETURN) GO TO 50C
IF (NAMEL .EQ. 6HAXIAL ) GO TO 110
IF (NAMEL .EQ. 6HHEAR ) GO TO 140
IF (NAMEL .EQ. 6HTRNGL ) GO TO 150
IF (NAMEL .EQ. 6HFLUID ) GO TO 151
IF (NAMEL .EQ. 6HQUAD ) GO TO 160
IF (NAMEL .EQ. 6HRECTSP) GO TO 162
IF (NAMEL .EQ. 6HGRAVITY) GO TO 171

NERROF=1
   GO TO 999

C BAR FINITE ELEMENT (AXIAL ONLY).
110 CALL AXIAL (XYZ, JDCF, EUL, NUTEL, NJ, *
    NUTMX, NUTXX, NULT, NUST, *
    W1, W2, W3, KRX, KRJ, KRE, KW)
   GO TO 50

C BAR FINITE ELEMENT (COMBINED AXIAL, TORSION, BENDING).
140 CALL BAR (XYZ, JDCF, EUL, NUTEL, NJ, *
    NUTMX, NUTKX, NUTB, NULT, NUST, *
    W1, W2, W3, KRX, KRJ, KRE, KW)
   GO TO 50

C TRIANGULAR PLATE ELEMENT.
150 CALL TRNGL (XYZ, JDCF, EUL, NUTEL, NJ, *
    NUTMX, NUTXX, NULT, NUST, *
    W1, W2, W3, KRX, KRJ, KRE, KW)
   GO TO 50

C FLUID ELEMENT.
151 CALL FLUID (XYZ, JDCF, EUL, NUTEL, NJ, *
    NUTMX, NUTXX, NULT, NUST, *
    W1, W2, W3, KRX, KRJ, KRE, KW)
   GO TO 50

C QUADRILATERAL PLATE ELEMENT.
160 CALL QUAD (XYZ, JDCF, EUL, NUTEL, NJ, *
    NUTMX, NUTKX, NUTP, NULT, NUST, *
    W1, W2, W3, KRX, KRJ, KRE, KW)
   GO TO 50

C RECTANGULAR SHEAR PANEL.
162 CALL RECTSP (XYZ, JDCF, EUL, NUTEL, NJ, *
    NUTMX, NUTKX, NULT, NUST, *
    W1, W2, W3, KRX, KRJ, KRE, KW)
   GO TO 50

C GRAVITY ELEMENT.
171 CALL GRAVITY (XYZ, JDCF, EUL, NUTEL, NJ, *
    NUTXX, *
    W1, W2, W3, KRX, KRJ, KRE, KW)
   GO TO 50

C TERMINATE FINITE ELEMENT DATA ON STORAGE DISKS.
500 IF (NUTMX .GT. 0) WRITE (NUTMX) IBLANK, (II, I=1, 30)
   IF (NUTKX .GT. 0) WRITE (NUTKX) IBLANK, (II, I=1, 30)
   IF (NUTP .GT. 0) WRITE (NUTP) IBLANK, (II, I=1, 30)
   IF (NULT .GT. 0) WRITE (NULT) IBLANK, (II, I=1, 30)
   IF (NUST .GT. 0) WRITE (NUST) IBLANK, (II, I=1, 30)

C SUM FINITE ELEMENT MATRICES.
   IF (NUTMX.GT.0) CALL YZER0 (NUTM, NDCF, NDCF)
   IF (NUTKX.GT.0) CALL YZER0 (NUTK, NDCF, NDCF)
IF (NUTMX .GT. 0) CALL YRVAD2 (NUTMX, NUTM, NDOF, W1, KW, V, LV, KV, NUT1, NUT2, NUT3)
* IF (NUTKX .GT. 0) CALL YRVAD2 (NUTKX, NUTK, NDOF, W1, KW, V, LV, KV, NUT1, NUT2, NUT3)
  RETURN

C

999 CALL ZZBOMB (6HFINEL, NERROR)
END
SUBROUTINE FLUID (XYZ, JDSCF, EUL, NUTEL, NJ,
* NUTMX, NUTKX, NULTL, NUST,
* W, T, S, KX, KJ, KE, KW)
DIMENSION XYZ(KX,1), JDSCF(KJ,1), EUL(KE,1), W(KW,1),
* TKW, 5(KW,1)
DIMENSION CJ(5,8), EJ(3,8), IV1(24), IV2TIE(12), JM(4,16), VL(10),
* DV(12), DIST(12,12), TV(24)
DATA NFW, NRS/24, 1/, IBLNK/6H //, 1ST /0/
DATA NIT, NOT/ 56 /
DATA NAME/output 6F/FLUID /
DATA KCOL/ 3 /, KJM/ 4 /, KDATA DIST/ 12 /, IFBAD/ 1 /
DATA JM/1, 2, 3, 4, 3, 6, 4, 2, 2, 6, 4, 5, 3, 5, 1, 2,
* 1, 3, 6, 5, 1, 6, 4, 5, 2, 7, 4, 5, 1, 7, 4, 5,
* 4, 7, 6, 5, 5, 2, 7, 6, 4, 2, 3, 7, 1, 3, 9, 6,
* 1, 6, 8, 5, 1, 3, 4, 8, 1, 3, 5, 6, 8, 3, 7, 6 /
C
C SUBROUTINE TO CALCULATE (ON OPTION) FINITE ELEMENT ... 
C MASS MATRICES AND IVECS (ON NUTMX),
C STIFFNESS MATRICES (SAME AS GLOBAL LOAD TRANSFORMATION MATRICES)
C AND IVECS (ON NUTMX),
C PRESSURE TRANSFORMATION MATRICES AND IVECS (ON NUST),
C FOR FLUID ELEMENTS.
C ELEMENT SHAPE MAY BE TETRAHEDRON, PENTAHEDRON, OR HEXAHEDRON.
C MASS, STIFFNESS MATRICES ARE IN GLOBAL COORDINATE DIRECTIONS.
C GLOBAL COORDINATE ORDER IS 
C (U,V,W) JOINT 1, THEN JOINT 2,3,4,(5,6,7,8).
C WHERE U,V,W ARE TRANSLATIONS.
C IVEC GIVES ELEMENT DOF INTO GLOBAL DOF. EXAMPLES...
C IVEC(6)=834 PLACES ELEMENT DOF 6 INTO GLOBAL DOF 834.
C IVEC(3)=0 OOMIT ELEMENT DOF 3 FROM GLOBAL DOF. THIS CONSTRAINS
C ELEMENT DOF 3 TO ZERO MOTION.
C PRESSURE TRANSFORMATION MATRICES RELATE CHANGE IN PRESSURE (DUE TO
C COMpressibility) TO DEFLECTIONS IN THE GLOBAL COORDINATE DIRECTIONS.
C PRESSURE CHANGE WITHIN THE FLUID ELEMENT IS CONSTANT. STATIC PRESSURE
C DUE TO GRAVITY AND FLUID DENSITY IS NOT INCLUDED.
C DATA ARRANGEMENT ON NUTMX, NUTKX, NUST FOR EACH FINITE ELEMENT IS
C (W=M,K,ST)
C WRITE (NUTW) NAME, NEL, NP, NC, NAMEN, (IBLNK, I=1,5),
C ((W(I,J), I=1, MR, J=1, NC), (IVEC(I), I=1, NC)
C CALLS FOR MAE SUBROUTINES TEGEM, VECROSS, VDOT, ZIPOMB.
C DEVELOPED BY C E EDENH. FEBRUARY 1974.
C LAST REVISION BY WA BENFIELD. MARCH 1976.
C
C INPUT DATA READ IN THIS SUBROUTINE FROM NUTEL. IF NUTEL = NIT, DATA IS
C READ FROM CARDS.
C NAME, NAMEK, NAMET, NAMEST FORMAT (4(A6, 4X)
C RC, EKM FORMAT (25X, E10)
C ZC NEL, J1, J2, J3, J4, J5, J6, J7, JE FORMAT (915)
C IF (J1 .EQ. 0) RETURN
C GC TO 20
C
C DEFINITION OF INPUT VARIABLES.
C NAME = TYPE OF MASS MATRIX WANTED.
C = M1, LUMPED MASS MATRIX.
C = M2, QUASI-IRRATIONAL CONSISTENT MASS MATRIX.
C = M3, IRRATIONAL MASS MATRIX.
C = 6p OR 6HNOmass, NO MASS MATRIX CALCULATED.
C NAMEK = TYPE OF STIFFNESS MATRIX WANTED.
C = K1, LINEAR DISPLACEMENT ASSUMED.
C = 6H OR 6HNOStiff, NO STIFFNESS MATRIX CALCULATED.
C NAMEST = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES, (NOT YET).
C NAMEST = IDENTIFICATION NAME FOR PRESSURE TRANSFORMATION MATRICES.
C = 6H OR 6HNOStiff, NO STIFFNESS MATRIX CALCULATED.
C RO = MASS DENSITY.
C BM = BULK MODULUS.
C NEL = FINITE ELEMENT NUMBER. FOR REFERENCE ONLY, NOT USED IN CALCULATIONS. WRITTEN ON NUTMX, ETC.
C J1 = JOINT NUMBER AT ELEMENT VERTEX 1.
C J2 = JOINT NUMBER AT ELEMENT VERTEX 2.
C J3 = JOINT NUMBER AT ELEMENT VERTEX 3.
C J4 = JOINT NUMBER AT ELEMENT VERTEX 4.
C FOR A TETRAHEDRON, FACE 1,2,3 MUST BE NUMBERED COUNTERCLOCKWISE AS VIEWED FROM OUTSIDE THE ELEMENT.
C J5 = JOINT NUMBER AT ELEMENT VERTEX 5. (USED FOR PENTAHEDRON AND HEXAHEDRON).
C J6 = JOINT NUMBER AT ELEMENT VERTEX 6. (USED FOR PENTAHEDRON AND HEXAHEDRON).
C FOR A PENTAHEDRON, FACE 1,2,3 MUST BE NUMBERED COUNTERCLOCKWISE AS VIEWED FROM OUTSIDE THE ELEMENT. FACE 4,5,6 IS NUMBERED IN THE SAME ORDER AS FACE 1,2,3. A LINE JOINING JOINTS 1 AND 4 MUST FORM AN EDGE OF THE PENTAHEDRON.
C J7 = JOINT NUMBER AT ELEMENT VERTEX 7. (USED FOR HEXAHEDRON).
C J8 = JOINT NUMBER AT ELEMENT VERTEX 8. (USED FOR HEXAHEDRON).
C FOR A HEXAHEDRON, FACE 1,2,3,4 MUST BE NUMBERED COUNTERCLOCKWISE AS VIEWED FROM OUTSIDE THE ELEMENT. FACE 5,6,7,8 IS NUMBERED IN THE SAME ORDER AS FACE 1,2,3,4. A LINE JOINING JOINTS 1 AND 5 MUST FORM AN EDGE OF THE HEXAHEDRON.
C EXPLANATION OF INPUT FORMATS. NUMBER INDICATES CARD COLUMNS USED.
C I = INTEGER DATA, RIGHT ADJUSTED.
C E = DECIMAL POINT DATA, ANYWHERE IN FIELD. EXponent RIGHT ADJUSTED.
C X = CARD COLUMNS SKIPPED.
C SUBROUTINE ARGUMENTS (ALL INPUT)
C XYZ = MATRIX OF JOINT GLOBAL X,Y,Z LOCATIONS. ROWS CORRESPOND TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE JOINT X,Y,Z LOCATIONS RESPECTIVELY. SIZE(NJ,3).
C JDOf = MATRIX OF JOINT GLOBAL DEGREES OF FREEDOM. ROWS CORRESPOND TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE JOINT TRANSLATION DOFS AND COLUMNS 4,5,6 CORRESPOND TO THE JOINT ROTATION DOFS. SIZE(NJ,6).
C EUL = MATRIX OF JOINT EULER ANGLES (DEGREES). ROWS CORRESPOND TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE GLOBAL X,Y,Z PERMUTATION. SIZE(NJ,3).
C NUTEL = LOGICAL NUMBER OF TAPE CONTAINING ELEMENT INPUT DATA FOR THIS SUBROUTINE. IF NUTEL = NIT, DATA IS READ FROM CARDS.
C NJ = NUMBER OF JOINTS OR ROWS IN MATRICES (XYZ), (JDOf), (EUL).
C NUTMx = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT MASS MATRICES AND IVECS ARE OUTPUT.
NUTMX MAY BE ZERO IF MASS MATRIX IS NOT FORMED.

USES FORTRAN READ, WRITE.

NUTKX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
STIFFNESS MATRICES (SAME AS GLOBAL LOADS TRANSFORMATION
MATRICES) AND IVECS ARE OUTPUT.

NUTKX MAY BE ZERO IF STIFFNESS MATRIX IS NOT FORMED.

USES FORTRAN READ, WRITE.

NUTLT = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT LOAD
TRANSFORMATION MATRICES AND IVECS ARE OUTPUT. (NOT YET).

NUTST = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
PRESSURE TRANSFORMATION MATRICES AND IVECS ARE OUTPUT.

NUTST MAY BE ZERO IF PRESSURE TRANSFORMATIONS ARE NOT FORMED.

USES FORTRAN READ, WRITE.

W = MATRIX WORK SPACE. MIN SIZE(24,24).
T = MATRIX WORK SPACE. MIN SIZE(24,24).
S = MATRIX WORK SPACE. MIN SIZE(24,24).
XK = ROW DIMENSION OF XYZ IN CALLING PROGRAM.
KJ = ROW DIMENSION OF JOOF IN CALLING PROGRAM.
KE = ROW DIMENSION OF EUL IN CALLING PROGRAM.

M ERROR EXPLANATION
1 = INCORRECT TETRAHEDRON GEOMETRY.
2 = INPUT JOINT NUMBER EXCEEDS MAXIMUM ALLOWABLE NUMBER OF JOINTS.
3 = NUTMX NOT POSITIVE.
4 = NUTKX NOT POSITIVE.
5 = NUTST NOT POSITIVE.

1001 FORMAT (5(A6,4X))
1002 FORMAT (3(5X,E10.0))
1003 FORMAT (9(I5))
2001 FORMAT (//25X 38X INPUT DATA FOR FLUID (TETRA, PENTA, OR
* 21H HEXAHEDRON) ELEMENTS)
2002 FORMAT (//20X 38X INPUT DATA FOR FLUID (TETRA, PENTA, OR
* 33H HEXAHEDRON) ELEMENTS (CONTINUED))
2003 FORMAT (/12X7HMAXS = A6,13X7HSTIFS = A6,6X13HLOAD TRANS = A5,
* 3X15HSTRESS TRANS = A6, 3X
* / 15X4HRD = E10.3, 13X7HULKM = E10.3,
* // 9X7HELEMENT 6 HJOINT 1 6X7HJOINT 2 6X7HJOINT 3 6X7HJOINT 4
* 6X7HJOINT 5 6X7HJOINT 6 6X7HJOINT 7 6X7HJOINT 8
* / 9X6HNUMBER)
2004 FORMAT (3X,9(8X,15))
3601 FORMAT (51H ** ** ** UNCONVENTIONAL JOINT NUMBERING ** ** **, /
* 915)

IF (I1ST .EQ. 1) GO TO 3
I1ST = 1
DO 4 I=1,4
11 = 3*I - 2
DO 4 J=1,4
J1 = 3*J - 2
4 CALL UNITY (DIST(I1,J1),3,K11ST)

3 NLINE = 0
CALL PAGEHD
WRITE (NOT,2001)
READ (NUTEL,1001) NAME,NAMES,NAMET,NAMET
READ (NUTEL,1002) RO, BKM
WRITE (NOT,2003) NAME,NAMES,NAMET,NAMET,
* RO, BKM
IF (JAMFM .NE. 6HM3 ) GO TO 20
DO 2 I=1,12
2 DIST(I,I) = 2.
C
20 READ (NUTEL,1003) NEL,J1,J2,J3,J4,J5,J6,J7,J8

C
C FORM INFINITE ELEMENT COORDINATE LOCATIONS, EULER ANGLES, REVADD IVEC.
C
LR = 10
NJN = 8
IF (J7 .NE. 0) GO TO 38
LR = 6
NJN = 6
IF (J5 .NE. 0) GO TO 38
LR = 1
NJN = 4
C
38 NCCL = 2*NJN
DO 5 I=1,NCCL
DO 5 J=1,NCCL
WI(I,J) = 0.
S(I,J) = 0.
5 T(I,J) = 0.
DO 40 I=1,3
CJ(I,1) = XYZ(J1,I)
CJ(I,2) = XYZ(J2,I)
CJ(I,3) = XYZ(J3,I)
CJ(I,4) = XYZ(J4,1)
EJ(I,1) = EUL(J1,1)
EJ(I,2) = EUL(J2,1)
EJ(I,3) = EUL(J2,1)
EJ(I,4) = EUL(J4,1)
IV1(I) = JDOF(J1,I)
IV1(I+3) = JDOF(J2,1)
CALL TESTOM (CJ, MJ, J3, I)

IV1(I+3) = JCDF(J3, I)

40 IV1(I+9) = JCDF(J4, I)

IF (LR < E0, 1) GO TO 50

C

DO 42 J=1, 3
    CJ(I, 5) = XYZ(J5, I)
    CJ(I, 6) = XYZ(J6, I)
    EJ(I, 5) = EUL(J5, I)
    EJ(I, 6) = EUL(J6, I)

IV1(I+12) = JCDF(J5, I)

42 IV1(I+15) = JCDF(J6, I)

IF (IFBAD < NE < 0) GO TO 50

C

DO 44 J=1, 3
    CJ(I, 7) = XYZ(J7, I)
    CJ(I, 8) = XYZ(J8, I)
    EJ(I, 7) = EUL(J7, I)
    EJ(I, 8) = EUL(J8, I)

IV1(I+18) = JCDF(J7, I)

44 IV1(I+21) = JDF(J8, I)

C

50 DO 52 L=1, LR
    LA = L
    IF (LR < E0, 10) LA = L+6

C

DO 52 J=1, 4
    JR = JM(I, LA)
    LI = 3*J - 2
    IVTET(L1) = 5*NOC - 2
    IVTET(L1+1) = 3*NOC - 1

53 IVTET(L1+2) = 3*NOC

C

CALL TESTOEM (CJ, JM, LA, VL, KV, KCJ, IFBAD)

IF (IFBAD < NE < 0) GO TO 51

WRITE (NO, 3001) NEL, J1, J2, J3, J4, J5, J6, J7, J8

IFBAD = -1

51 SM = RO*VL(L)/16.0

IF (NAMEM < NE, 6HM) SM = RO*VL(L)/20.0

IF (LR < E0, 1) SM = SM/2.

CALL REVADD (1, DV, IVTET, T, '12, LR, NCOL, I, KW)

C

52 CALL REVADD (SM, DIST, IVTET, IVTET, W, 12, 12, NCOL, NCOL, KDIST, KW)

C

IF (NAMEM < NE, 6HM) GO TO 220

DO 210 I=1, NCOL
    SAVE = 0.0

DO 215 J=1, NCOL
    SAVE = SAVE + W(I, J)

215 W(I, J) = 0.0

210 W(I, I) = SAVE

C

220 IF (LR < E0, 1) GO TO 60

DO 55 I=2, LR
    VL(I) = VL(I) + VL(I)

DO 55 J=1, NCOL

55 T(I, J) = T(I, J) + T(I, J)

VL(I) = VL(I)/2.
DO 56 J=1,NCOL
56 T(I,J) = T(I,J)/2.

C

60 DO 61 J=1,NCOL
61 TV(J) = T(I,J)
   DC 65 J=-1,NJN
   J1 = 3*J - 2

65 CALL EULE: (EJ(I,J), SJ(I,J1,J1), KW)
   IF (NAMEST.EQ.6H) GOTO 90
   CALL PRESS (CJ,T,JN,NCOL,JCJ,KW)
   CALL MULTI (TS,JN,NCOL,NCOL,KW,KW)
   CALL RTAP: (WS,NCOL,NCOL,KW,KW)
   CALL MULTI (TV,S,1,NCOL,NCOL,1,KW)
   BOV = EKM/VL(I)
   DO 70 I=1,NCOL
   DO 70 J=1,NCOL
   S(I,J) = BOV*TV(I)*TV(J)
70 S(I,J) = S(I,J)

C

IF (NAMEM.EQ.6H) GOTO 110
   OR. NAMEM.EQ.6HNCMASS) GOTO 110
   NERROR=3
   IF (NUTMX.LE.0) GOTO 999
   WRITE (NUTMX) NAMEM,NEL,NCOL,NAMEL,(IBLNK,I=1,5),
   * (W(I,J),I=1,NCOL), J=1,NCOL), (IVL(I),I=1,NCOL)
C

110 IF (NAMEK.EQ.6H) GOTO 120
   OR. NAMEK.EQ.6HNOSTIF) GOTO 120
   NERROR=4
   IF (NUTKX.LE.0) GOTO 999
   WRITE (NUTKX) NAMEK,NEL,NCOL,NAMEL,(IBLNK,I=1,5),
   * (S(I,J),I=1,NCOL), J=1,NCOL), (IVL(I),I=1,NCOL)
C

120 IF (NAMEST.EQ.6H) GOTO 20
   OR. NAMEST.EQ.6HNOSTRS) GOTO 20
   NERROR=5
   IF (NUTST.LE.0) GOTO 999
   NJNP1 = NJN + 1
   CALL MULTI (TS,T(NJNP1,1),NJN,NCOL,NCOL,KW,KW)
   CALL MULTI (T,W,NJN,NCOL,NCOL,KW,KW)
   NRST = 2*NJN
   WRITE (NUTST) NAMEST,NEL,NRST,NAMEL,VL(I),(I=1,4),
   * (T(I,J),I=1,NRST), J=1,NCOL), (IVL(I),I=1,NCOL)
   GOTO 26
C

999 CALL ZSTOPF (6HFLUID,NERROR)
END
SUBROUTINE GRAVITY (XYZ,JDOF,EUL,NUL,NUJ,
* NUTXX,  
* W, T, S, KK, KJ, KE, KW)
DIMENSION XYZ(KK,1),JDOF(KJ,1), EUL(KE,1), W(KW,1),
* (KW,1), S(KW,1)
DIMENSION CJ(3,4),EJ(3,4),IVL(12),IVTRI(9),JM(3,4),GV(3),EV(3)
DATA IBLNK/6H/
DATA NIT,NOT/5,6/
DATA NAMEI /6HGRAVITY/
DATA KCJM/3/
DATA JM/1,2,3,1,3,4,1,2,4,4,2,3/

SUBROUTINE TO CALCULATE (ON OPTION) FINITE ELEMENT ...
STIFFNESS MATRICES (SAME AS GLOBAL LOAD TRANSFORMATION MATRICES)
AND IVECS (ON NUTXX),
FOR GRAVITY ELEMENTS.
STIFFNESS MATRICES ARE 9- Glo21- 300R49-1T 4IR 090-58
GLOBAL COORDINATE ORDER IS
(U,V,W) JOINT 1, THEN JOINT 2,3,(4).
WHERE U,V,W ARE TRANSLATIONS.
IVEC GIVES ELEMENT DOF INTO GLOBAL DOF. EXAMPLES...
IVEC(6)=834 PLACES ELEMENT DOF 6 INTO GLOBAL DOF 834.
IVEC(3)=0 omits ELEMENT DOF 3 FROM GLOBAL DOF. THIS CONSTRAINTS
ELEMENT DOF 3 TO ZERO MOTION.
DATA ARRANGEMENT ON NUTXX FOR EACH FINITE ELEMENT IS
(W=K)
WRITE (NUTXX) NAMEN,NEL, NR, NC, NAMEL, (IBLNK, I=1,5),
((W(I,J), I=1, NP), J=1, NC), (IVEC(I), I=1, NC)
CALLS SUBROUTINES KGRAV, MULTA, MULTE, VCROSS, ZZBOMB.
DEVELOPED BY C S BEADLEY. FEBRUARY 1974.
LAST REVISION BY WA BENDFIELD. MARCH 1976.

**********************************************************************
INPUT DATA READ IN THIS SUBROUTINE FROM NUTEL. IF NUL = NIT, DATA IS
READ FROM CARDS.
NAME, NAMEK FORM/ (I4,2A6,4X)
RO FORM/ (5X, 10)
(CV(I), I=1,3) FORM (3(5X,E10))
20 NEL,J1,J2,J3,J4 FORM (15)
IF (J1 + E0.0) RETURN
GO TO 20

DEFINITION OF INPUT VARIABLES.
NAME = TYPE OF MASS MATRIX WANTED.
= 6H OR 6HNOMASS, NO MASS MATRIX CALCULATED.
NAMEK = TYPE OF STIFFNESS MATRIX WANTED.
= K1, LINEAR DISPLACEMENT ASSUMED.
= 6H OR 6HNOSTIF, NO STIFFNESS MATRIX CALCULATED.
RO = MASS DENSITY.
EV = GRAVITY VECTORS.
NEL = FINITE ELEMENT NUMBER, FOR REFERENCE ONLY, NOT USED IN
CALCULATIONS, WRITTEN ON NUTXX.
J1 = JOINT NUMBER AT ELEMENT VERTEX 1.
J2 = JOINT NUMBER AT ELEMENT VERTEX 2.
J3 = JOINT NUMBER AT ELEMENT VERTEX 3.
GRAVITY-- 2/4

C J4 = JOINT NUMBER AT ELEMENT VERTEX 4. (USED FOR QUADRILATERAL).
C THE ELEMENT MUST BE NUMBERED CLOCKWISE AS VIEWED FROM THE FLUID SIDE
C OF THE ELEMENT.
C
C EXPLANATION OF INPUT FORMATS. NUMBER INDICATES CARD COLUMNS USED.
C I = INTEGER DATA, RIGHT ADJUSTED.
C E = DECIMAL POINT DATA, ANYWHERE IN FIELD. EXPONENT RIGHT ADJUSTED.
C X = CARD COLUMNS SKIPPED.
C
C*******************************************************************************
C
C SUBROUTINE ARGUMENTS (ALL INPUT)
C XYZ = MATRIX OF JOINT GLOBAL X,Y,Z LOCATIONS. ROWS CORRESPOND
C TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE JOINT
C X,Y,Z LOCATIONS RESPECTIVELY. SIZE(NJ,3).
C JDOF = MATRIX OF JOINT GLOBAL DEGREES OF FREEDOM. ROWS CORRESPOND
C TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE JOINT
C TRANSLATION DOFS AND COLUMNS 4,5,6 CORRESPOND TO THE JOINT
C ROTATION DOFS. SIZE(NJ,6).
C EUL = MATRIX OF JOINT EULER ANGLES (DEGREES). ROWS CORRESPOND
C TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE
C GLOBAL X,Y,Z PERMUTATION. SIZE(NJ,3).
C NUTEL = LOGICAL NUMBER OF TAPE CONTAINING ELEMENT INPUT DATA FOR
C THIS SUBROUTINE. IF NUTEL = NIT, DATA IS READ FROM CARDS.
C NJ = NUMBER OF JOINTS OR ROWS IN MATRICES (XYZ), (JDOF), (EUL).
C NUTKX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
C STIFFNESS MATRICES (SAME AS GLOBAL LOADS TRANSFORMATION
C MATRICES) AND IVCS ARE OUTPUT.
C NUTKX MAY BE ZERO IF STIFFNESS MATRIX IS NOT FORMED.
C USES FORTRAN READ, WRITE.
C W = MATRIX WORK SPACE. MIN SIZE(12,12).
C T = MATRIX WORK SPACE. MIN SIZE(12,12).
C S = MATRIX WORK SPACE. MIN SIZE(12,12).
C KX = ROW DIMENSION OF XYZ IN CALLING PROGRAM.
C KJ = ROW DIMENSION OF JDOF IN CALLING PROGRAM.
C KE = ROW DIMENSION OF EUL IN CALLING PROGRAM.
C KW = ROW DIMENSION OF W, T, AND S IN CALLING PROGRAM. MIN=12.
C
C NERVE EXPLANATION
C 1 = INPUT JOINT NUMBER EXCEEDS MAXIMUM ALLOWABLE NUMBER OF JOINTS.
C 2 = NUTKX NOT POSITIVE.
C
1001 FORMAT (5(A6,4X))
1002 FORMAT (3(I5,E10.0))
1003 FORMAT (5(I5))
2001 FORMAT (//25X 45INPUT DATA FOR GRAVITY STIFFNESS (TRIANGLE OR
* 24H QUADRILATERAL) ELEMENTS)
2002 FORMAT (//20X 45INPUT DATA FOR GRAVITY STIFFNESS (TRIANGLE OR
* 36H QUADRILATERAL) ELEMENTS (CONTINUED))
2003 FORMAT (/12X7HMAX = A6,13X7HSIF = A6,6X
* /15X,4HRG = E10.3, 13X5HGXX = E10.3, 13X5HGYY = E10.3,
* 13X5HGZZ = E10.3,
* //15X7HFLEME 13X7HJOINT 1 13X7HJOINT 2 13X7HJOINT 3
* 13X7HJOINT 4
* /15X6HNUMBER)
2004 FORMAT (15X9(I5,15X))
C
C
NLINE = 0
CALL PAGEHD
WRITE (NOT,2001)
READ (NUTEL,1001) NAMEK
READ (NUTEL,1002) PO
READ (NUTEL,1002) (GV(I),I=1,3)
WRITE (NOT,2003) NAMEK, NAMEK,
*   RC, (GV(I),I=1,3)
C
20 READ (NUTEL,1003) NEL,J1,J2,J3,J4
   IF (J1 .LE. 0) RETURN
   NLINE = NLINE + 1
   IF (NLINE .LE. 42) GO TO 30
   CALL PAGEHD
   WRITE (NOT,2002)
   WRITE (NOT,2003) NAMEK, NAMEK,
   *   RC, (GV(I),I=1,3)
   NLINE = 0
30 WRITE (NOT,2004) NEL,J1,J2,J3,J4
   NERROR=1
   IF (J1.GT.NJ .OR. J2.GT.NJ .OR. J3.GT.NJ .OR. J4.GT.NJ) GO TO 999
C
C
FORM FINITE ELEMENT COODINATE LOCATIONS, EULER ANGLES, REVADD IVEC.
C
LP = 4
NJN = 4
   IF (J4 .NE. 0) GO TO 38
   LP = 1
   NJN = 3
38 NCOL = 3*NJN
DO 5 I=1,NCOL
    DO 5 J=1,NCOL
      W(I,J) = C.
    5   T(I,J) = 0.
   S(I,J) = 0.
5 T(I,J) = 0.
C
DO 40 I=1,3
   CJ(I,1) = XYZ(J1,I)
   CJ(I,2) = XYZ(J2,I)
   CJ(I,3) = XYZ(J3,I)
   FJ(I,1) = FUL(J1,I)
   FJ(I,2) = FUL(J2,I)
   FJ(I,3) = FUL(J3,I)
   IVI(I) = JDCF(J1,I)
   IVI(I+3) = JDCF(J2,I)
40 IVI(I+6) = JDCF(J5,I)
   IF (LP .NE. 1) GO TO 50
C
DO 42 I=1,3
   CJ(I,4) = XYZ(J4,I)
   FJ(I,4) = FUL(J4,I)
42 IVI(I+9) = JDCF(J4,I)
50 G = SQRT(GV(1)**2 + GV(2)**2 + GV(3)**2)
   DO 51 I=1,3
51 EV(I) = -GV(I)/G
   DO 52 =-1,LR
      CALL KGRAV (CJ,JM(I,L),EV,A,W,KW,KCJM)
C
      DO 53 I=1,3
         JNO = JM(I,L)
         L1 = 3*I - 2
         IVTRI(L1) = 3*JNO - 2
         IVTRI(L1+1) = 3*JNO - 1
      53 IVTRI(L1+2) = 3*JNO
         SS = RO*G*A/24.
         IF (LR .lt. 1) SS = SS/2.
   52 CALL REVADD (SS,W,IVTRI,IVTRI,S,9,9,NCOL,NCOL,KW,KW)
C
      DO 65 J=1,NJN
         J1 = 3*J - 2
      65 CALL EULEP (FJ(J,J),T(J1,J1),KW)
         CALL ETABA (S,T,NCOL,NCOL,KW,KW)
C
      IF (NAMEK .eq. '6H') GO TO 20
         IF (NUTKY .le. 0) GC TO 999
            WRITE (NUTKX) NAMEK,NFL,NCOL,NCOL,NAMEL,(IBLNK,I=1,5),
            * (S(I,J),I=1,NCOL),J=1,NCOL), (IVII(I),I=1,NCOL)
      20 GO TO 20
C
999 CALL ZEROMP (6HGRAVY,NERROR)
END
SUBROUTINE KIA1 (A1,A2,RL,E,2,TS,KZ,KTS)
DIMENSION Z(2KTS,1), TS(KTS,1)

C
C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C STIFFNESS MATRIX,
C STRESS TRANSFORMATION MATRIX,
C FOR AN AXIAL ROD ELEMENT WITH UNRESTRAINED BOUNDARIES.
C ROD MAY BE LINEARLY TAPERED OR UNIFORM.
C CONSTANT FORCE ASSUMED.
C STIFFNESS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C STRESS TRANSFORMATION MATRIX RELATES STRESS AT ROD ENDS IN LOCAL
C COORDINATE SYSTEM TO DEFLECTIONS IN LOCAL COORDINATE SYSTEM.
C ROW ORDER IN STRESS TRANSFORMATION MATRIX IS
C SIGMA-X1, SIGMA-X2
C WHERE SIGMA 1 IS NORMAL STRESS.
C SX1(-), SX2(*) IS TENSION. SX1(+), SX2(-) IS COMPRESSION.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE ROD TO LIE ALONG THE X AXIS
C WITH JOINT 1 AT THE ORIGIN, JOINT 2 ALONG THE POSITIVE X AXIS.
C LOCAL COORDINATE ORDER IS
C DX1,DX2
C WHERE DX IS TRANSLATION.
C DEVELEPED BY RL WOHLEN. SEPTEMBER 1972.
C LAST REVISION BY RL WOHLEN. SEPTEMBER 1973.
C
C SUBROUTINE ARGUMENTS
A1 = INPUT CROSS-SECTION AREA AT ROD END 1.
A2 = INPUT CROSS-SECTION AREA AT ROD END 2.
RL = INPUT ROD LENGTH.
E = INPUT YOUNG'S MODULUS OF ELASTICITY.
Z = OUTPUT STIFFNESS MATRIX. SIZE(2,2).
TS = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(2,2).
KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=2.
KTS = INPUT ROW DIMENSION OF TS IN CALLING PROGRAM. MIN=2.
C
S = A1*E/RL
R = A2/A1
IF (AMSL(R-1.)*GT. .01) S = (A2-A1)*E / (RL*ALOG(R))

C STIFFNESS MATRIX.
Z(1,1) = S
Z(1,2) = -S
Z(2,1) = -S
Z(2,2) = S

C STRESS TRANSFORMATION MATRIX.
TS(1,1) = Z(1,1)/A1
TS(1,2) = Z(1,2)/A1
TS(2,1) = Z(2,1)/A2
TS(2,2) = Z(2,2)/A2

C RETURN
END
SUBROUTINE KIP1 (B11, B12, C1, C2, A1, A2, SF, RL, E, G, Z, TS, K2, KTS)
DIMENSION ZI(K2,1), TS(KTS,1)
DATA EPS/1.0E-15/

C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C STIFFNESS MATRIX,
C STRESS TRANSFORMATION MATRIX,
C FOR A BENDING (PLUS SHEAR) BEAM ELEMENT WITH UNRESTRAINED BOUNDARIES.
C BEAM MAY BE LINEARLY TAPERED OR UNIFORM.
C UNIFORM SHEAR AND LINEAR BENDING MOMENT VARIATION IS ASSUMED.
C SHEAR STIFFNESS USES SF*A1*G AND SF*A2*E. IF ANY OF THESE VARIABLES
C ARE ZERO, THERE IS NO SHEAR DEFORMATION IN BENDING.
C STIFFNESS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C STRESS TRANSFORMATION MATRIX RELATES STRESS AT BEAM ENDS IN LOCAL
C COORDINATE SYSTEM TO DEFLECTIONS IN LOCAL COORDINATE SYSTEM.
C ROW ORDER IN STRESS TRANSFORMATION MATRIX IS
C TAU-X1, TAU-X2, SIGMA-X1, SIGMA-X2
C WHERE SIGMA IS NORMAL STRESS (ML/I) AND TAU IS SHEAR STRESS (P/A).
C THE LOCAL COORDINATE SYSTEM ASSUMES THE BEAM TO LIE IN THE X-Z PLANE
C WITH JOINT 1 AT THE ORIGIN, JOINT 2 ALONG THE POSITIVE X AXIS.
C LOCAL COORDINATE ORDER IS
C D21, D22, TY1, TY2
C WHERE DZ IS TRANSLATION AND TY IS ROTATION.
C LAST REVISION BY RL WOHLEN. APRIL 1976.

C SUBROUTINE ARGUMENTS
C B11 = INPUT CROSS-SECTION AREA MOMENT OF INERTIA AT BEAM END 1.
C B12 = INPUT SAME AS B11 AT BEAM END 2.
C C1 = INPUT DISTANCE FROM BENDING NEUTRAL AXIS TO OUTER FIBER
C AT BEAM END 1.
C C2 = INPUT SAME AS C1 AT BEAM END 2.
C A1 = INPUT CROSS-SECTION AREA AT BEAM END 1. CAN BE ZERO FOR NO
C SHEAR DEFORMATION IN BENDING. SHEAR STRESS IN STRESS
C TRANSFORMATION WILL BE SET TO ZERO.
C A2 = INPUT SAME AS A1 AT BEAM END 2.
C SF = INPUT SHAPE FACTOR (K) FOR SHEAR IN KAG.
C USE SF=0.0 FOR NO SHEAR DEFORMATION IN BENDING.
C SF=1.0 FOR A SOLID CIRCULAR CYLINDER.
C SF=0.5 FOR A THIN WALLED CIRCULAR CYLINDER.
C RL = INPUT ROD LENGTH.
C E = INPUT YOUNG'S MODULUS OF ELASTICITY.
C G = INPUT SHEAR MODULUS OF ELASTICITY. CAN BE ZERO FOR NO SHEAR
C DEFORMATION IN BENDING.
C Z = OUTPUT STIFFNESS MATRIX. SIZE(4,4).
C TS = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(4,4).
C K2 = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=4.
C KTS = INPUT ROW DIMENSION OF TS IN CALLING PROGRAM. MIN=4.
C
C BENDING FLEXIBILITY.
C RPI = F12/F11
REIM1 = RPI-1.
IF (ARCTAN(REIM1)*LT. 0.01) GO TO 15
ERR = F11*RPI*P*IM1
REILN = ALOG(RPI)
F11 = (.5 - 1./REIM1 + REILN/REIM1**2) * (RL**3) / EBR
F12 = (1. - REILN/REIM1) * (RL**2) / EBR
F22 = RL* REILN / EER
GO TO 20
15 F11 = RL**3 / (3.*E*EII)
   F12 = RL**2 / (2.*E*EII)
   F22 = RL / (E*EII)
C SHEAR FLEXIBILITY.
20 IF (SF*LT_EPS .OR. A1*LT_EPS .OR. A2*LT_EPS .OR. G*LT_EPS)GO TO 30
   RA = A2/A1
   IF (ABS(RA-1.)*LT_ .01) GO TO 25
   F11 = F11 + RL * ALOG(RA) / (SF*G*(A2-A1))
   GO TO 30
C
C BENDING + SHEAR STIFFNESS MATRIX.
30 D = F11*F22 - F12**2
   Z(1,1) = F22/D
   Z(1,2) =-Z(1,1)
   Z(1,3) =-F12/D
   Z(1,4) = (-RL*F22 + F12)/D
   Z(2,1) = Z(1,1)
   Z(2,2) = Z(1,3)
   Z(2,3) = Z(2,4)
   Z(3,4) = F11/D
   Z(3,4) = (RL*F12 - F11)/D
   Z(4,4) = (F22*RL**2 - 2.*RL*F12 + F11)/D
C SYMMETRIZE LOWER HALF.
   DO 40 J=1,4
   DO 40 I=J,4
40   Z(I,J) = Z(J,I)
C
C STRESS TRANSFORMATION MATRIX.
   DO 55 J=1,4
   T5(1,J) = 0.*0
   T5(2,J) = 0.*0
   IF (A1 .GT. .0) T5(1,J) = Z(1,J)/A1
   IF (A2 .GT. .0) T5(2,J) = Z(2,J)/A2
   T5(3,J) = Z(3,J)*C1/B11
55   T5(4,J) = Z(4,J)*C2/E12
C
RETURN
END
SUBROUTINE KIC1 (TJ1, TJ2, R1, R2, RL, G, Z, TS, K2, KTS)
DIMENSION Z(K2,1), TS(KTS,1)
C
C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C STIFFNESS MATRIX,
C STRESS TRANSFORMATION MATRIX,
C FOR A TORSION ROD ELEMENT WITH UNRESTRAINED BOUNDARIES.
C ROD MAY BE LINEARLY TAPERED OR UNIFORM.
C CONSTANT TORQUE ASSUMED.
C STIFFNESS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C STRESS TRANSFORMATION MATRIX RELATES STRESS AT ROD ENDS IN LOCAL
C COORDINATE SYSTEM TO ROTATIONS IN LOCAL COORDINATE SYSTEM.
C ROW ORDER IN STRESS TRANSFORMATION MATRIX IS
C TAU-X1, TAU-X2
C WHERE TAU IS SHEAR STRESS.
C STRESS IS + OR - AS RIGHT HAND AXIS BETWEEN END JOINTS 1 AND 2.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE ROD TO LIE ALONG THE X AXIS
C WITH JOINT 1 AT THE ORIGIN, JOINT 2 ALONG THE POSITIVE X AXIS.
C LOCAL COORDINATE ORDER IS
C TX1, TX2
C WHERE TX IS ROTATION.
C DEVELOPED BY RL WOHLLEN. FEBRUARY 1973.
C
C SUBROUTINE ARGUMENTS
C TJ1 = INPUT CROSS-SECTION SAINT VENANTS TORSION CONSTANT (J) IN JG
C AT ROD END 1. E.G., TJ1=.5*PI*PI**4 FOR A SOLID CIRCULAR
C CYLINDER. TJ1=2.*PI*T*R1**3 FOR A THIN WALLED CIRCULAR
C CYLINDER.
C TJ2 = INPUT CROSS-SECTION SAINT VENANTS TORSION CONSTANT (J) IN JG
C AT ROD END 2.
C R1 = INPUT DISTANCE FROM TORSION AXIS TO OUTER FIBER AT ROD END 1.
C R2 = INPUT DISTANCE FROM TORSION AXIS TO OUTER FIBER AT ROD END 2.
C RL = INPUT ROD LENGTH.
C G = INPUT SHEAR MODULUS OF ELASTICITY.
C Z = OUTPUT STIFFNESS MATRIX. SIZE(2,2).
C TS = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(2,2).
C K2 = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=2.
C KTS = INPUT ROW DIMENSION OF TS IN CALLING PROGRAM. MIN=2.
C
S = TJ1*G/RL
R = TJ2/TJ1
IF (ABS(R-1.) .GT. .01) S = (TJ2-TJ1)*G / (RL*ALOG(R))
C
STIFFNESS MATRIX.
Z(1,1) = S
Z(1,2) = -S
Z(2,1) = -S
Z(2,2) = S
C
STRESS TRANSFORMATION MATRIX.
TS(1,1) = Z(1,1)*R1/TJ1
TS(1,2) = Z(1,2)*R1/TJ1
TS(2,1) = Z(2,1)*R2/TJ2
TS(2,2) = Z(2,2)*R2/TJ2
C
RETURN
END

KICI -- 2/2
DIMENSION Z(KZ, 1), T(KT, 1), R(KR, 1)
DIMENSION XE(3), ET(3)

C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C STIFFNESS MATRIX,
C STRESS TRANSFORMATION MATRIX,
C FOR A MEMBRANE TRIANGLE PLATE ELEMENT WITH UNRESTRAINED BOUNDARIES.
C QUADRATIC DISPLACEMENT (LINEAR STRAIN) FIELD IS USED.
C STIFFNESS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C STRESS TRANSFORMATION MATRIX RELATES STRESS AT TRIANGLE VERTICES
C IN LOCAL COORDINATE SYSTEM TO DEFLECTIONS IN THE LOCAL SYSTEM.
C ROW ORDER IN STRESS TRANSFORMATION MATRIX IS
C (SIGMA-X, SIGMA-Y, TAU-XY) JOINT 1, THEN JOINT 2, 3.
C WHERE SIGMA IS NORMAL STRESS AND TAU IS SHEAR STRESS.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE PLATE TO LIE IN AN X-Y PLANE
C WITH JOINT 1 AT THE X-Y ORIGIN, JOINT 2 LIES ALONG THE POSITIVE
C X AXIS, AND JOINT 3 IS IN THE POSITIVE Y DIRECTION.
C LOCAL COORDINATE ORDER IS
C (DX, DY, TZ) JOINT 1, THEN JOINT 2, 3.
C WHERE DX, DY ARE TRANSLATION AND TZ IS ROTATION.
C CALLS F5PFA SUBROUTINES ETAEA AND MLTA.
C DEVELOPED BY CS EDDELEY, WA BEENFIELD, MARCH 1973.
C LAST REVISION BY CS EDDELEY, SEPTEMBER 1973.

C SUBROUTINE ARGUMENTS
C X2 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 2.
C X3 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 3.
C Y3 = INPUT LOCAL Y COORDINATE LOCATION OF JOINT 3.
C TH = INPUT PLATE THICKNESS.
C E = INPUT YOUNG'S MODULUS OF ELASTICITY.
C ANU = INPUT POISSON'S RATIO. (E/2G)-1.
C Z = OUTPUT STIFFNESS MATRIX. SIZE(9, 9).
C T = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(9, 9).
C R = OUTPUT MATRIX WORK SPACE. SIZE(8, 9).
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=9.
C KT = INPUT ROW DIMENSION OF T IN CALLING PROGRAM. MIN=9.
C KR = INPUT ROW DIMENSION OF R IN CALLING PROGRAM. MIN=8.

DO 5 I=1, 9
DO 5 J=1, 9
5 T(I, J) = 0.0
DO 10 I=1, 9
DO 10 J=1, 9
10 Z(I, J) = 0.0
IF (TH .LT. 0.0) RETURN
X22 = X2*X2
Y32 = Y3*Y3
X2Y3 = X2*Y3
SE1 = X3/X2
G = E/(2.* + 2.*ANU)
DD = F*TH/(1. - ANU**2)
DNU = DD*ANU
DG = G*TH
DO 15 I=1,8
DC 15 J=1,9
15 R(I,J) = 0.
C
F00 = X2Y3/2.
F10 = X2Y3*(1. + SE1)/6.
F01 = X2Y3/6.
F20 = X2Y3*(1. + SE1 + SE1**2)/12.
F11 = X2Y3*(1. + 2.*SE1)/24.
F02 = X2Y3/12.
C
Z(1,1) = DG*F00/X22
Z(1,3) = DD*F01/X22
Z(1,6) = DNU*F00/X2Y3
Z(1,8) = DNU*F10/X2Y3
Z(2,2) = DG*F00/Y32
Z(2,3) = DG*F10/Y32
Z(2,4) = 2.*DG*F01/Y32
Z(2,5) = DG*F00/X2Y3
Z(2,7) = 2.*DG*F10/X2Y3
Z(2,8) = DG*F01/X2Y3
Z(3,3) = DD*F02/X22 + DG*F20/Y32
Z(3,4) = 2.*DG*F11/Y32
Z(3,5) = DG*F10/X2Y3
Z(3,6) = DNU*F01/X2Y3
Z(3,7) = 2.*DG*F20/X2Y3
Z(3,8) = DNU*F11/X2Y3 + DG*F11/X2Y3
Z(4,4) = 4.*DG*F02/Y32
Z(4,5) = 2.*DG*F01/X2Y3
Z(4,7) = 4.*DG*F11/X2Y3
Z(4,8) = 2.*DG*F02/X2Y3
Z(5,5) = DG*F00/X22
Z(5,7) = 2.*DG*F10/X22
Z(5,8) = DG*F01/X22
Z(6,6) = DD*F00/Y32
Z(6,8) = DD*F10/Y32
Z(7,7) = 4.*DG*F20/X22
Z(7,8) = 2.*DG*F11/X22
Z(8,8) = DD*F20/Y32 + DG*F02/X22
DC 20 I=1,8
DC 20 J=I,8
20 Z(I,J) = Z(I,J)
C
R(1,1) = -1.
R(1,..) = 1.*
R(2,1) = SF1 - 1.*
F(2,3) = -Y3
R(2,4) = -SF1
R(2,7) = 1.*
R(2,9) = Y3
R(3,3) = Y2
R(3,6) = -Y3
R(4,3) = Y3*(1. - S11)
R(4,6) = Y3*SF1
R(4,9) = -Y3
\( R(5,2) = -1 \cdot \)
\( R(5,3) = X2 \)
\( R(5,5) = 1 \cdot \)
\( R(5,6) = -X2 \)
\( R(6,2) = SE1 - 1 \cdot \)
\( R(6,5) = -SE1 \)
\( R(6,6) = X3 \)
\( R(6,8) = 1 \cdot \)
\( R(6,9) = -X3 \)
\( R(7,3) = -X2 \)
\( R(7,6) = X2 \)
\( P(8,3) = X2*(SE1 - 1) \cdot \)
\( R(8,6) = -X3 \)
\( R(8,9) = X2 \)

C

CALL BDATA (Z,R,E9,KZ,KR)

C

D71 = DC/TH
D12 = ANY*D71
D33 = 6
XE(1) = 0.
XE(2) = 1.
XE(3) = SE1
ET(1) = 0.
ET(2) = 0.
ET(3) = 1.
DC 20 I = 1,3
K1 = 3*I - 2
K2 = K1 + 1
K3 = K1 + 2
T(K1,1) = D11/X2
T(K1,5) = D11*ET(1)/X2
T(K1,6) = D12/Y3
T(K1,6) = D12*XE(1)/Y3
T(K2,1) = D12*/X2
T(K2,3) = D12*ET(1)/X2
T(K2,6) = D11/Y3
T(K2,8) = D11*XE(1)/Y3
T(K3,2) = D33/Y2
T(K3,3) = D33*XE(1)/Y3
T(K3,4) = 2.*D33*ET(1)/Y3
T(K3,5) = D33/X2
T(K3,7) = 2.*D33*XE(1)/X2
50 T(K3,9) = 2.*ET(1)/X2
CALL MULT. (T,R,E9,E9,KT,KR)

C

RETURN
END
SUBROUTINE K2E (X2, X3, Y3, TH, E, ANU, Z, TS, T, KZ, KTS, KT)
DIMENSION Z(KZ), TS(KTS), T(KT)
DIMENSION R(10, 10), IVEC(10), CCEF(9), XE(3), ET(3)

C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C STIFFNESS MATRIX,
C STRESS TRANSFORMATION MATRIX,
C FOR A FENDING TRIANGLE PLATE ELEMENT WITH UNPRESERVED BOUNDARIES.
C CUBIC DISPLACEMENT (LINEAR CURVATURE) FIELD IS USED.
C STIFFNESS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C STRESS TRANSFORMATION MATRIX RELATES STRESS AT JOINTS IN LOCAL
C COORDINATE SYSTEM TO DEFLECTIONS IN THE LOCAL SYSTEM.
C NEW ORDER IN STRESS TRANSFORMATION MATRIX IS
C (SIGMA-X, SIGMA-Y, TAU-XY) FOR (Z-TH/2) AT JOINT 1, THEN JOINT 2, 3,
C (SIGMA-X, SIGMA-Y, TAU-XY) FOR (Z-TH/2) AT JOINT 1, THEN JOINT 2, 3.
WHERE SIGMA IS NORMAL STRESS AND TAU IS SHEAR STRESS.
THE LOCAL COORDINATE SYSTEM ASSUMES THE PLATE TO LIE IN AN X-Y PLANE
WITH JOINT 1 AT THE X-Y ORIGIN, JOINT 2 LIES ALONG THE POSITIVE
X AXIS, AND JOINT 3 IS IN THE POSITIVE Y DIRECTION.
LOCAL COORDINATE ORDER IS
(Z2, X, Y) JOINT 1, THEN JOINT 2, 3.
WHERE Z2 IS TRANSLATION AND TX, TY ARE ROTATIONS.
CALLS FORMA SUBROUTINES TRAC AND MULT.
DEVELOPED BY CS EODLEY, MARCH 1973.
LAST PREFERENCE BY CS EODLEY, SEPTEMBER 1973.

C SUBROUTINE ARGUMENTS
C X2 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 2.
C X3 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 3.
C Y3 = INPUT LOCAL Y COORDINATE LOCATION OF JOINT 3.
C TH = INPUT PLATE THICKNESS.
C E = INPUT YOUNG'S MODULUS OF ELASTICITY.
C ANU = INPUT POISSON RATIO. (E/2G)-1.
C Z = OUTPUT STIFFNESS MATRIX. SIZE(9, 9).
C TS = OUTPUT LOCAL STRESS TRANSFORMATION MATRIX SIZE(18, 9).
C T = OUTPUT MATRIX WORK SPACE. SIZE(10, 10).
C KZ = INPUT FLOW DIMENSION OF 2 IN CALLING PROGRAM. MIN=9.
C KTS = INPUT FLOW DIMENSION OF 5 IN CALLING PROGRAM. MIN=18.
C KT = INPUT FLOW DIMENSION OF T IN CALLING PROGRAM. MIN=10.

DO 10 I=1, 10
P 10 J=1, 10
10 Z(I, J) = 0.0
DO 11 I=1, 10
11 J=1, 10
11 TS(I, J) = 0.0
12 IF (TH < 0.0) THEN
12 X2 = X2*X2
Y24 = Y24*Y24
Y32 = Y32*Y32
Y34 = Y34*Y34
SE1 = X2/X2
SE2 = SE1*SE1
SE3 = SE2*SE1
SE4 = SE3*SE1
S = (1. + SE1)/3.
SEC1 = SEC1**2
SEC2 = SEC1**3
G = E/(2. + 2.*ANU)
DD = (E+1)**3/(12.*(1.+ANU**2))
DNU = DD/ANU
DG = (G+T)**3/12.
AL = DD/Y3
BE = DNU/(Y22+Y32)
GA = D/Y34
DE = 4.*DG/(X22+Y32)

C

T(1,1) = 1.
T(2,2) = 1.
T(3,3) = 1.
T(4,4) = 1.
T(4,2) = 1.
T(4,7) = 1.
T(5,3) = 1.
T(5,5) = 1.
T(6,8) = 1.
T(6,2) = 1.
T(6,5) = 2.
T(6,7) = 3.
T(7,1) = 1.
T(7,2) = SE1
T(7,3) = 1.
T(7,4) = SE2
T(7,5) = SE1
T(7,6) = 1.
T(7,7) = SE3
T(7,8) = SE2
T(7,9) = SE1
T(7,10) = 1.
T(8,1) = 1.
T(8,2) = SE1
T(8,3) = 2.
T(9,8) = SE2
T(8,9) = 2.*SE1
T(9,10) = 0.
T(9,2) = 1.
T(9,4) = 2.*SE1
T(9,5) = 1.
T(9,7) = 2.*SE2
T(9,6) = 2.*SE1
T(9,9) = 1.
T(10,1) = 1.
T(10,2) = SE1
T(10,3) = 1./C.
T(10,4) = SE2
T(10,5) = SEC1/3
T(10,6) = 1./9.*
T(10,7) = SEC2
T(16,8) = SEC2/3.
T(16,9) = SEC1/9.
T(16,10) = 1.*/27.*

C
DO 5 I=1,10
DO 7 J=1,10
5 R(I,J) = 0.
7 R(I,1) = 1.

C
DC 160 L=1,10
JEIG = 1
A1 = ABS(T(L,1))
DC 15 J=2,10
A2 = ABS(T(L,J))
IF (A2 .LT. A1) GO TO 15
A1 = A2
JEIG = J
15 CONTINUE
IVEC(L) = JEIG
ALJIG = T(L,JEIG)
DC 17 J=1,10
T(L,J) = T(L,J)/ALJIG
17 R(L,J) = F(L,J)/ALJIG
DC 25 I=1,10
AIJEIG = T(I,JEIG)
IF ("*",EC,L) GO TO 25
DC 35 J=1,10
T(I,J) = T(I,J) - AIJEIG*T(L,J)
30 R(I,J) = F(I,J) - AIJEIG*R(L,J)
25 CONTINUE
100 CONTINUE

C
DC 40 I=1,10
IP = IVEC(I)
DC 40 J=1,10
40 T(IF,J) = R(I,J)
DC 50 I=1,10
DC 50 J=1,10
50 R(I,J) = T(I,J)

C
DC 26 I=1,10
R(I,2) = Y2*(1,2)
R(I,3) = -Y2*(1,2)
R(I,5) = Y2*X(I,5)
R(I,6) = -X2*(1,6)
R(I,8) = Y2*X(I,8)
20 R(I,9) = -X2*X(I,9)

C
COEF(1) = 1./*2.
COEF(2) = 2*/1.
COEF(3) = -(X2+X2)/1E.
COEF(4) = 1./*3.
CCOF(5) = Y3/18.
CCOF(6) = (2*X2 - X3)/18.
CCOF(7) = 1./2.
CCOF(9) = (2*X3 - X2)/18.
DO 60 I=1,10
DO 60 J=1,9
80 R(I,J) = R(I,J) + R(I,10)*CCOF(J).
C
DC 55 I=1,10
DO 55 J=1,10
55 T(I,J) = 0.
C
F00 = X2*Y3/2.
F10 = X2*Y3*(1. + SE1)/6.
F01 = X2*Y3/6.
F20 = X2*Y3*(1. + SE1 + SE2)/12.
F11 = X2*Y3*(1. + 2.*SE1)/24.
F02 = X2*Y3/12.
C
T(4,4) = 4.*AL*FO0
T(4,6) = 4.*EE*F00
T(4,7) = 12.*AL*F10
T(4,8) = 4.*AL*F01
T(4,9) = 4.*EE*F10
T(4,10) = 12.*EE*F01
T(5,5) = DE*F00
T(5,6) = 2.*DE*F10
T(5,7) = 2.*DE*F01
T(6,6) = 4.*GA*F00
T(6,7) = 12.*EE*F10
T(6,8) = 4.*EE*F01
T(6,9) = 4.*GA*F10
T(6,10) = 12.*GA*F01
T(7,7) = 36.*AL*F20
T(7,8) = 12.*AL*F11
T(7,9) = 12.*EE*F20
T(7,10) = 36.*EE*F11
T(8,8) = 4.*AL*F02 + 4.*DE*F02
T(8,9) = 4.*EE*F11 + 4.*DE*F11
T(8,10) = 12.*EE*F02
T(9,9) = 4.*GA*F20 + 4.*DE*F02
T(9,10) = 12.*GA*F11
T(10,10) = 36.*GA*F02
C
DC 60 I=1,10
DC 60 J=1,10
60 T(J,I) = T(I,J)
CALL ETAFA (T,1,10,9,KT,10)
DC 85 I=1,6
DC 85 J=1,6
85 Z(I,J) = T(I,J)
C
DC 73 I=1,9
DC 73 J=1,10
73 T(I,J) = 0
D11 = -6.*OO/((X2*Y3)**2)
D21 = ANU*D11
D22 = -6.*OO/((Y3*TH)**2)
D12 = ANU*D22
D33 = -12.*OO/((X2*Y3)*TH**2)
XE(1) = C
XE(2) = 1
XE(3) = XE1
ET(1) = 0
ET(2) = 0
ET(3) = 1
DO 75 I=1,3
K1 = 3*I - 2
K2 = K1 + 1
K3 = K1 + 2
DK1 = D11
DK2 = D12
DK3 = D12*XE(I)
DK5 = 6.*D11*ET(I)
DK6 = 2.*D12*XE(I)
DK7 = 6.*D11*ET(I)
DK8 = 2.*D12*XE(I)
DK9 = 6.*D12*ET(I)
DK10 = 2.*D21
DK11 = D21
DK12 = D22
DK13 = D22*XE(I)
DK14 = 2.*D21*ET(I)
DK15 = 2.*D22*XE(I)
DK16 = 2.*D22*ET(I)
DK17 = D33
DK18 = 2.*D33*XE(I)
75 DK3 = 2.*D33*ET(I)
CALL MULTI((T,K,5,10,0,KT,16))
DO 77 I=1,9
IP9 = I + 0
DO 77 J=1,9
77 T(I,J) = T(I,J)
C
RETURN
END
SUBROUTINE K3C1 (X3,Y3,Th,G,Z,T,KZ,KT)
DIMENSION Z(KZ,1), T(KT,1)

C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C STIFFNESS MATRIX,
C STRESS TRANSFORMATION MATRIX,
C FOR A RECTANGULAR SHEAR PANEL ELEMENT WITH UNRESTRAINED BOUNDARIES.
C LINEAR DISPLACEMENT (CONSTANT STRAIN) FIELD IS USED.
C STIFFNESS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C STRESS TRANSFORMATION MATRIX RELATES PANEL SHEAR STRESS (CONSTANT)
C IN LOCAL COORDINATE SYSTEM TO DEFLECTIONS IN THE LOCAL SYSTEM.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE PANEL TO LIE IN AN X-Y PLANE
C WITH JOINT 1 AT THE X-Y ORIGIN, JOINT 2 LIES ALONG THE POSITIVE
C X AXIS, JOINT 3 IS IN THE POSITIVE X,Y DIRECTION, AND JOINT 4 LIES
C ALONG THE POSITIVE Y AXIS.
C LOCAL COORDINATE ORDER IS
C DX1,DX2,DX3,DY4, DY1,DY2,DY3,DY4
C WHERE DX, DY ARE TRANSLATIONS.
C DEVELOPED BY RL WOHLER. APRIL 1974.
C
C SUBROUTINE ARGUMENTS
C X3 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 3.
C Y3 = INPUT LOCAL Y COORDINATE LOCATION OF JOINT 3.
C Th = INPUT PANEL THICKNESS.
C G = INPUT SHEAR MODULUS OF ELASTICITY.
C Z = OUTPUT STIFFNESS MATRIX. SIZE(8,8).
C T = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(8,8).
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=8.
C KT = INPUT ROW DIMENSION OF T IN CALLING PROGRAM. MIN=1.
C
C STIFFNESS MATRIX.
C = Th*G/4.
A = G*X3/Y3
B = G*Y3/X3
Z(1,1) = A
Z(1,2) = A
Z(1,3) = -A
Z(1,4) = -A
Z(1,5) = C
Z(1,6) = -C
Z(1,7) = -C
Z(1,8) = C
Z(2,1) = A
Z(2,3) = -A
Z(2,4) = -A
Z(2,5) = C
Z(2,6) = -C
Z(2,7) = -C
Z(2,8) = C
Z(3,5) = A
Z(3,4) = -A
Z(3,5) = -C
Z(3,6) = C
Z(3,7) = C
Z(3,8) = -C

K3C1 -- 1/2
Z(4,4) = A
Z(4,5) = C
Z(4,6) = C
Z(4,7) = C
Z(4,8) = -C
Z(5,5) = F
Z(5,6) = -F
Z(5,7) = -F
Z(5,8) = B
Z(6,6) = B
Z(6,7) = B
Z(6,8) = B
Z(7,7) = B
Z(7,8) = F
Z(8,8) = F

C. SYMMETRIZE LOWER HALF.
   DO 10 J=1,8
   DC 10 I=J,F
10   Z(I,J) = Z(J,I)
C
C STRESS TRANSFORMATION MATRIX.
   DO 20 J=1,6
20   T(I,J) = 2.*Z(3,J)/(TH*X3)
C
RETURN
FND
SUBROUTINE KGRAV (CJ, JM, EV, A, W, KW, KCJ)
DIMENSION CJ(KCJ), JM(JM), EV(EV), W(KW, 1)
DIMENSION E(3, 4), R12(3), R13(3), VN(3), F(3, 3)
DATA KEF / 3 /
C
C SUBROUTINE TO DERIVE STIFFNESS MATRIX FOR A TRIANGULAR GRAVITY ELEMENT.
C CALLS FORMA SUBROUTINES MULTA, MULTB, VCROSS.
C DEVELOPED BY C S EDDLEY, FEBRUARY 1974.
C LAST REVISION BY C S EDDLEY, NOVEMBER 1974.
C
SUBROUTINE ARGUMENTS
C
C CJ = INPUT MATRIX OF JOINT COORDINATES. SIZE (3, 4).
C JM = INPUT VECTOR OF JOINTS DEFINING A TRIANGLE. SIZE (3).
C EV = INPUT VECTOR NORMALIZED GRAVITY. SIZE = 3.
C A = OUTPUT AREA.
C W = OUTPUT STIFFNESS MATRIX.
C KW = INPUT ROW DIMENSION SIZE OF W IN CALLING PROGRAM. MIN=9.
C KCJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM. MIN=3.
C
J1 = JM(1)
J2 = JM(2)
J3 = JM(3)
DO 5 I=1, 3
DO 5 J=1, 2
W(I, J) = 0.
5 E(J, I) = 0.
DO 7 I=1, 3
F12(I) = CJ(I, J2) - CJ(I, J1)
F13(I) = CJ(I, J3) - CJ(I, J1)
DO 8 J=1, 3
F(J, I) = 1.
7 F(I, I) = 2.
C
CALL VCROSS (F12, R13, VN, VAMAG, VEMAG, A, SINAB)
DO 10 I=1, 3
10 VN(I) = VN(I) / A
ACUM = 0.0
DO 15 I=1, 3
11 = 3 * I - 3
ACUM = ACUM + VN(I) * EV(I)
DO 15 J=1, 2
E(I, 11+J) = VN(J)
15 W(I1+J, I) = VN(I)
C
CALL MULTB (F, E, 3, 2, 0, KEF, KEF)
CALL MULTA (W, E, 3, 2, 0, KEF, KEF)
A = A * ACUM * ACUM * ACUM
C
RETURN
END
SUBROUTINE M1A1 (A1,A2,RL,RO,Z,KZ)
DIMENSION Z(KZ,1)

SUBROUTINE TO CALCULATE FINITE ELEMENT...
LUMPED MASS MATRIX
FOR AN AXIAL ROD ELEMENT WITH UNRESTRAINED BOUNDARIES.
ROD MAY BE LINFARLY TAPERED OR UNIFORM.
MASS MATRIX IS IN LOCAL COORDINATE SYSTEM.
The local coordinate system assumes the rod to lie along the x axis
with joint 1 at the origin, joint 2 along the positive x axis.
LOCAL COORDINATE ORDER IS
DX1,DX2
WHERE DX IS TRANSLATION.
LAST REVISION BY RL WOHLEN. SEPTEMBER 1973.

SUBROUTINE ARGUMENTS
A1 = INPUT CROSS-SECTION AREA AT ROD END 1.
A2 = INPUT CROSS-SECTION AREA AT ROD END 2.
RL = INPUT ROD LENGTH.
RO = INPUT MASS DENSITY.
Z = OUTPUT MASS MATRIX, SIZE(2,2).
KZ = INPUT FLOW DIMENSION OF Z IN CALLING PROGRAM, MIN=2.

W1 = A1*RL*RO/6.
W2 = A2*RL*RO/6.
Z(1,1) = 2*W1 + W2
Z(1,2) = 0.
Z(2,1) = 0.
Z(2,2) = W1 + 2*W2

RETURN
END
SUBROUTINE MIA2 (A1, A2, RL, RC, Z, KZ)
DIMENSION Z(KZ, 1)

SUBROUTINE TO CALCULATE FINITE ELEMENT...
CONSISTENT MASS MATRIX
FOR AN AXIAL ROD ELEMENT WITH UNRESTRAINED BOUNDARIES.
ROD MAY BE LINEARLY TAPERED OR UNIFORM.
LINEAR DISPLACEMENT FUNCTION ASSUMED.
MASS MATRIX IS IN LOCAL COORDINATE SYSTEM.
THE LOCAL COORDINATE SYSTEM ASSUMES THE ROD TO LIE ALONG THE X AXIS
WITH JOINT 1 AT THE ORIGIN, JOINT 2 ALONG THE POSITIVE X AXIS.
LOCAL COORDINATE ORDER IS
DX1, DX2
WHERE DX IS TRANSLATION.
DEVELOPED BY RL WOHLEN. SEPTEMBER 1972.
LAST REVISION BY RL WOHLEN. SEPTEMBER 1973.

SUBROUTINE ARGUMENTS
A1 = INPUT CROSS-SECTION AREA AT ROD END 1.
A2 = INPUT CROSS-SECTION AREA AT ROD END 2.
RL = INPUT ROD LENGTH.
RC = INPUT MASS DENSITY.
Z = OUTPUT MASS MATRIX. SIZE(2, 2).
KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=2.

W1 = A1*RL*RC/12.
W2 = A2*RL*RC/12.
Z(1,1) = 3.*W1 + W2
Z(1,2) = W1 + W2
Z(2,1) = Z(1,2)
Z(2,2) = W1 + 3.*W2

RETURN
END
SUBROUTINE M1P1 (A1,A2,RL,RO,Z,KZ)
DIMENSION Z(KZ,1)

C
C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C LUMPED MASS MATRIX
C FOR A BENDING BEAM ELEMENT WITH UNRESTRAINED BOUNDARIES.
C BEAM MAY BE LINEARLY TAPERED OR UNIFORM.
C MASS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE BEAM TO LIE IN THE X-Z PLANE
C WITH JOINT 1 AT THE ORIGIN, JOINT 2 ALONG THE POSITIVE X AXIS.
C LOCAL COORDINATE ORDER IS
C D21,D22,TY1,TY2
C WHERE D2 IS TRANSLATION AND TY IS ROTATION.
C LAST REVISION BY RL WCHLEN. SEPTEMBER 1975.
C
C SUBROUTINE ARGUMENTS
C A1 = INPUT CROSS-SECTION AREA AT BEAM END 1.
C A2 = INPUT CROSS-SECTION AREA AT BEAM END 2.
C RL = INPUT BEAM LENGTH.
C RO = INPUT MASS DENSITY.
C Z = OUTPUT MASS MATRIX. SIZE(4,4).
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=4.
C
C W1 = A1*RL*RO/6.
W2 = A2*RL*RO/6.
DO 10 J=1,4
DO 10 I=1,4
10 Z(I,J) = 0.*0
Z(1,1) = 2.*W1 + W2
Z(1,2) = W1 + 2.*W2

C RETURN
END
SUBROUTINE M182 (A1, A2, RL, KO, Z, KZ)
DIMENSION Z(KZ, 1)

C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C CONSISTENT MASS MATRIX
C FOR A BENDING BEAM ELEMENT WITH UNRESTRAINED BOUNDARIES.
C BEAM MAY BE LINEARLY TAPERED OR UNIFORM.
C CUBIC DISPLACEMENT FUNCTION ASSUMED.
C MASS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE BEAM TO LIE IN THE X-Z PLANE
C WITH JOINT 1 AT THE ORIGIN, JOINT 2 ALONG THE POSITIVE X AXIS.
C LOCAL COORDINATE ORDER IS
C D21, D22, TY1, TY2
C WHERE D2 IS TRANSLATION AND TY IS ROTATION.
C DEVELOPED BY RL WOHLLEN. FEBRUARY 1973.
C
C SUBROUTINE ARGUMENTS
C A1 = INPUT CROSS-SECTION AREA AT BEAM END 1.
C A2 = INPUT CROSS-SECTION AREA AT BEAM END 2.
C RL = INPUT BEAM LENGTH.
C KO = INPUT MASS DENSITY.
C Z = OUTPUT MASS MATRIX. SIZE(4, 4).
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=4.
C
W1 = A1*RL*KO/4.0
W2 = A2*RL*KO/4.0
RL2 = RL**2
Z(1,1) = 240.*W1 + 72.*W2
Z(1,2) = 54.*W1 + 54.*W2
Z(2,2) = 72.*W1 + 240.*W2
Z(1,3) = -30.*W1 + 14.*W2*RL
Z(1,4) = -14.*W1 + 12.*W2*RL
Z(2,3) = -12.*W1 + 14.*W2*RL
Z(2,4) = -14.*W1 + 30.*W2*RL
Z(3,3) = 5.*W1 + 3.*W2*RL2
Z(3,4) = 3.*W1 + 3.*W2*RL2
Z(4,4) = 3.*W1 + 5.*W2*RL2
DO 10 J=1, 4
   DO 10 I=J, 4
   10 Z(I, J) = Z(J, I)
C
RETURN
END
SUBROUTINE M1C1 (PI1, PI2, RL, RO, Z, KZ)

DIMENSION Z(KZ, 1)

SUBROUTINE TO CALCULATE FINITE ELEMENT...
LUMPED MASS MATRIX
FOR A TORSION ROD ELEMENT WITH UNRESTRAINED BOUNDARIES.
ROD MAY BE LINEARLY TAPERED OR UNIFORM.
MASS MATRIX IS IN LOCAL COORDINATE SYSTEM.
THE LOCAL COORDINATE SYSTEM ASSUMES THE ROD TO LIE ALONG THE X AXIS
WITH JOINT 1 AT THE ORIGIN, JOINT 2 ALONG THE POSITIVE X AXIS.
LOCAL COORDINATE ORDER IS
TX1, TX2
WHERE TX IS NOTATION.
LAST REVISION BY RL WOHLEN. SEPTEMBER 1973.

SUBROUTINE ARGUMENTS
PI1 = INPUT CROSS-SECTION POLAR AREA MOMENT OF INERTIA AT ROD END 1.
PI2 = INPUT CROSS-SECTION POLAR AREA MOMENT OF INERTIA AT ROD END 2.
RL = INPUT ROD LENGTH.
RO = INPUT MASS DENSITY.
Z = OUTPUT MASS MATRIX SIZE(2,2).
KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=2.

W1 = PI1*RL*RO/6.
W2 = PI2*RL*RO/6.
Z(1,1) = 2*W1 + W2
Z(1,2) = 0.
Z(2,1) = 0.
Z(2,2) = W1 + 2*W2

RETURN
END
SUBROUTINE MIC, (P11, P12, RL, RO, Z, KZ)
DIMENSION Z(KZ, 1)
C
C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C CONSISTENT MASS MATRIX
C FOR A TOPSISIION FLD ELEMENT WITH UNRESTRANDED BOUNDARIES.
C ROD MAY BE LINEARLY TAPEPPED OR UNIFORM.
C LINEAR DISPLACEMENT FUNCTION ASSUMED.
C MASS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE ROD TO LIE ALONG THE X AXIS
C WITH JOINT 1 AT THE ORIGIN, JOINT 2 ALONG THE POSITIVE X AXIS.
C LOCAL COORDINATE ORDER IS
C TX1, TX2
C WHERE TX IS ROTATION.
C LAST REVISION BY RL WOHLEN. SEPTEMBER 1973.
C
C SUBROUTINE ARGUMENTS
C P11 = INPUT CROSS-SECTION POLAR AREA MOMENT OF INERTIA AT ROD END 1.
C P12 = INPUT CROSS-SECTION POLAR AREA MOMENT OF INERTIA AT ROD END 2.
C RL = INPUT ROD LENGTH.
C RO = INPUT MASS DENSITY.
C Z = OUTPUT MASS MATRIX. SIZE(2,2).
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=2.

W1 = P11*RL/12.
W2 = P12*RL/12.
Z(1,1) = 3.*W1 + W2
Z(1,2) = W1 + W2
Z(2,1) = Z(1,2)
Z(2,2) = W1 + 3.*W2
C
RETURN
END
SUBROUTINE M2A1 (X2,Y3,TH,RC,Z,KZ)
DIMENSION Z(KZ,1)

C
C SUBROUTINE M2A1: CALCULATE FINITE ELEMENT...
C LUMPED MASS MAT.
C FOR A MEMBRANE TRIANGLE PLATE ELEMENT WITH UNRESTRAINED BOUNDARIES.
C MASS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE PLATE TO LIE IN AN X-Y PLANE
C WITH JOINT 1 AT THE Y-Y ORIGIN, JOINT 2 LIES ALONG THE POSITIVE
C X AXIS, AND JOINT 3 IS IN THE POSITIVE Y DIRECTION.
C LOCAL COORDINATE ORIGIN IS
C (EX,DY,TZ) JOINT 1, THEN JOINT 2, 3.
C WHERE EX, DY ARE TRANSLATIONS AND TZ IS ROTATION.
C DEVELOPED BY W.B. BENGFIELD, FEBRUARY 1972.
C
C SUBROUTINE ARGUMENTS
C X2 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 2.
C Y3 = INPUT LOCAL Y COORDINATE LOCATION OF JOINT 3.
C TH = INPUT PLATE THICKNESS.
C RC = INPUT MASS DENSITY.
C Z = OUTPUT MASS MATRIX SIZE(9,9).
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=9.
C
AREA = 0.5*X2*Y3
CM = (RC*TH*AREA)/3.0
DO 10 I=1,6
  DO 10 J=1,6
  10 Z(I,J) = CM
DO 20 I=1,6
  DO 20 J=1,6
    20 Z(I,J) = CM
RETURN
END
SUPERCUTIN M2A2 (X2,X3,Y3,TH,PHC,Z,T,R,K2,K1,KR)
DIMENSION 2(K2+1),T(K1+1),F(KR,1)

SUBROUTINE TO CALCULATE FINITE ELEMENT...

CONSISTENT MASS MATRIX,

FOR A MEMBRANE TRAPEZOIDAL PLATE ELEMENT WITH UNRESTRAINED BOUNDARIES.

QUADRATIC DISPLACEMENT (LINEAR STRAIN) FIELD IS USED.

MASS MATRIX IS IN LOCAL COORDINATE SYSTEM.

THE LOCAL COORDINATE SYSTEM assumes THE PLATE To LIE IN AN X-Y PLANE

WITH JOINT 1 AT THE X-Y ORIGIN, JOINT 2 LIES ALONG THE POSITIVE

X AXIS, AND JOINT 3 IS IN THE POSITIVE Y DIRECTION.

LOCAL COORDINATE ORDER IS

(iX,iY,iZ) JOINT 1, THEN JOINT 2, 3.

WHERE iX,iY ARE TRANSLATIONS AND iZ IS ROTATION.

CALLED FROM SUBROUTINES ETAL.

DEVELOPED BY CF EGGLETON. MARCH 1973.

LAST REVISION BY WA BENFIELD. SEPTEMBER 1973.

SUBROUTINE ARGUMENTS

X2 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 2.

X3 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 3.

Y3 = INPUT LOCAL Y COORDINATE LOCATION OF JOINT 3.

TH = INPUT PLATE THICKNESS.

PHC = INPUT MASS DENSITY.

Z = OUTPUT MASS MATRIX. SIZE(9,9).

T = OUTPUT MATRIX WORK SPACE. SIZE(10,10).

R = OUTPUT MATRIX WORK SPACE. SIZE(10,10).

K2 = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=9.

K1 = INPUT ROW DIMENSION OF T IN CALLING PROGRAM. MIN=10.

KR = INPUT ROW DIMENSION OF R IN CALLING PROGRAM. MIN=10.

SE1 = X2*X2

SE2 = SE1*SE1

SE3 = SE2*SE1

SE4 = SE3*SE1

X2*Y3 = X2*Y2*PHC*TH;

DO 10 I=1,10

DO 10 J=1,10

T(I,J) = 0.

10 R(I,J) = 0.

F00 = X2*Y2/2

F10 = X2*Y2*(1. + SE1/6.

F11 = X2*Y2/6.

F20 = X2*Y2*(1. + SE1 + SE2/12.

F11 = X2*Y2*(1. + 2.*SE1/24.

F20 = X2*Y2/12.


F12 = X2*Y2*(1. + 3.*SE1/60.

F22 = X2*Y2*(1. + 3.*SE1 + 6.*SE2/180.)
F13 = Y3*Y3*(1. + 4. * SE1)/120.
F04 = Y3*Y3/30.
T(1,1) = F00
T(1,2) = F10
T(1,3) = F61
T(1,4) = F11
T(1,5) = F02
T(2,2) = F20
T(2,3) = F11
T(2,4) = F21
T(2,5) = F12
T(3,2) = F02
T(3,4) = F12
T(3,5) = F65
T(4,4) = F22
T(4,5) = F30
T(5,5) = F64
T(6,5) = F10
T(6,7) = F10
T(6,8) = F61
T(6,9) = F26
T(6,10) = F11
T(7,7) = F26
T(7,8) = F11
T(7,9) = F26
T(7,10) = F21
T(9,8) = F22
T(8,9) = F21
T(8,10) = F12
T(9,9) = F46
T(10,10) = F21
DC 20 J=1,10
D0 30 J=1,10

30 T(J+1) = T(1,J)

C
F(1,1) = 1.
R(2,1) = -1.
P(3,1) = SF1 - 1.
\( k(3,3) = -Y3 \\
F(4,4) = -SE1 \\
P(5,7) = 1. \\
R(3,6) = Y3 \\
P(4,5) = Y3 \\
P(4,6) = -Y3 \\
R(5,3) = Y3*(1. - SE1) \\
P(5,6) = Y3*SE1 \\
R(5,9) = -Y3 \\
R(6,2) = 1. \\
P(7,2) = -1. \\
F(7,3) = Y2 \\
P(7,4) = 1. \\
P(7,6) = -Y2 \\
P(8,2) = SE1 - 1.
\[ \begin{align*}
F(\rho,5) &= -5\epsilon_1 \\
F(\rho,6) &= \chi_3 \\
F(\rho,8) &= 1. \\
F(2,\alpha) &= -\nu_2 \\
F(\alpha,3) &= -\nu_2 \\
F(\alpha,6) &= \nu_2 \\
F(10,\alpha) &= \nu_2(\epsilon_1 - 1.0) \\
F(1u,6) &= -\nu_3 \\
F(10,\alpha) &= \nu_2 \\
\end{align*} \]

\textbf{C}

\texttt{CALL PTAE (T,F,10,9,KT,KP)}

\texttt{DC 46 I=1.0}

\texttt{DC 46 J=1.0}

\texttt{40 Z(I,J) = T(I,J)}

\textbf{C}

\texttt{RETURN}

\texttt{END}
SUBROUTINE M281 (X2,Y3,TH,RO,Z,KZ)
DIMENSION Z(KZ,1)
C
SUBROUTINE TO CALCULATE FINITE ELEMENT...
C LUMPED MASS MATRIX.
C FOR A HANGING TRIANGLE PLATE ELEMENT WITH UNRESTRANDED BOUNDARIES.
C MASS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE PLATE LIES IN AN X-Y PLANE.
C WITH JOINT 1 AT THE X-Y ORIGIN, JOINT 2 LIES ALONG THE POSITIVE
C X AXIS, AND JOINT 3 IS IN THE POSITIVE Y DIRECTION.
C LOCAL COORDINATE ORDER IS
C (D2,TX,TY) JOINT 1, THEN JOINT 2, 3.
C WHERE D2 IS TRANSLATION AND TX,TY ARE ROTATIONS.
C
SUBROUTINE ARGUMENTS
C X2 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 2.
C Y3 = INPUT LOCAL Y COORDINATE LOCATION OF JOINT 3.
C TH = INPUT PLATE THICKNESS.
C RO = INPUT MASS DENSITY.
C Z = OUTPUT MASS MATRIX. SIZE(9,9).
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=9.
C
AREA = 0.5*X2*Y3
CM = (RO*TH*AREA)/3.0
DO 10 I=1,6
DO 10 J=1,6
10 Z(I,J) = 0.0
DO 20 I=1,6
20 Z(I,I) = CM
RETURN
END

SUGRECUTINE ARGUMENTS
Z2 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 2.
Z3 = INPUT LOCAL Y COORDINATE LOCATION OF JOINT 3.
Z4 = INPUT PLATE THICKNESS.
Z5 = INPUT MASS DENSITY.
Z6 = OUTPUT MASS MATRIX. SIZE(9,9).
Z7 = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=9.

CM = (Z5*TH*AREA)/3.0
DO 10 I=1,6
DO 10 J=1,6
10 Z(I,J) = 0.0
DO 20 I=1,6
20 Z(I,I) = CM
RETURN
END
DIMENSION 2(KZ,1),1(KT,1),K(KR,1)
DIMENSION IVEC(10),GCEF(19)

C C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C C CONSISTENT MASS MATRIX,
C FOR A BENDING TRIANGLE PLATE ELEMENT WITH UNRESTRAINED BOUNDARIES.
C CUBIC DISPLACEMENT (LINEAR CURVATURE) FIELD IS USED.
C THIS IS NOT THE SI' CALLED STRICKLAND ELEMENT.
C MASS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE PLATE TO LIE IN AN X-Y PLANE
C WITH JOINT 1 AT THE X-Y ORIGIN, JOINT 2 LIES ALONG THE POSITIVE
C X AXIS, AND JOINT 3 IS IN THE POSITIVE Y DIRECTION.
C LOCAL COORDINATE CHECK IS
C (OZ,TX,TY) JOINT 1, THEN JOINT 2, 3.
C WHERE OZ IS TRANSLATION AND TX,TY ARE ROTATIONS.
C CALLS FROM SUBROUTINES BTAEA.
C DEVELOPED BY CAFL POOLEY MARCH 1973.
C LAST REVISION BY WA BENFIELD. SEPTEMBER 1973.
C
C SUBROUTINE ARGUMENTS
C X2 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 2.
C Y3 = INPUT LOCAL Y COORDINATE LOCATION OF JOINT 3.
C TH = INPUT PLATE THICKNESS.
C FHO = INPUT MASS DENSITY.
C Z  = OUTPUT MASS MATRIX. SIZE(9,9).
C Y  = INPUT MATRIX WORK SPACE. SIZE(10,10).
C R  = INPUT MATRIX WORK SPACE. SIZE(10,10).
C K2 = INPUT NUMBER DIMENSION OF Z IN CALLING PROGRAM. MIN=9.
C KT = INPUT NUMBER DIMENSION OF T IN CALLING PROGRAM. MIN=10.
C KR = INPUT NUMBER DIMENSION OF R IN CALLING PROGRAM. MIN=10.
C
C S1 = X2/Y3
S2 = S1*SEC1
S3 = S1*S2
S4 = S3*S1
S5 = S4*S1
S6 = S5*S1
SEC1 = (1.0 + S1**3).
SEC2 = S1**2
SEC3 = SEC1**2

C 10 10 J=1,10
20 10 L=1,10
10 T(1,J) = 0.
C
T(1,1) = 1.
T(2,1) = 1.
T(3,1) = 1.
T(4,1) = 1.
T(4,2) = 1.
T(4,3) = 1.
T(4,4) = 1.
T(4,7) = 1.
T(5,3) = 1.
T(5,5) = 1
T(5,8) = 1
T(6,2) = 1
T(6,4) = 2
T(6,7) = 3
T(7,1) = 1
T(7,2) = SE1
T(7,3) = 1
T(7,4) = SE2
T(7,5) = SE1
T(7,6) = 1
T(7,7) = SE2
T(7,8) = SE2
T(7,9) = SE1
T(7,10) = 1
T(8,2) = 1
T(8,5) = SE1
T(8,6) = 2
T(8,8) = SE2
T(8,9) = 2*SE1
T(8,10) = 3
T(9,2) = 1
T(9,4) = 2*SE1
T(9,5) = 1
T(9,7) = 2*SE2
T(9,8) = 2*SE1
T(9,9) = 1
T(10,1) = 1
T(10,2) = SEC1
T(10,3) = 1/5
T(10,4) = SEC2
T(10,5) = SEC1/2
T(10,6) = 1/9
T(10,7) = SEC2
T(10,8) = SEC2/3
T(10,9) = SEC1/9
T(10,10) = 1/27

C  DO 5 I=1,10
DO 7 J=1,10
7 R(I,J) = 0.
5 R(I,I) = 1.

C  DO 100 L=1,16
  JRIG = 1
  A1 = AES(T(L,1))
  DO 15 J=2,16
  A2 = AES(T(L,J))
  IF (A2 .LT. A1) GO TO 15
  A1 = A2
  JRIG = J
15 CONTINUE
  IVFCT(L) = JRIG
  ALJREIG = T(L,JRIG)
  DC 17 J=1,10
T(L,J) = T(L,J)/AIJFIG
17 R(L,J) = R(L,J)/AIJBIG
DC 25 I=1,10
AIJFIG = T(I,J)/AIJFIG
IF (I .EQ. L) GC TC 25
DO 30 J=1,10
T(I,J) = T(I,J) - AIJBIG*T(L,J)
30 R(I,J) = R(I,J) - AIJBIG*R(L,J)
25 CONTINUE
100 CONTINUE
C
DO 40 I=1,10
IF = IVEC(I)
DC 40 J=1,10
40 T(R,J) = R(I,J)/C
DC 50 I=1,10
CO 50 J=1,10
50 R(I,J) = T(I,J)
C
DO 20 I=1,10
R(I,2) = Y3*P(I,2)
R(I,3) = -X2*F(I,3)
R(I,5) = Y3*P(I,5)
R(I,6) = -X2*R(I,6)
R(I,8) = Y3*F(I,8)
20 R(I,9) = -X2*F(I,9)
C
CCEF(1) = 1./3.
CCEF(2) = Y3/18.
CCEF(3) = -(X2+X3)/18.
CCEF(4) = 1./3.
CCEF(5) = Y3/18.
CCEF(6) = (2.*X2 - X3)/18.
CCEF(7) = 1./3.
CCEF(8) = -Y3/6.
CCEF(9) = (2.*X3 - X2)/18.
DO 60 I=1,10
DO 60 J=1,9
60 R(I,J) = R(I,J) + R(I,10)*CCEF(J)
C
DO 55 I=1,10
DC 55 J=1,10
55 T(I,J) = 0.
C
X2Y3 = Y2*Y3*TH*RHO
F10 = X2Y3/2.
F10 = X2Y3*(1. + SE1)/6.
F01 = X2Y3/6.
F20 = Y2*Y3*(1. + SE1 + SE2)/12.
F11 = X2Y3*(1. + 2.*SE1)/24.
F02 = X2Y3/12.
F20 = X2Y3*(1. + SE1 + SE2 + SE3)/20.
F21 = X2Y3*(1. + 2.*SE1 + 3.*SE2)/60.
F22 = X2Y3*(1. + 3.*SE1)/60.
FG = X2Y3/20.
F40 = X2Y3*(1. + SE1 + SE2 + SE3 + SE4)/30.
F31 = X2Y3*(1. + 2.*SE1 + 3.*SE2 + 4.*SE3)/120.
F22 = X2Y3*(1. + 3.*SE1 + 6.*SE2)/120.
F13 = X2Y3*(1. + 4.*SE1)/120.
F04 = X2Y3/30.
F05 = X2Y3*(1. + SE1 + SE2 + SE3 + SE4 + SE5)/42.
F32 = X2Y3*(1. + 3.*SE1 + 6.*SE2 + 10.*SE3)/420.
F23 = X2Y3*(1. + 4.*SE1 + 10.*SE2)/420.
F14 = X2Y3*(1. + 5.*SE1)/210.
F05 = X2Y3/42.
F60 = X2Y3*(1. + SE1 + SE2 + SE3 + SE4 + SE5 + SE6)/56.
F42 = X2Y3*(1.+3.*SE1+6.*SE2+10.*SE3+15.*SE4)/840.
F33 = X2Y3*(1.+4.*SE1+10.*SE2+20.*SE3)/1120.
F24 = X2Y3*(1.+5.*SE1+15.*SE2)/840.
F15 = X2Y3*(1.+6.*SE1)/336.
F06 = X2Y3/56.

T(1,1) = F00
T(1,2) = F10
T(1,3) = F01
T(1,4) = F20
T(1,5) = F11
T(1,6) = F02
T(1,7) = F30
T(1,8) = F21
T(1,9) = F12
T(1,10) = F03
T(2,2) = F20
T(2,3) = F11
T(2,4) = F20
T(2,5) = F21
T(2,6) = F12
T(2,7) = F40
T(2,8) = F51
T(2,9) = F22
T(2,10) = F13
T(3,3) = F02
T(3,4) = F21
T(3,5) = F12
T(3,6) = F03
T(3,7) = F31
T(3,8) = F22
T(3,9) = F13
T(3,10) = F04
T(4,4) = F40
T(4,5) = F31
T(4,6) = F22
T(4,7) = F60
T(4,8) = F41
T(4,9) = F32
T(4,10) = F23
T(5,5) = F22
T(5,6) = F13
C

DO 60 I=1,10
DO 60 J=1,10

60 T(J,1) = T(I,J)
       CALL RTARA(T,R,10,9,KT,KR)
       DO 85 I=1,9
       DO 85 J=1,9

85 Z(I,J) = T(I,J)

C
RETURN
END
C
SUBROUTINE M3C1 (X3,Y3,TH,RO,Z,KZ)
DIMENSION Z(2,KZ,1)
!
C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C LUMPED MASS MATRIX
C FOR A RECTANGULAR SHEET PANEL ELEMENT WITH UNRESTRAINED BOUNDARIES.
C MASS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE PANEL TO LIE IN AN X-Y PLANE.
C WITH JOINT 1 AT THE X-Y ORIGIN, JOINT 2 LIES ALONG THE POSITIVE
C X AXIS, JOINT 3 IS IN THE POSITIVE X,Y DIRECTION, AND JOINT 4 LIES
C ALONG THE POSITIVE Y AXIS.
C LOCAL COORDINATE ORDER IS
C   DX1,DX2,DY2,DY4, DY1,DY2,DY3,DY4
C WHERE DX, DY ARE TRANSLATIONS.
C DEVELOPED BY RL WOHLER. APRIL 1974.
C
C SUBROUTINE ARGUMENTS
C X3 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 3.
C Y3 = INPUT LOCAL Y COORDINATE LOCATION OF JOINT 3.
C TH = INPUT PANEL THICKNESS.
C RO = INPUT MASS DENSITY.
C Z = OUTPUT MASS MATRIX. SIZE(8,8).
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=8.
C
CM = RO*TH*X3*Y3/4
DO 10 J=1,8
   DO 10 I=1,8
      10 Z(I,J) = CM
DO 20 I=1,8
   20 Z(I,1) = CM
!
RETURN
END

SUBROUTINE MASIA (CJ, EJ, A1, A2, RU, NAMEM, Z, KCJ, KEJ, KZ)

DIMENSION CJ(KCJ, 1), EJ(KEJ, 1), Z(1:3, 1)
DIMENSION E1(1:3, 3), E2(1:3, 3), W(1:2, 2)

C
C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C
C MASS MATRIX
C FOR AN AXIAL ROD ELEMENT WITH UNRESTRAINED BOUNDARIES.
C ROD MAY BE LINEARLY TAPERED OR UNIFORM.
C MASS MATRIX IS IN GLOBAL COORDINATE DIRECTIONS.
C GLOBAL COORDINATE ORDER IS
C (U, V, W) JOINT 1, THEN JOINT 2.
C WHERE U, V, W ARE TRANSLATIONS.
C EULER ANGLE CONVENTION IS GLOBAL X, Y, Z PERMUTATION.
C CALLS FORMA SUBROUTINES EULER, M1A1, M1A2, ZZBOMB.
C DEVELOPED BY RL WOHLER. SEPTEMBER 1972.
C LAST REVISION BY WA BENFIELD. MARCH 1976.
C
C SUBROUTINE ARGUMENTS
C CJ = INPUT MATRIX OF GLOBAL X, Y, Z COORDINATES AT ROD JOINTS.
C ROWS 1, 2, 3 CORRESPOND TO X, Y, Z COORDINATES.
C COLS 1, 2 CORRESPOND TO JOINTS 1, 2. SIZE(3, 2).
C EJ = INPUT MATRIX OF EULER ANGLES (DEGREES) AT ROD JOINTS.
C ROWS 1, 2, 3 CORRESPOND TO GLOBAL X, Y, Z PERMUTATION.
C COLS 1, 2 CORRESPOND TO JOINTS 1, 2. SIZE(3, 2).
C A1 = INPUT CROSS-SECTION AREA AT ROD END 1.
C A2 = INPUT CROSS-SECTION AREA AT ROD END 2.
C RO = INPUT MASS DENSITY.
C NAMEM = INPUT TYPE OF MASS MATRIX WANTED.
C = M1, LUMPED.
C = M2, CONSISTENT.
C Z = OUTPUT MASS MATRIX. SIZE(6, 6).
C KCJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM. MIN=3.
C KEJ = INPUT ROW DIMENSION OF EJ IN CALLING PROGRAM. MIN=3.
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=6.
C
C NERROR EXPLANATION
C 1 = DIMENSION SIZE EXCEEDED (KZ).
C 2 = NAMEM IMPROPERLY DEFINED.
C
C IF (KZ .LT. 6) GO TO 999
DC 5 J=1, 6
DO 1 I=1, 6
5 Z(I,J) = 0.0
RL = E0PT((CJ(I, 2) - CJ(I, 1))**2 + (CJ(2, 2) - CJ(2, 1))**2
* + (CJ(3, 2) - CJ(3, 1))**2)
IF (NAMEM .EQ. 'M1A1') GO TO 110
IF (NAMEM .EQ. 'M1A2') GO TO 126
GO TO 999
C
C LUMPED.
110 CALL M1A1 (A1, A2, RL, RO, W, Z)
DC 112 I=1, 5
112 Z(I, 1) = W(I, 1)
DO 114 I=4,6
114  Z(I,J) = W(2,2)
RETURN

C CONSISTENT.
120 CALL MLA2 (A1,A2,RL,RO,W,2)
DO 122 T=1,3
122  Z(I,I) = W(1,1)
       CALL EULER (EJ(1,1),E1,3)
       CALL EULER (EJ(1,2),E2,3)
       CALL ATXRB (E1,E2,3,3,3,3,3)
       DO 124 I=1,3
       DO 124 J=4,6
       Z(I,J) = W(1,2)*E2(I,J-3)
124  Z(J,I) = Z(I,J)
       DO 126 I=4,6
126  Z(I,1) = W(2,2)
RETURN

C 999 CALL ?ZBUMB (6HMAS1A ,NERROR)
END
SUBROUTINE MAS16 (CJ,EJ,A1,A2,PI1,PI2,RO,NAMEM,Z,W,KCJ,KEJ,KZ,KW)
DIMENSION CJ(KCJ,1), EJ(KEJ,1), Z(KZ,1), W(KW,1)

SUBROUTINE TO CALCULATE FINITE ELEMENT...

MASS MATRIX
FOR A COMBINED AXIAL-TORSION-BENDING BAR ELEMENT WITH UNRESTRAINED
BOUNDARIES.
BAR MAY BE LINEARLY TAPERED OR UNIFORM.
MASS MATRIX IS IN GLOBAL COORDINATE DIRECTIONS.
GLOBAL COORDINATE ORDER 1:
(U,V,W,P,Q,R) JOINT 1, THEN JOINT 2
WHERE U,V,W ARE TRANSLATIONS AND P,Q,R ARE ROTATIONS.
EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
CALLS FORMA SUBROUTINES ETABA, DCOS1B, M1A1, M1A2, M1B1, M1B2, M1C1, M1C2,
2ZPOM.
DEVELOPED BY RL WOHNLE. FEBRUARY 1973.
LAST REVISION BY WA BENFIELD. MARCH 1976.

SUBROUTINE ARGUMENTS
CJ = INPUT MATRIX OF GLOBAL X,Y,Z COORDINATES AT BAR JOINTS.
ROWS 1,2,3 CORRESPOND TO X,Y,Z COORDINATES.
COLS 1,2 CORRESPOND TO JOINTS 1,2. COL 3 CORRESPONDS
TO REFERENCE POINT TO DEFINE LOCAL XY PLANE. SIZE(3,3).
EJ = INPUT MATRX OF EULER ANGLES (DEGREES) AT BAR JOINTS.
ROWS 1,2,3 CORRESPOND TO GLOBAL X,Y,Z PERMUTATION.
COLS 1,2 CORRESPOND TO JOINTS 1,2. SIZE(3,2).
A1 = INPUT CROSS-SECTION AREA AT BAR END 1.
A2 = INPUT CROSS-SECTION AREA AT BAR END 2.
PI1 = INPUT CROSS-SECTION POLAR AREA MOMENT OF INERTIA AT END 1.
PI2 = INPUT CROSS-SECTION POLAR AREA MOMENT OF INERTIA AT END 2.
RO = INPUT MASS DENSITY.
NAMEM = INPUT TYPE OF MASS MATRIX WANTED.
= M1, LUMPED.
= M2, CONSISTENT.
Z = OUTPUT MASS MATRIX. SIZE(12,12).
W = INPUT WORK SPACE MATRIX. SIZE(12,12).
KCJ = INPUT PCW DIMENSION OF CJ IN CALLING PROGRAM. MIN=3.
KEJ = INPUT PCW DIMENSION OF CJ IN CALLING PROGRAM. MIN=3.
KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=12.
KW = INPUT ROW DIMENSION OF W IN CALLING PROGRAM. MIN=12.

NEPROP EXPLANATION
I = DIMENSION SIZE EXCEEDED KZ,KW).
2 = NAMEM IMPROPERLY DEFINED.

IF (KZ .LT. 12 .OR. KW .LT. 12) GO TO 999
DC = J=1,12
DG = I=1,12
5 7(I,J) = 0.0
RL = SCOT ((CJ(1,1)-CJ(1,1))**2 + (CJ(2,2)-CJ(2,2))**2
* + (CJ(3,3)-CJ(3,3))**2
IF (NAMEM .EQ. 1 .OR. 2) GO TO 110
IF (NAMEM .EQ. 6 .OR. 2) TO TC 120

NERROR=1
GO TO 005

C

AXIAL=M1A1 (LUMPED), TORSION=M1C1 (LUMPED), BENDING=M1B1 (LUMPED).

110 CALL M1A1 (A1, A2, PL, KC, Z, KZ)
   CALL M1C1 (P11, P12, RL, RC, Z(3,3), KZ)
   CALL M1S1 (A1, A2, RL, RC, Z(5,5), KZ)
   CALL M1R1 (A1, A2, RL, RC, Z(9,9), KZ)
   GO TO 320

C

AXIAL=M1A2 (LINEAR DISP), TORSION=M1C2 (LINEAR DISP),
BENDING=M1F2 (CURVIC DISP).

120 CALL M1A2 (A1, A2, PL, RC, Z, KZ)
   CALL M1C2 (P11, P12, RL, RC, Z(3,3), KZ)
   CALL M1F2 (A1, A2, RL, RC, Z(5,5), KZ)
   DO 125 J=7,8
   DO 125 I=5,6
   Z(I,J) = -Z(I,J)
   125 Z(J,I) = -Z(J,I)
   CALL M1F2 (A1, A2, PL, RC, Z(9,9), KZ)

C

300 CALL M1S1F (CJ, EJ, K, KCJ, KEJ, KW)
   CALL M1AFA (Z, W, 12, 12, KZ, KW)
   RETURN

C

999 CALL ZZFCMP (6-MASIE, XERFOP)
   END
SUBROUTINE MAS2 (CJ, EJ, TMAS, RO, NAMEM, Z, W1, W2, KCJ, KEJ, KZ, KW1, KW2)

DIMENSION CJ(KCJ,1), EJ(KEJ,1), Z(KZ,1), W1(KW1,1), W2(KW2,1)

DIMENSION IVEC(11)

DATA IVFC/1,2,6,7,8,12,13,14,18,3,4,5,9,10,11,15,16,17/ 
C
C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C
C MASS MATRIX
C FOR A COMBINED MEMBRANE-BENDING TRIANGLE PLATE ELEMENT WITH 
C UNRESTRAINED BOUNDARIES.
C MASS MATRIX IS IN GLOBAL COORDINATE DIRECTIONS.
C GLOBAL COORDINATE ORDER IS 
C (U,V,W,P,C,R) JUNCT 1, THEN JUNCT 2, 3.
C WHERE U,V,W ARE TRANSLATIONS AND P,Q,R ARE ROTATIONS.
C FULL ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
C CALLS FOR A SUBROUTINES \&TABA, DCCS2, M2A1, M2A2, M2B1, M2B2, Z2BOMB.
C DEVELOPED BY WA FENWICK, FL WOCHEN. FEBRUARY 1973.
C LAST REVISION BY KZ BENFIELD. MARCH 1976.

C SUBROUTINE ARGUMENTS
C CJ = INPUT MATRIX OF GLOBAL X,Y,Z COORDINATES AT TRIANGLE JOINTS. 
C ROWS 1,2,3 CORRESPOND TO X,Y,Z COORDINATES.
C COLS 1,2,3 CORRESPOND TO JOINTS 1,2,3. SIZE(3,3).
C EJ = INPUT MATRIX OF EULER ANGLES (DEGREES) AT TRIANGLE JOINTS. 
C ROWS 1,2,3 CORRESPOND TO GLOBAL X,Y,Z PERMUTATION. 
C COLS 1,2,3 CORRESPOND TO JOINTS 1,2,3. SIZE(3,3).
C TMAS = INPUT EFFECTIVE MASS THICKNESS.
C RO = INPUT MASS DENSITY.
C NAMEM = INPUT TYPE OF MASS MATRIX WANTED.
C = M1, LUMPED.
C = M2, CONSISTENT.
C Z = OUTPUT MASS MATRIX. SIZE(18,18).
C W1 = INPUT WORK SPACE MATRIX. SIZE(18,18).
C W2 = OUTPUT WORK SPACE MATRIX. SIZE(10,10).
C KCJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM. MIN=3.
C KEJ = INPUT ROW DIMENSION OF EJ IN CALLING PROGRAM. MIN=3.
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=18.
C KW1 = INPUT ROW DIMENSION OF W1 IN CALLING PROGRAM. MIN=18.
C KW2 = INPUT ROW DIMENSION OF W2 IN CALLING PROGRAM. MIN=10.
C
C NEPROP EXPLANATION
C 1 = DIMENSION SIZE EXCEEDED (KZ,KW1,KW2).
C 2 = NAMEM IMPROPERLY DEFINED.

IF (KZ .LT. 1E+16 .OR. KW1 .LT. 1E+10 .OR. KW2 .LT. 1E+10) GO TO 999
DC 5, J=1,16
DC 5, I=1,16
5 Z(I,J) = 0.0
SL12 = SQRT((CJ(1,2)-CJ(1,1))*2 + (CJ(2,2)-CJ(2,1))*2) 
* + (CJ(3,2)-CJ(3,1))*2) 
SL23 = SQRT((CJ(1,2)-CJ(1,1))*2 + (CJ(2,3)-CJ(2,2))*2) 
* + (CJ(3,3)-CJ(3,2))*2) 
SL13 = SQRT((CJ(1,3)-CJ(1,1))*2 + (CJ(2,3)-CJ(2,1))*2) 
* + (CJ(3,3)-CJ(3,1))*2) 
X3 = (SL13**2+SL12**2-SL23**2)/(2.0*SL12)
\text{NERROR}=2
\begin{verbatim}
Y3 = SQRT(SL13**2-X3**2) IF (NAMEM .EQ. 6HM1 ) GO TO 110 IF (NAMEM .EQ. 6HM2 ) GO TO 120 GO TO 999 C MEMERANE = M2A1 (LUMPED), BENDING = M2F1 (LUMPED).
110 CALL M2A1 (SL12,Y3,TMAS,IC,W1,KW1) CALL M2F1 (SL12,Y3,TMAS,PC,W1(10,10),KW1) DC 115 IW=1,15 IZ = IVFC(IW)
115 Z(IZ,IJ) = W1(IW,IW) RETURN C MEMERANE = M2A2 (CONSISTENT), BENDING = M2E2 (CONSISTENT).
120 CALL M2A2 (SL12,X3,Y3,TMAS,RC,Z,W1,W2,KZ,KW1,KW2) CALL M2E2 (SL12,X3,Y3,TMAS,PO,Z(10,10),W1,W2,KZ,KW1,KW2) CALL SQLCS (CJ,EJ,W1,KCJ,KEJ,KW1) CALL FTRB (Z,W1,1E,1F,KZ,KW1)
RETURN C 999 CALL ZZLOMB ( +HMAS2 ,NERROR) END
\end{verbatim}
SUBROUTINE MAS3 (CJ,EJ,TMAS,RC,NAMFM,Z,W1,2,KCJ,KEJ,KZ,KW1,KW2)
DIMENSION (JJK,CJ,EJ,EKJ,11,ZKZ,11,W1,KW1,11),W2(KW2,11)
DIMENSION CW1(3,3), CW2(3,3), IV1(18), IV2(18), IV3(18), IV4(18),
  W3(10,10)
DATA IV1/ 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18/,
  IV2/ 1, 2, 3, 4, 5, 6, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24/,
  IV3/ 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 19, 20, 21, 22, 23, 24/,
  IV4/ 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24/

SUBROUTINE TO CALCULATE FINITE ELEMENT...

FOR A COMBINED MEMBRANE-BENDING QUADRILATERAL PLATE ELEMENT WITH
UNRESTRAINED BOUNDARIES.

MASS MATRIX IS IN GLOBAL COORDINATE DIRECTIONS.
GLOBAL COORDINATE ORDER IS
(U,V,W,P,Q,R) JOINT 1, THEN JOINT 2, 3, 4.
WHERE U,V,W ARE TRANSLATIONS AND P,Q,R ARE ROTATIONS.
EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
CALLS FORM K SUBROUTINES MAS2, FVADD, ZZPOMR.
LAST REVISION BY W. BENFIELD. MARCH 1976.

SUBROUTINE ARGUMENTS
CJ = INPUT MATRIX OF GLOBAL X,Y,Z COORDINATES AT QUAD JOINTS.
  ROWS 1,2,3 CORRESPOND TO X,Y,Z COORDINATES.
  COLS 1,2,3,4 CORRESPOND TO JOINTS 1,2,3,4. SIZE(3,4).
EJ = INPUT MATRIX OF EULER ANGLES (DEGREES) AT QUAD JOINTS.
  ROWS 1,2,3 CORRESPOND TO GLOBAL X,Y,Z PERMUTATION.
  COLS 1,2,3,4 CORRESPOND TO JOINTS 1,2,3,4. SIZE(3,4).
TMAS = INPUT EFFECTIVE MASS THICKNESS.
RD = INPUT MASS DENSITY.
NAMFM = INPUT TYPE OF MASS MATRIX WANTED.
  = M1, LUMPED. 4 TRIANGLES, OVERLAP AVERAGE.
  = M2, CONSISTENT. 4 TRIANGLES, OVERLAP AVERAGE.
Z = OUTPUT MASS MATRIX. SIZE(24,24).
W1 = INPUT WORK SPACE MATRIX. SIZE(18,18).
W2 = INPUT WORK SPACE MATRIX. SIZE(18,18).
KCJ = INPUT LOCAL DIMENSION OF CJ IN CALLING PROGRAM. MIN=3.
KEJ = INPUT LOCAL DIMENSION OF EJ IN CALLING PROGRAM. MIN=3.
KZ = INPUT LOCAL DIMENSION OF Z IN CALLING PROGRAM. MIN=24.
KW1 = INPUT LOCAL DIMENSION OF W1 IN CALLING PROGRAM. MIN=18.
KW2 = INPUT LOCAL DIMENSION OF W2 IN CALLING PROGRAM. MIN=18.

NERRCR = ERROR INDICATION
  = 1 = DIMENSION SIZE EXCEEDED (K2,KW1,KW2).
  = 2 = NAMFM IMPROPERLY DEFINED.

IF (K2 .LT. 24 .OR. KW1 .LT. 18) GO TO 999
   CO = 0.124
   CO = 1.24
   5  KEJ = J = 1,24
   5  J = J = 1,24
IF (NAMFM .EQ. 6FM1) GO TO 110
IF (NAMFM .EQ. 6FM2) GO TO 110

NERRCR=1

NERRCR=2
GO TO 999

C

110 DO 112 I=1,3
    CW(I,1) = CJ(I,1)
    EW(I,1) = EJ(I,1)
    CW(I,2) = CJ(I,2)
    EW(I,2) = EJ(I,2)
    CW(I,3) = CJ(I,3)
112 EW(I,3) = EJ(I,3)
    CALL MAS2 (CW,EW,THAS,RO,NAMEM,W1,W2,W3,3,3,KW1,KW2,10)
    CALL REVADD (.5,W1,IV1,IV1,2, 18,18,24,24, KM1,KZ)
    DC 113 I=1,3
    CW(I,1) = CJ(I,1)
    EW(I,1) = EJ(I,1)
    CW(I,2) = CJ(I,2)
    EW(I,2) = EJ(I,2)
    CW(I,3) = CJ(I,3)
113 EW(I,3) = EJ(I,3)
    CALL MAS2 (CW,EW,THAS,RC,NAMEM,W1,W2,W3,3,3,KW1,KW2,10)
    CALL REVADD (.5,W1,IV2,IV2,2, 18,18,24,24, KM1,KZ)
    DC 114 I=1,3
    CW(I,1) = CJ(I,1)
    EW(I,1) = EJ(I,1)
    CW(I,2) = CJ(I,2)
    EW(I,2) = EJ(I,2)
    CW(I,3) = CJ(I,3)
114 EW(I,3) = EJ(I,3)
    CALL MAS2 (CW,EW,THAS,RC,NAMEM,W1,W2,W3,3,3,KW1,KW2,10)
    CALL REVADD (.5,W1,IV3,IV3,2, 18,18,24,24, KM1,KZ)
    DC 115 I=1,3
    CW(I,1) = CJ(I,1)
    EW(I,1) = EJ(I,1)
    CW(I,2) = CJ(I,2)
    EW(I,2) = EJ(I,2)
    CW(I,3) = CJ(I,3)
115 EW(I,3) = EJ(I,3)
    CALL MAS2 (CW,EW,THAS,RC,NAMEM,W1,W2,W3,3,3,KW1,KW2,10)
    CALL REVADD (.5,W1,IV4,IV4,2, 18,18,24,24, KM1,KZ)
    RETURN

C

999 CALL ZZ6CKS (SHMAS3 ,NERROR)
END
SUBROUTINE MAS3A (CJ,EJ,TMAS,RO,NAMEM,Z,W1,W2,KCJ,KEJ,KZ,KW1,KW2)
DIMENSION CJ(KCJ,1), EJ(KEJ,1), Z(KZ,1), W1(KW1,1), W2(KW2,1)

C
C SUBRoutines TO CALCULATE FINITE ELEMENT...
C MASS MATRIX
C FOR A RECTANGULAR SHEAR PANEL ELEMENT WITH UNRESTRAINED BOUNDARIES.
C MASS MATRIX IS IN LOCAL COORDINATE DIRECTIONS.
C GLOBAL COORDINATE ORDER IS
C (U,V,W) JONIT 1, THEN JONIT 2, 3, 4.
C WHERE U,V,W ARE TRANSLATIONS.
C EULER ANGLE CONV'TION IS GLOBAL X,Y,Z PERMUTATION.
C CALLS FORMA SUBROUTINES M3CI,Z2LZME.
C DEVELOPED BY RL WOHLEN, APRIL 1974.
C LAST REVISION BY RL WOHLEN, MAY 1976.
C
C SUBROUTINE ARGUMENTS
C CJ = INPUT MATRIX OF LOCAL X,Y,Z COORDINATES AT PANEL JOINTS.
C DO'S 1,2,3 CORRESPOND TO X,Y,Z COORDINATES.
C COLS 1,2,3,4 CORRESPOND TO JOINTS 1,2,3,4. SIZE(3,4).
C EJ = INPUT MATRIX OF EULER ANGLES (DEGREES) AT PANEL JOINTS.
C DO'S 1,2,3 CORRESPOND TO GLOBAL X,Y,Z PERMUTATION.
C COLS 1,2,3,4 CORRESPOND TO JOINTS 1,2,3,4. SIZE(3,4).
C TMAS = INPUT EFFECTIVE MASS THICKNESS.
C RO = INPUT MASS DENSITY.
C NAMEM = INPUT TYPE OF MASS MATRIX WANTED.
C = M1, LUMPED.
C Z = OUTPUT MASS MATRIX. SIZE(12,12).
C W1 = INPUT WORK SPACE MATRIX. SIZE(12,12).
C W2 = INPUT WORK SPACE MATRIX. SIZE(12,12).
C KCJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM. MIN=3.
C KEJ = INPUT ROW DIMENSION OF EJ IN CALLING PROGRAM. MIN=3.
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=3.
C KW1 = INPUT ROW DIMENSION OF W1 IN CALLING PROGRAM. MIN=12.
C KW2 = INPUT ROW DIMENSION OF W2 IN CALLING PROGRAM. MIN=12.

C NEFFRO EXPLANATION
C 1 = DIMENSION SIZE EXCEEDED (KZ,KW1,KW2).
C 2 = NAMEM IMPROPERLY DEFINED.
C
C IF (KZ LT 12 .OR. KW1 LT 12 .OR. KW2 LT 0) GO TO 999
C SL12 = SQRT((CJ(1,2)-CJ(1,1))**2 + (CJ(2,2)-CJ(2,1))**2
C * + (CJ(3,2)-CJ(3,1))**2)
C SL14 = SQRT((CJ(1,4)-CJ(1,1))**2 + (CJ(2,4)-CJ(2,1))**2
C * + (CJ(3,4)-CJ(3,1))**2)
C IF (NAMEM .EQ. 6) GO TO 110
C
C NERROR=1
C GO TO 999
C
C LUMPED.
C 110 FO 112 J=1,12
C DC 112 := 1,12
C 112 Z(I+J) = 0.0
C CALL M3CI (SL12,SL14,TMAS,RO,W1,W2)
C DC 115 TM=1,4
C
IZ = 3*(IW-1)
Z(IZ+1,IZ+1) = W1(IW,IW)
Z(IZ+2,IZ+2) = W1(IW,IW)
115 Z(IZ+3,IZ+3) = W1(IW,IW)
RETURN

C
999 CALL ZZBOMB (6HAMAS3A ,NERROR)
END
SUBROUTINE PRESS (CJ, T, N, NCOL, K, CJ, KW)
DIMENSION CJ(K,CJ), T(KW)
DIMENSION A(8,8), JNM(3,42), VN(3), C(3,9), IV(3), JV(19)

C C C
C **** SUBROUTINE TO CALCULATE FLUID ELEMENT PRESSURE TRANSFORMATION
C *** MORE DESCRIPTIVE COMMENT CARDS TO BE ADDED AT A LATER DATE.
C *** DEVELOPED BY CAPL BODLEY, OCTOBER 1974.
C LAST REVISION BY C S BODLEY, NOVEMBER 1974.

C DATA JNM / * 1,2,3, 2,4,3, 3,4,1, 1,4,2, 1,2,3, 6,5,4, * 2,6,2, 2,5,6, 4,5,2, 4,2,1, 3,6,4, 3,4,1, * 3,5,6, 3,2,5, 4,5,1, 1,5,2, 1,3,4, 1,6,4, * 1,5,2, 5,6,2, 5,8,7, 5,7,6, 4,7,8, 4,3,7, * 1,2,4, 2,3,4, 1,4,5, 4,8,5, 2,6,7, 2,7,3, * 1,5,6, 1,6,2, 5,8,6, 6,8,7, 3,7,8, 3,8,4, * 1,2,3, 1,3,4, 1,8,5, 1,4,8, 2,6,3, 6,7,3 /

C CALL ZERO (T, N, NCOL, K, CW)
LC = 18
NTF = 24
IF (N,N + EC - 8) GO TO 5
LO = 4
NTF = 14
IF (N,N + EC - 6) GO TO 5
LO = 0
NTF = 4
5 CONTINUE
C
DO 20 N=1,NTF
LOC = N + LC
J1 = JNM(1,LOC)
J2 = JNM(2,LOC)
J3 = JNM(3,LOC)
VN(1) = CJ(2, J2) - CJ(2, J1) + (CJ(3, J3) - CJ(3, J1))
* - (CJ(3, J2) - CJ(3, J1)) + (CJ(2, J3) - CJ(2, J1))
VN(2) = (CJ(3, J2) - CJ(3, J1)) * (CJ(1, J3) - CJ(1, J1))
* - (CJ(1, J2) - CJ(1, J1)) * (CJ(3, J3) - CJ(3, J1))
VN(3) = (CJ(1, J2) - CJ(1, J1)) * (CJ(2, J3) - CJ(2, J1))
* - (CJ(2, J2) - CJ(2, J1)) * (CJ(1, J3) - CJ(1, J1))
C = SCF(VN(1) * VN(1) + VN(2) * VN(2) + VN(3) * VN(3))
DC 25 I=1,3
25 25 VN(I) = VN(I) / AC
AC = AC / 4F.
IF (LOC + LT + 6) AC = 2 * AC
DO 30 I=1,3
IV(I) = JNM(1, LOC)
DC 30 J=1,3
J1 = 3*1 - 3 + J
JL = (IV(I) - I)*3 + J
30 JV(I,J1) = JL
C
DO 35 L=1,3
DO 35 1=1,2
35 35
IL = I + 3*(L - 1)
DO 35 J=1,3
  F = 1.
  IF (L .GE. J) F = 2.
35 C(J,IL) = F*VN(J)
  CALL REVADD (AC,C,IV,JV,T,3,9,NJN,NCOL,3,KW)
  CONTINUE

C
DO 40 I=1,NJN
DC 40 J=I,NJN
  A(I,J) = 0.
DO 40 K=1,NCOL
40 A(I,J) = A(I,J) + T(I,K)*T(J,K)
  CALL INVINV (A,T,NJN,8)
  CALL MULTE (A,T,NJN,8,KW)

C
RETURN
END
SUBROUTINE TO CALCULATE (IN OPTION) FINITE ELEMENT...

MASS MATRICES AND IVECS (IN NUTMX)
STIFFNESS MATRICES (SAME AS GLOBAL LOAD TRANSFORMATION MATRICES)
AND IVECS (IN NUTLX)
UNIT LOAD BUCKLING MATRICES AND IVECS (IN NUTBX), (NOT YET)
LOCAL LOAD TRANSFORMATION MATRICES AND IVECS (IN NUTLT), (NOT YET)
STRESS TRANSFORMATION MATRICES AND IVECS (IN NUST), (NOT YET)
FOR COMBINED MEMBRANE-BENDING QUADRILATERAL PLATE ELEMENTS.
MASS, STIFFNESS, BUCKLING MATRICES ARE IN GLOBAL COORDINATE
DIRECTIONS.

GLOBAL COORDINATE ORDER IS

\( u, v, w, p, q, r \) JOIN 1, THEN JOIN 2, 3, 4

WHERE \( u, v, w \) ARE TRANSLATIONS AND \( p, q, r \) ARE ROTATIONS.
IVEC GIVES ELEMENT DOF INTO GLOBAL DOF. EXAMPLES...
IVEC(6) = 834 PLACES ELEMENT DOF 6 INTO GLOBAL DOF 834.
IVEC(3) = 0 OMITS ELEMENT DOF 3 FROM GLOBAL DOF. THIS CONSTRAINTS
ELEMENT DOF 3 TO ZERO MOTION.

GLOBAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT QUAD VERTICES IN
GLOBAL COORDINATE DIRECTIONS TO DEFLECTIONS IN THE GLOBAL COORDINATE
DIRECTIONS.

ROW ORDER IN GLOBAL LOAD TRANSFORMATION MATRIX IS

\( (p_u, p_v, p_w, p_r, p_r) \) JOIN 1, THEN JOIN 2, 3, 4.
WHERE \( p \) IS FORCE AND \( M \) IS MOMENT.
LOCAL LOAD TRANSFORMATION MATRICES RELATES LOAD AT QUAD VERTICES IN
LOCAL COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE
DIRECTIONS.
STRESS TRANSFORMATION MATRICES RELATES STRESS AT QUAD VERTICES IN
LOCAL COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE
DIRECTIONS.

DATA ARRANGEMENT ON NUTMX, NUTLX, NUTEX, NULTE, NUST FOR EACH FINITE
ELEMENT IS (\( w = M, P, N \), E, LT, ST)
WRITE (NUTMX) NAMEW, NELW, NKE, NCNAMEW, (I, I = 1, NLC),
\((w(1, 1), i = 1, NKE), j = 1, NC), (IVEC(1), i = 1, NC)
CALLS FORMA SUBROUTINES MAS3, PAGHD, STF3, Z2POMR.

LAST REVISION BY RL WHALEN. MAY 1976.

**********************************************************************
** INPUT DATA READ IN THIS SUBROUTINE FROM NUTEL. IF NUTEL = 5, DATA IS
** READ FROM CARDS.
** NAMEW, NAMX, NAMTL, NAMEST, NAMEF
** PD, E, NNU
** TMAC, TMAC, TMAC, TMAC
** NEL, J1, J2, J3, J4, TMASV, TMASV, TMASV
** IF (J1 = 0) RETURN
** GO TO 20
**********************************************************************
C DEFINITION OF INPUT VARIABLES.
C NAMEM = TYPE OF MASS MATRIX WANTED.
C    = M1, DIAGONAL LUMPED, OVERLAP AVERAGE OF FOUR TRIANGLES.
C    = M2, CONSISTENT, OVERLAP AVERAGE OF FOUR TRIANGLES.
C    = 6H OR 6HNCMSS, NO MASS MATRIX CALCULATED.
C NAMEK = TYPE OF STIFFNESS MATRIX WANTED.
C    = K1, OVERLAP AVERAGE OF FOUR TRIANGLES.
C    = 6H OR 6HNCSTIF, NO STIFFNESS MATRIX CALCULATED.
C NAMELT = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES.
C    = 6H OR 6HNCLOAD, NO LOAD TRANSFORMATIONS CALCULATED.
C NAMEST = IDENTIFICATION NAME FOR STRESS TRANSFORMATION MATRICES.
C    = 6H OR 6HNCSTRESS, NO STRESS TRANSFORMATIONS CALCULATED.
C NAMEB = TYPE OF BUCKLING MATRIX WANTED.
C    = 6H OR 6HNCB, NO BUCKLING MATRIX CALCULATED.
C RC = MASS DENSITY.
C E = YOUNG'S MODULUS OF ELASTICITY.
C ANU = POISSONS RATIO. (E/2G)-1.
C TMAST = EFFECTIVE MASS THICKNESS, CONSTANT.
C TMASTV = EFFECTIVE MASS THICKNESS, VARIABLE.
C IF .LE. C, TMAST IS USED.
C TMMEMC = EFFECTIVE MEMBRANE THICKNESS, CONSTANT.
C TMMEMV = EFFECTIVE MEMBRANE THICKNESS, VARIABLE.
C IF .LE. C, TMMEM IS USED.
C TBENC = EFFECTIVE BENDING THICKNESS, CONSTANT.
C TBENV = EFFECTIVE BENDING THICKNESS, VARIABLE.
C IF .LE. C, TBENC IS USED.
C NEL = FINITE ELEMENT NUMBER. FOR REFERENCE ONLY, NOT USED IN
C EQUATIONS. WRITTEN ON NUTMX, ETC.
C J1 = JOINT NUMBER AT QUADRILATERAL VERTEX 1.
C J2 = JOINT NUMBER AT QUADRILATERAL VERTEX 2.
C J3 = JOINT NUMBER AT QUADRILATERAL VERTEX 3.
C J4 = JOINT NUMBER AT QUADRILATERAL VERTEX 4.
C
C EXPLANATION OF INPUT "MATS. NUMER INDICATES CARD COLUMNS USED.
C I = INTEGER DATA, RIGHT ADJUSTED.
C E = DECIMAL POINT DATA, ANYWHERE IN FIELD. EXPONENT RIGHT ADJUSTED
C X = CARD COLUMNS SKIPPED.
C
C SUBROUTINE ARGUMENTS (ALL INPUT)
C XYZ = MATRIX OF JOINT GLOBAL X,Y,Z LOCATIONS. ROWS CORRESPOND
C TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE JOINT
C X,Y,Z LOCATIONS RESPECTIVELY. SIZE(NJ,3).
C JDOP = MATRIX OF JOINT GLOBAL DEGREES OF FREEDOM. ROWS CORRESPOND
C TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE JOINT
C TRANSLATION DOFS AND COLUMNS 4,5,6 CORRESPOND TO THE JOINT
C ROTATION DOFS. SIZE(NJ,6).
C EUL = MATRIX OF JOINT EULER ANGLES (DEGREES). ROWS CORRESPOND
C TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE
C "C"LOWE X,Y,Z PERMUTATION. SIZE(NJ,3).
C NUTEL = LOGICAL NUMBER OF TAPE CONTAINING ELEMENT INPUT DATA FOR
C THIS SUBROUTINE. IF NUTEL = 5, DATA IS READ FROM CARDS.
C NJ = NUMBER OF JOINTS (OF ROWS IN MATRICES (XYZ), (JDOP), (EUL).
C NUTMX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
C MASS MATRICES AND IVECS ARE OUTPUT.
C NUTMX MAY BE ZERO IF MASS MATRIX IS NOT FORMED.
C USES FORTRAN READ, WRITE.
C NUTKX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
C STIFFNESS MATRICES (SAME AS GLOBAL LOADS TRANSFORMATION
C MATRICES) AND IVECS ARE OUTPUT.
C NUTKX MAY BE ZERO IF STIFFNESS MATRIX IS NOT FORMED.
C USES FORTRAN READ, WRITE.
C NUTRX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT UNIT LOAD
C BUCKLING MATRICES AND IVECS ARE OUTPUT.
C NUTRX MAY BE ZERO IF BUCKLING MATRIX IS NOT FORMED.
C USES FORTRAN READ, WRITE.
C NUMTX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT LOCAL
C LOAD TRANSFORMATION MATRICES AND IVECS ARE OUTPUT.
C NUMTX MAY BE ZERO IF LOCAL TRANSFORMATIONS ARE NOT FORMED.
C USES FORTRAN READ, WRITE.
C NUMTL = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
C STRESS TRANSFORMATION MATRICES AND IVECS ARE OUTPUT.
C NUMTL MAY BE ZERO IF STRESS TRANSFORMATIONS ARE NOT FORMED.
C USES FORTRAN READ, WRITE.
C W = MATRIX WORK SPACE. MIN SIZE(24,24).
C T = MATRIX WORK SPACE. MIN SIZE(24,24).
C S = MATRIX WORK SPACE. MIN SIZE(24,24).
C KX = ROW DIMENSION OF XYZ IN CALLING PROGRAM.
C KJ = ROW DIMENSION OF JOINF IN CALLING PROGRAM.
C
C NEQCR: EXPLANATION
C 1 = JOINT NUMBER GREATER THAN NUMBER OF JINTS.
C 2 = MASS MATRIX FORMED, NUTMX .LE. ZERO.
C 3 = STIFFNESS MATRIX FORMED, NUTKX .LE. ZERO.
C 4 = LT MATRIX FORMED, NUMTL .LE. ZERO.
C 5 = ST MATRIX FORMED, NUMST .LE. ZERO.
C 1001 FORMAT (5(A6,4X))
C 1002 FORMAT (3(I6,F10.0))
C 1003 FORMAT (5(I6,3E15.6))
C 2001 FORMAT (/25X,40HINPUT DATA FOR COMBINED MEMBRANE-BENDING
C * 20H QUADRILATERAL PLATE ELEMENTS)
C 2002 FORMAT (/25X,40HINPUT DATA FOR COMBINED MEMBRANE-BENDING
C * 41H QUADRILATERAL PLATE ELEMENTS (CONTINUED))
C 2003 FORMAT (/13X7HMASS = A6, 13X7HTIF = A6, 6X13LOAD TRANS = A6,
C * 3X15HSTRESS TRANS = A6, 3X11HBUCKLING = A6,
C * 15X4=EO = E10.3, 13X3HE = E10.3,
C * 3X11HT(MASS) = E10.3, 12X4=NU = E10.3,
C * 3X11HT(MEMBRANE) = E10.3,
C * 3X11HT(BENDING) = E10.3,
C * 3X11HT(MEMBRANE) = E10.3,
C * 3X11HT(FEAST) = E10.3,
C * 3X11HT(ELEMENT) = E10.3,
C * 3X11HT(JOINT) = E10.3,
C * 3X11HT(ELEMENT) = E10.3,
C * 3X11HT(JOINT) = E10.3,
C * 3X11HT(JOINT) = E10.3,
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C * 3X11HT(JOINT) = E10.3,
C * 3X11HT(JOINT) = E10.3,
C * 3X11HT(JOINT) = E10.3,
C * 3X11HT(JOINT) = E10.3,
C * 3X11HT(JOINT) = E10.3,
C * 3X11HT(JOINT) = E10.3,
C * 3X11HT(JOINT) = E10.3,
C * 3X11HT(JOINT) = E10.3,
C * 3X11HT(JOINT) = E10.3,
C * 3X11HT(JOINT) = E10.3,
C * 3X11HT(JOINT) = E10.3,
C * 3X11HT(JOINT) = E10.3,
C * 3X11HT(JOINT) = E10.3,
C * 3X11HT(JOINT) = E10.3,
C * 3X11HT(JOINT) = E10.3,
C * 3X11HT(JOINT) = E10.3,
C * 3X11HT(JOINT) = E10.3,
NLINE = 0
CALL PAGEHD
WRITE (NOT,2001)
READ (NUTEL,1001) NAMEK,NAMEF,NAMET,NAMER
READ (NUTEL,1002) RC,E,ANU
READ (NUTEL,1002) TMASC,TMEMC,TRENC
WRITE (NOT,2003) NAMEK,NAMEF,NAMET,NAMER,
* RC,E,TMASC,ANU,TMEMC,TRENC
20 READ (NUTEL,1003) NEL,J1,J2,J3,J4,TMASV,TMEMV,TBENV
NC THK = 1
IF (TMASV.LE.0. AND. TMEMV.LE.0.) AND. TBENV.LE.0.) NO THK=0
IF (J1.LE.0) RETURN
NLINE = NLINE + 1
IF (NLINE.LE.42) CC TO 30
CALL PAGEHD
WRITE (NOT,2002)
WRITE (NOT,2003) NAMEK,NAMEF,NAMET,NAMER,
* RC,E,TMASC,ANU,TMEMC,TRENC
NLINE = 0
30 IF (NC.THK.EQ.1)
*WRITE (NOT,2004) NEL,J1,J2,J3,J4,TMASV,TMEMV,TBENV
IF (NC.THK.EQ.0) WRITE (NOT,2005) NEL,J1,J2,J3,J4
IF (J1.GT.NJ .OR. J2.GT.NJ .OR. J3.GT.NJ .OR. J4.GT.NJ) GO TO 999
NERROR = 1
C
C SET THICKNESS.
TMAS = TMASC
TMEM = TMEMC
TEEN = TRENC
IF (TMASV.GT.0.) TMAS=TMASV
IF (TMEMV.GT.0.) TMEM=TMEMV
IF (TBENV.GT.0.) TBENV=TEEN
C
C FORM FINITE ELEMENT COORDINATE LOCATIONS, EULER ANGLES, REVADD 1VEL.
DO 42 I=1,3
CJ(I,1) = YYZ(J1,1)
CJ(I,2) = YYZ(J2,1)
CJ(I,3) = YYZ(J3,1)
CJ(I,4) = YYZ(J4,1)
EJ(I,1) = 0
EJ(I,2) = 0
EJ(I,3) = 0
EJ(I,4) = 0
42 EJ(I,4) = 0
DO 44 I=1,4
IV(I) = JDIF(J1,I)
IV(I+1) = JDIF(J2,I)
IV(I+12) = JDIF(J3,I)
44 IV(I+12) = JDIF(J4,I)
C
C FORM MASS MATRIX (W).
IF (NAMM .LT. 6) GO TO 110
CALL MAT5 (CJ,EJ,TMAS,ANU,NAMEM,W,1..NCJ,6K,JW,KW)
NERROR = 2
IF (NULMX .LT. 6) GO TO 999
WRITE (NULMX) NAMEK,NEL,NPW,NPM .NAMEK,(IFLNK,I=1,2),
FORM STIFFNESS MATRIX \( W \), LOCAL LOAD TRANSFORMATION MATRIX \( T \),
STRESS TRANSFORMATION MATRIX \( S \).

110 IF (NAMEK .EQ. 6H) 
     OR. NAMEK .EQ. 6H1HSTIF) GO TO 20
     CALL STF3 
     ((W(I,J),I=1,NRW),J=1,NRW), (IVI(I),I=1,NRW)
     KLJ,KCJ,KW,KW,KW)
     NERROR=3

     IF (NUTKX .LE. 0) GO TO 999
     WRITE (NUTKX) NAMEK,NFL,NRW,NAMEL,(IELNK,I=1,5),
     *      ((W(I,J),I=1,NRW),J=1,NRW), (IVI(I),I=1,NRW)
     IF (NAMELT .EQ. 6H) 
     *      DF, NAMELT .EQ. 6H1HLOAD) GO TO 115
     NERRCH=4

     IF (NUTLT .LE. 0) GO TO 999
     WRITE (NUTLT) NAMELT,ME1,NRLT,NAMEL,(IELNK,I=1,5),
     *      ((T(I,J),I=1,NRLL),J=1,NRW), (IV1(I),I=1,NRW)
     115 IF (NAMEST .EQ. 6H) 
     *      OR. NAMEST .EQ. 6H1HSTRES) GO TO 20
     NERROP=5

     IF (NUTST .LE. 0) GO TO 999
     WRITE (NUTST) NAMEST,ME1,NRST,NPW,NAMEL,(IBLNK,I=1,5),
     *      ((S(I,J),I=1,NRST),J=1,NPW), (IV1(I),I=1,NRW)
     GO TO 20

999 CALL ZZPUMP (6MQUAD ,NERROR)
END
SUBROUTINE RECTSP (XYZ, JDOL, EUL, NUTFL, NJ,
   MUTMX, NITKX, NULT, NUSTR,
   W, T, S, KX, K, KE, KW)

DIMENSION XYZ(KX+1,1), JDOL(KJ,1), EUL(KF,1), W(KW,1), T(KW,1), S(KW,1)
DIMENSION CJ(3,4), FJ(3,4), IVE(12)
DATA NAMEN, INPUTVARJ, NPF, NELT/12, 8, IBLNK/6H
/, KCJ/3/
DATA NIT, NOKT/5, 4/

SUBROUTINE TO CALCULATE (ON OPTION) FINITE ELEMENT ...
 LOCAL MATRICES AND IVECS (ON NUTMX),
 STIFFNESS MATRICES (SAME AS GLOBAL LOAD TRANSFORMATION MATRICES)
 AND IVECS (ON NULT),
 LOCAL LOAD TRANSFORMATION MATRICES AND IVECS (ON NUTL),
 STRESS TRANSFORMATION MATRICES AND IVECS (ON NUSTR),
 FOR RECTANGULAR SHEAR PANEL ELEMENTS.
 MAT'S, STIFFNESS MATRICES ARE IN GLOBAL COORDINATE DIRECTIONS.
 GLOBAL COORDINATE ORDER IS
 (U,V,W) JOINT 1, THEN JOINT 2, 3, 4.
 WHERE U,V,W ARE TRANSLATIONS.
 IVEC GIVES ELEMENT DOF INTO GLOBAL DOF. EXAMPLES...
 IVEC(6)=634 PLACES ELEMENT DOF 6 INTO GLOBAL DOF 834.
 IVEC(3)=6 PLACES ELEMENT DOF 3 FROM GLOBAL DOF. THIS CONSTRAINTS
 ELEMENT DOF 3 TO ZERO MOTION.
 GLOBAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT PANEL VERTICES IN
 GLOBAL COORDINATE DIRECTIONS TO DEFLECTION IN THE GLOBAL COORDINATE
 DIRECTIONS.
 ROW ORDER IN GLOBAL LOAD TRANSFORMATION MATRIX IS
 (U,P,V,PW) JOINT 1, THEN JOINT 2, 3, 4.
 WHERE P IS FORCE.
 LOCAL LOAD TRANSFORMATION MATRICES RELATES LOAD AT PANEL VERTICES IN
 LOCAL COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE
 DIRECTIONS.
 STRESS TRANSFORMATION MATRICES RELATES PANEL SHEAR STRESS (CONSTANT)
 IN LOCAL COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE
 DIRECTIONS.
 DATA ARRANGEMENT ON NUTMX, NUTKX, NULT, NUSTR FOR EACH FINITE
 ELEMENT IS
 (W,K,L,T,ST)
 WHITE (NUTMX) NAMEN, NEL, MR, NC, NAMEN, (JBLNK, I=1, 5),
 ((W(I,J), I=1, NP), J=1, NC), (IVEC(I), I=1, NC)
 CALLS FORMA SUBROUTINES MASSA, PAGEHD, STF3A, ZEBMR.
 DEVELOPED BY PL WHEELER, APRIL 1974.
 LAST REVISION BY WA BENFIELD, MARCH 1976.

******************************************************************************
** INPUT DATA FORMAT IN THIS SUBROUTINE FROM NUTEL. IF NUTEL = 5, DATA IS**
** READ FROM CPDS.**
** NAMEN, NAMEN, NAMEN, NAMEST FORMAT (4(A6,4X))**
** PC, 6 FORMAT (15X,E10))**
** TMAS, TSF FORMAT (5I5)**
** 20 NEL, J1, J2, J3, J4**
** IF (J1, FC, 0) RETURN**
** GO TO 20**
****
** DEFINITION OF INPUT VARIABLES.**
** NAMEN = TYPE OF MASS MATRIX WANTED.**

C.2
NAMEK = TYPE OF STIFFNESS MATRIX WANTED.
C = K1, LINEAR DISPLACEMENT (CONSTANT STRAIN).
C = 6H OR 6HMSCIF, NO STIFFNESS MATRIX CALCULATED.
NAMELT = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES.
C = 6H OR 6HMSLOAD, NO LOAD TRANSFORMATIONS CALCULATED.
NAMEST = IDENTIFICATION NAME FOR STRESS TRANSFORMATION MATRICES.
C = 6H OR 6HSTFRS, NO STRESS TRANSFORMATIONS CALCULATED.
C = 6H, CONSIDERED.
C = M2, CONSISTENT.
C = M1, DIAGONAL LUMPED.
C = 6H OR 6HNMASS, NO MASS MATRIX CALCULATED.
C = M1, DIAGONAL LUMPED.  PROPERTIES.
C = M2, CONSISTENT.
C = 6H OR 6HNMASS, NO MASS MATRIX CALCULATED.
C = NAMEK = TYPE OF STIFFNESS MATRIX WANTED.
C = K1, LINEAR DISPLACEMENT (CONSTANT STRAIN).
C = 6H OR 6HMSCIF, NO STIFFNESS MATRIX CALCULATED.
NAMELT = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES.
C = 6H OR 6HMSLOAD, NO LOAD TRANSFORMATIONS CALCULATED.
NAMEST = IDENTIFICATION NAME FOR STRESS TRANSFORMATION MATRICES.
C = 6H OR 6HSTFRS, NO STRESS TRANSFORMATIONS CALCULATED.
C = NAMEK = TYPE OF STIFFNESS MATRIX WANTED.
C = K1, LINEAR DISPLACEMENT (CONSTANT STRAIN).
C = 6H OR 6HMSCIF, NO STIFFNESS MATRIX CALCULATED.
NAMELT = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES.
C = 6H OR 6HMSLOAD, NO LOAD TRANSFORMATIONS CALCULATED.
NAMEST = IDENTIFICATION NAME FOR STRESS TRANSFORMATION MATRICES.
C = 6H OR 6HSTFRS, NO STRESS TRANSFORMATIONS CALCULATED.
C = NAMEK = TYPE OF STIFFNESS MATRIX WANTED.
C = K1, LINEAR DISPLACEMENT (CONSTANT STRAIN).
C = 6H OR 6HMSCIF, NO STIFFNESS MATRIX CALCULATED.
NAMELT = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES.
C = 6H OR 6HMSLOAD, NO LOAD TRANSFORMATIONS CALCULATED.
NAMEST = IDENTIFICATION NAME FOR STRESS TRANSFORMATION MATRICES.
C = 6H OR 6HSTFRS, NO STRESS TRANSFORMATIONS CALCULATED.
C = NAMEK = TYPE OF STIFFNESS MATRIX WANTED.
C = K1, LINEAR DISPLACEMENT (CONSTANT STRAIN).
C = 6H OR 6HMSCIF, NO STIFFNESS MATRIX CALCULATED.
C STRESS TRANSFORMATION MATRICES AND IVECS ARE OUTPUT.
C NUTST MAY BE ZERO IF STRESS TRANSFORMATIONS ARE NOT FORMED.
C USES FCPTWSN READ, WRITE.
C W = MATRIX WORK SPACE. MIN SIZE(12,12).
C T = MATRIX WORK SPACE. MIN SIZE(12,12).
C S = MATRIX WORK SPACE. MIN SIZE(12,12).
C KX = ROW DIMENSION OF XYZ IN CALLING PROGRAM.
C KJ = ROW DIMENSION OF JOCF IN CALLING PROGRAM.
C KE = ROW DIMENSION OF EUL IN CALLING PROGRAM.
C KW = ROW DIMENSION OF W, T, AND S IN CALLING PROGRAM. MIN=12.
C
C NEROR EXPLANATION
C 1 = INPUT JOINT NUMBER EXCEEDS MAXIMUM ALLOWABLE NUMBER OF JOINTS.
C 2 = NUTMX NON POSITIVE.
C 3 = NUTXK NON POSITIVE.
C 4 = NUTLT NON POSITIVE.
C 5 = NUTST NON POSITIVE.
C
C 1001 FORMAT (4(A6,4X))
C 1002 FORMAT (2(5X,E10.0))
C 1003 FORMAT (5(I5))
C 2001 FORMAT (/3EX 47HINPUT DATA FCP RECTANGULAR SHEAR PANEL ELEMENTS)
C 2002 FORMAT (/32X 47HINPUT DATA FOR RECTANGULAR SHEAR PANEL ELEMENTS
C * 12H (CONTINUED))
C 2003 FORMAT (/ 14X7HMASS = A6, 14X7HSTIF = A6, 11X3HLLOAD TRANS = A6,
C * 8X15HSTRESS TRANS = A6,
C * / 16X4HRO = E10.3, 14X3HG = E10.3,
C * / 11X3H(MASS) = E10.3, 8X9HT(STIF) = E10.3,
C * //18X7H-ELEMENT 15X7HJOINT 1 13X7HJOINT 2 13X7HJOINT 3
C * //13X7HJOINT 4 / 18X6HNUMBER)
C 2004 FORMAT (1FX,5(15,15X))
C
C READ AND WRITE FINITE ELEMENT DATA.
C NLINE = 0
C CALL PAGEHD
C WRITE (NCT,2001)
C READ (NUTFL,1001) NAMEI,NAMEK,NAMET,NAMEST
C READ (NUTFL,1002) RO,G
C READ (NUTFL,1002) TMAS,TSTF
C WRITE (NCT,2003) NAMEI,NAMEK,NAMET,NAMEST,RO,G,TMAS,TSTF
C 20 READ (NUTFL,1603) NEL,J1,J2,J3,J4
C IF (JL LE. 6) RETURN
C NLINE = NLINE + 1
C IF (NLINE LE. 42) GO TO 30
C CALL PAGEHD
C WRITE (NCT,2002)
C WRITE (NCT,2003) NAMEI,NAMEK,NAMET,NAMEST,RO,G,TMAS,TSTF
C NLINE = 0
C 30 WRITE (NCT,2004) NEL,J1,J2,J3,J4
C NERROR=1
C IF (J1.GT.NJ .OR. J2.GT.NJ .OR. J3.GT.NJ .OR. J4.GT.NJ) GO TO 999
C
C FORM FINITE ELEMENT COORDINATE LOCATIONS, EULER ANGLES, REVADD IVEC.
D0 42 1=1,3
CJ(I,1) = YZ(J1,1)
C FORM MASS MATRIX (M).
IF (NAMFM .EQ. 6) CALL MASM3A (CJ,EJ,TMAS,RQ,NAMFM,W,T,S,KCJ,KCJ,KW,KW)
                   NERROR=2
IF (NUTMX .LE. 0) GO TO 999
WRITE (NUTMX) NAMFM,NFL,NRW,NRW,NAMFL,(IBLNK,I=1,5),
               ((W(I,J),I=1,NRW),J=1,NRW),(IVI(I),I=1,NRW)
C FORM STIFFNESS MATRIX (K), LOCAL LOAD TRANSFORMATION MATRIX (T),
C STRESS TRANSFORMATION MATRIX (S).
110 IF (NAMFK .EQ. 6) CALL STF3A (CJ,EJ,TSTF,G,NAMFK,NAMFST,W,T,S,NRST,
               * KCJ,KCJ,KW,KW,KW)
                   NERROR=3
IF (NUTKX .LE. 0) GO TO 999
WRITE (NUTKX) NAMFK,NEL,NRW,NRW,NAMFL,(IBLNK,I=1,5),
               (((W(I,J),I=1,NRW),J=1,NRW),(IVI(I),I=1,NRW)
IF (NAMELT .EQ. 6) CALL HNLOAD (CJ,EJ,TSTF,G,NAMELT,NAMELST,W,T,S,NRST,
                     * KCJ,KCJ,KW,KW,KW)
                   NERROR=4
IF (NUTLT .LE. 0) GO TO 999
WRITE (NUTLT) NAMELT,NEL,NRLT,NKW,NAMFL,(IBLNK,I=1,5),
               (((T(I,J),I=1,NRLT),J=1,NKW),(IVI(I),I=1,NKW)
115 IF (NAMEST .EQ. 6) CALL HNOSTR (CJ,EJ,TSTF,G,NAMEST,NAMGST,W,T,S,NRST,
                    * KCJ,KCJ,KW,KW,KW)
                   NERROR=5
IF (NUTST .LE. 0) GO TO 999
WRITE (NUTST) NAMGST,NEL,NRKT,NPW,NAMFL,(IBLNK,I=1,5),
               (((S(I,J),I=1,NRKT),J=1,NPW),(IVI(I),I=1,NPW)
   GO TO 20
C 999 CALL ZEROM (6HRECTP,NERROR)
END
SUBROUTINE STFIA (CJ,EJ,A1,A2,E,NAMEK,NAMES,T,TL,TS,NREST)

**DIMENSION** CJ(1), EJ(1), A1(1), A2(1), E(1), NAMEK(1), NAMES(1), T(1), TL(1), TS(1)

**SUBROUTINE** To calculate finite element... 
**STIFFNESS** matrix (same as global load transformation matrix),
**LOCAL** load transformation matrix,
**STRESS** transformation matrix,
**For** an axial rod element with unrestrained boundaries.
**Rods** may be linearly tapered or uniform.
**STIFFNESS** matrix is in global coordinate directions.
**GLOBAL** coordinate order is

U, V, W joint 1, then joint 2.

**WHERE** U, V, W are translations.
**GLOBAL** load transformation matrix relates loads at rod ends in global
**COORDINATE** directions to deflections in the global coordinate
**DIRECTIONS**.
**ROW** order in global load transformation matrix is

(U, V, W) joint 1, then joint 2.

**WHERE** P is force.
**LOCAL** load transformation matrix relates loads at rod ends in local
**COORDINATE** system to deflections in the global coordinate directions.
**ROW** order in local load transformation matrix is

PX1, PX2

**WHERE** PX is axial force.
**PX1**(-), PX2(+) is tension. PX1(+), PX2(-) is compression.
**STRESS** transformation matrix relates stress at rod ends in local
**COORDINATE** system to deflections in the global coordinate directions.
**ROW** order in stress transformation matrix is

SIGMA-X1, SIGMA-X2

**WHERE** SIGMA is normal stress.
**SX1**(-), SX2(+) is tension. SX1(+), SX2(-) is compression.
**EULER** angle convention is global X, Y, Z PERMUTATION.
**CALLS** FORMA SUBROUTINES ATXBAI, DCG1A1, K1AI, MULTA, ZZ6OMB.
**DEVELOPED** BY RL WOHLLEN. SEPTEMBER 1972.
**LAST** REVISION BY WA BENFIELD. MARCH 1976.

**SUBROUTINE** arguments

CJ = input matrix of global X, Y, Z coordinates at rod joints.
**ROWS** 1, 2, 3 correspond to X, Y, Z coordinates.
**COLS** 1, 2 correspond to joints 1, 2. **SIZE**(3, 2).

EJ = input matrix of Euler angles (degrees) at rod joints.
**ROWS** 1, 2, 3 correspond to global X, Y, Z permutation.
**COLS** 1, 2 correspond to joints 1, 2. **SIZE**(3, 2).

A1 = input cross-section area at rod end 1.
A2 = input cross-section area at rod end 2.
E = input Young's modulus of elasticity.
NAMEK = input type of stiffness matrix wanted.
= K1, constant axial force assumed.
NAMEST = input option for stress transformation.
= 6H or 6HNOSTRS, no stress trans calculated.
S = output stiffness matrix (same as global load transformation matrix).
**SIZE**(6, 6).
TL = output local load transformation matrix. **SIZE**(NRST, 6).
TS = output stress transformation matrix. **SIZE**(NRST, 6).
NRST = OUTPUT NUMBER OF ROWS IN STRESS TRANSFORMATION MATRIX.
KDJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM. MIN=3.
KEJ = INPUT ROW DIMENSION OF EJ IN CALLING PROGRAM. MIN=3.
KS = INPUT ROW DIMENSION OF S IN CALLING PROGRAM. MIN=6.
KTL = INPUT ROW DIMENSION OF TL IN CALLING PROGRAM. MIN=2.
KTS = INPUT ROW DIMENSION OF TS IN CALLING PROGRAM. MIN=NRST.

C NERROR EXPLANATION
1 = SIZE LIMITATION EXCEEDED.
2 = NAMEK IMPROPERLY DEFINED.

NRS1 = 2
IF (KS .LT. 6 .OR. KTL .LT. 2 .OR. KTS .LT. NRST) GO TO 999
PL = SQRT((CJ(1,2)-CJ(1,1))*2 + (CJ(2,2)-CJ(2,1))*2)
* + (CJ(3,2)-CJ(3,1))*2)
IF (NAMEK .EQ. 6HK1) GO TO 110

GO TO 999
110 CALL KIA1 (A1,A2,PL,E,TL,TS,KTL,KTS)

CALL DCCS1A (CJ,EJ,S,KCJ,KEJ,KS)
CALL MULTA (TL,S,2,2,6,KTL,KS)
IF (NAMEST .EQ. 6P .OR. NAMEST .EQ. 6HNOH) GO TO 210
CALL MULTA (TS,S,NRST,2,6,KTS,KS)
210 CALL ATXBA1 (S,TL,2,6,KS,KTL)
RETURN

999 CALL ZZBOMR (6HSTF1A,NERROR)
END
SUBROUTINE STF10  (CJ,CJ,KCODE,A1,A2,TJ1,TJ2,R121,B122,B1Y1,B1Y2, *
   K1,R2,CY1,CY2,CZ1,CZ2,SF,E,NAMEK,NAMEST, *
   S,TL,TS,NST,KCJ,KEJ,KS,KTL,KTS)
   DIMENSION CJ(KCJ,1),EJ(KEJ,1),KCODE(1),S(KS,1),KTL(KTL,1),TS(KTS,1)

SUBROUTINE TO CALCULATE FINITE ELEMENT...
STIFFNESS MATRIX (SAME AS GLOBAL LOAD TRANSFORMATION MATRIX),
LOCAL LOAD TRANSFORMATION MATRIX,
STRESS TRANSFORMATION MATRIpX,
FOR A COMBINED AXIAL-TORSION-BENDING BAR ELEMENT WITH UNRESTRAINED
BOUNDARIES.
BAR MAY BE LINEARLY TAPERED OR UNIFORM.
STIFFNESS MATRIX IS IN GLOBAL COORDINATE DIRECTIONS.
GLOBAL COORDINATE ORDER IS
(U,V,W,P,Q,R) JOINT 1, THEN JOINT 2
WHERE U,V,W ARE TRANSLATIONS AND P,Q,R ARE ROTATIONS.
GLOBAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT BAR ENDS IN GLOBAL
COORDINATE DIRECTIONS TO DEFORMATIONS IN THE GLOBAL COORDINATE
DIRECTIONS.
ROW ORDER IN GLOBAL LOAD TRANSFORMATION MATRIX IS
(P1,P2,P3,P4,P5,P6) JOINT 1, THEN JOINT 2.
WHERE P IS FORCE AND M IS MOMENT.
LOCAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT BAR ENDS IN LOCAL
COORDINATE SYSTEM TO DEFORMATIONS IN THE GLOBAL COORDINATE
DIRECTIONS.
ROW ORDER IN LOCAL LOAD TRANSFORMATION MATRIX IS
PX1,PX2,MX1,MX2,PY1,PY2,MY1,MY2
WHERE P IS FORCE AND M IS MOMENT.
STRESS TRANSFORMATION MATRIX RELATES STRESS AT BAR ENDS IN LOCAL
COORDINATE SYSTEM TO DEFORMATIONS IN THE GLOBAL COORDINATE
DIRECTIONS.
ROW ORDER IN STRESS TRANSFORMATION MATRIX IS
PX1/A1,PX2/A2, MX1/R1/TJ1,MX2/R2/TJ2, *
PY1/A1,PY2/A2,MZ1/CY1/E121,MZ2/CY2/B122, *
PZ1/A1,PZ2/A2,MY1/CZ1/B1Y1,MY2/CZ2/B1Y2
WHERE P IS FORCE AND M IS MOMENT.
EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
CALLS FORMA SUBROUTINES ATXFA,DCOSIB,KIA,KIB,KIC,MULTA,ZZBOMA.
LAST REVISION BY RL WOHLEN. APRIL 1976.

SUBROUTINE ARGUMENTS
CJ = INPUT MATRIX OF GLOBAL X,Y,Z COORDINATES AT BAR JOINTS.
PWS 1,2,3 CORRESPOND TO X,Y,Z COORDINATES.
COLS 1,2 CORRESPOND TO JOINTS 1,2.  COL 3 CORRESPONDS
TO REFERENCE POINT TO DEFINE LOCAL XY PLANE. SIZE(3,3).
EJ = INPUT MATPIX OF EULER ANGLES (DEGREES) AT BAR JOINTS.
PWS 1,2,3 CORRESPOND TO GLOBAL X,Y,Z PERMUTATION.
COLS 1,2 CORRESPOND TO JOINTS 1,2. SIZE(3,2).
KODE = INPUT OPTION CODE FOR AXIAL, TORSION, BENDING Z, BENDING Y
LOCAL STIFFNESS. IF BLANK, ALL FOUR ARE CALCULATED.
SIZE(4).
KODE(1)=A , LOCAL STIFFNESS MATRIX IS CALCULATED
FOR AXIAL (ALONG LOCAL X-AXIS).
KODE(2)=T , LOCAL STIFFNESS MATRIX IS CALCULATED
FOR TORSION (ABOUT LOCAL X-AXIS).
KODE(3)=BZ, LOCAL STIFFNESS MATRIX IS CALCULATED
FOR BENDING (ABOUT LOCAL Z-AXIS).

A1 = INPUT CROSS-SECTION AREA AT BAR END 1.
A2 = INPUT SAME AS A1 AT BAR END 2.
TJ1 = INPUT CROSS-SECTION SAINT VENANTS TORSION CONSTANT (J) IN LOCAL Z-AXIS (FOR BENDING) AT BAR END 1.
TJ2 = INPUT SAME AS TJ1 AT BAR END 2.
B1Z1 = INPUT CROSS-SECTION AREA MOMENT OF INERTIA ABOUT LOCAL Z-AXIS (FOR BENDING) AT BAR END 1.
B1Z2 = INPUT SAME AS B1Z1 AT BAR END 2.
B1Y1 = INPUT CROSS-SECTION AREA MOMENT OF INERTIA ABOUT LOCAL Y-AXIS (FOR BENDING) AT BAR END 1.
B1Y2 = INPUT SAME AS B1Y1 AT BAR END 2.
R1 = INPUT DISTANCE FROM LOCAL X-AXIS TO OUTER FIBER FOR TORSION STRESS CALCULATION AT BAR END 1.
R2 = INPUT SAME AS R1 AT BAR END 2.
CY1 = INPUT DISTANCE FROM XZ PLANE TO OUTER FIBER FOR BENDING STRESS CALCULATION AT BAR END 1. LOCAL Y DIRECTION.
CY2 = INPUT SAME AS CY1 AT BAR END 2.
CZ1 = INPUT DISTANCE FROM XY PLANE TO OUTER FIBER FOR BENDING STRESS CALCULATION AT BAR END 1. LOCAL Z DIRECTION.
CZ2 = INPUT SAME AS CZ1 AT BAR END 2.
SF = INPUT SHAPE FACTOR (K) FOR SHEAR IN KAG.
SF = 0.0 FOR NO SHEAR DEFORMATION IN BENDING.
SF = 1.0 FOR A SOLID CIRCULAR CYLINDER.
SF = 0.5 FOR A THIN WALLED CIRCULAR CYLINDER.
E = INPUT YOUNG'S MODULUS OF ELASTICITY.
G = INPUT SHEAR MODULUS OF ELASTICITY.
NAMEK = INPUT TYPE OF STIF MATR}}X XANTED. = K1, USES K1A1 FOR AXIAL, K1C1 FOR TORSION, K1B1 FOR BENDING.
NAMEST = INPUT OPTION FOR STRESS TRANSFORMATION. = 6H OR 6HNSTRS, NO STRESS TRANS CALCULATED.
S = OUTPUT STIFFNESS MATRIX (SAME AS GLOBAL LOAD TRANSFORMATION MATRIX). SIZE(12,12).
TL = OUTPUT LOCAL LOAD TRANSFORMATION MATRIX. SIZE(12,12).
TS = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(NPST,12).
NRST = OUTPUT NUMBER OF ROWS IN STRESS TRANSFORMATION MATRIX.
KCJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM. MIN=3.
KEJ = INPUT ROW DIMENSION OF EJ IN CALLING PROGRAM. MIN=3.
KS = INPUT ROW DIMENSION OF S IN CALLING PROGRAM. MIN=12.
KTL = INPUT ROW DIMENSION OF TL IN CALLING PROGRAM. MIN=12.
KTS = INPUT ROW DIMENSION OF TS IN CALLING PROGRAM. MIN=NRST.

NRST = 12

IF (KS .LT. 12 .OR. KTL .LT. 12 .OR. KTS .LT. NRST) GO TO 999
DO 5 J=1,12
DO 5 I=1,12
TL(I,J) = 0.0
5 TS(I,J) = 0.0
   RL = SQRT((CJ(1,2)-CJ(1,1))**2 + (CJ(2,2)-CJ(2,1))**2 + (CJ(3,2)-CJ(3,1))**2)
   *
   KODEA = 1
   KODET = 1
   KODEBZ = 1
   KODEBY = 1
   IF (KODE(1) .EQ. 1H .AND. KODE(2) .EQ. 1H .AND. KODE(3) .EQ. 2H .AND. KODE(4) .EQ. 2H ) GO TO 10
   IF (KODE(1) .NE. 1HA ) KODEA = 0
   IF (KODE(2) .NE. 1HT ) KODET = 0
C LAST HALF OF NEXT TWO CARDS ALLOW FOR OLD DATA. INSERTED APRIL 1976.
   IF (KODE(3) .NE. 2HBZ .AND. KODE(3) .NE. 2HBY) KODEBZ = 0
   IF (KODE(4) .NE. 2HBZ .AND. KODE(4) .NE. 2HBY) KODEBY = 0
10 IF (NAMEK .EQ. 6HK1 ) GO TO 110
     MERROR=2
   GO TO 999
C
C AXIAL = K1A1 (CONSTANT FORCE), TORSION = K1C1 (CONSTANT TORQUE),
C BENDING = K1B1 (CONSTANT SHEAR, LINEAR BENDING MOMENT).
C
110 IF (KODEA .EQ. 1) CALL K1A1 (A1,A2,RL,F,TL,T5,KTL,KTS)
   IF (KODET .EQ. 1) CALL K1C1 (TJ1,TJ2,R1,R2,RL,G,TL(3,3),TS(3,3),KTL,KTS)
   *
   IF (KODEBZ .EQ. 1) CALL K1B1 (B1Z1,B1Z2,CY1,CY2,A1,A2,SR,RL,E,G,
   *      TL(5,5),TS(5,5),KTL,KTS)
   DC 115 J=7,8
   DO 115 I=5,6
   TL(I,I) =-TL(I,I)
   TS(I,I) =-TS(I,I)
   TL(J,I) =-TL(J,I)
   TS(J,I) =-TS(J,I)
115 IF (KODEBY .EQ. 1) CALL K1B1 (PIY1,PIY2,CZ1,CZ2,A1,A2,SR,RL,E,G,
   *      TL(9,9),TS(9,9),KTL,KTS)
   TL=K
C
CALL DCOS1F (CJ,EJ,S,KJ,KFJ,KS)
CALL MLTA (TL,S,12,12,12,KTL,KS)
   IF (NAMEST .EQ. OR .NAMEST .EQ. 6HNOSTRS) GO TO 210
   CALL MLTA (TS,S,7S5,12,12,KTS,KS)
210 CALL ATXEA1 (5,TL,12,12,KS,KTL)
   RETURN
C
999 CALL ZZECME (6HTF1B ,MERROR)
END
SUBROUTINE STF2 (CJ,EJ,TMEM,TENN,E,ANU,NAMEK,NAMESST,S,TL,TS,NRST, *
K CJ,KEJ,K,S,KTL,KTS)

DIMENSION CJ(KCJ,1), EJ(KEJ,1), S(KS,1), TL(KTL,1), TS(KTS,1)

C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C STIFFNESS MATRIX (SAME AS GLOBAL LOAD TRANSFORMATION MATRIX),
C LOCAL LOAD TRANSFORMATION MATRIX,
C STRESS TRANSFORMATION MATRIX,
C FOR A COMBINED MEMBRANE-BENDING TRIANGLE PLATE ELEMENT WITH
C UNRESTRAINED BOUNDARIES.
C STIFFNESS MATRIX IS IN GLOBAL COORDINATE DIRECTIONS.
C GLOBAL COORDINATE ORDER IS
C (U,V,W,P,O,R) JOINT 1, THEN JOINT 2, 3.
C WHERE U,V,W ARE TRANSLATIONS AND P,0,R ARE ROTATIONS.
C GLOBAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT TRNGL VERTICES IN
C GLOBAL COORDINATE DIRECTIONS TO DEFLECTIONS IN THE GLOBAL COORDINATE
C DIRECTIONS.
C ROW ORDER IN GLOBAL LOAD TRANSFORMATION MATRIX IS
C (PU,PV,PW,MP,M0,MR) JOINT 1, THEN JOINT 2,3.
C WHERE P IS FORCE AND M IS MOMENT.
C LOCAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT TRNGL VERTICES IN
C LOCAL COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE
C DIRECTIONS.
C ROW ORDER IN LOCAL LOAD TRANSFORMATION MATRIX IS
C (PX,PY,PZ) JOINT 1 THEN 2,3, NEXT
C (PZ,PM,PY) JOINT 1 THEN 2,3.
C WHERE P IS FORCE AND M IS MOMENT.
C STRESS TRANSFORMATION MATRIX RELATES STRESS AT TRNGL VERTICES IN LOCAL
C COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE DIRECTIONS.
C ROW ORDER IN STRESS TRANSFORMATION MATRIX IS
C (SIGMA-X,SIGMA-Y,TAU-XY) FOR (Z=TBEN/2) AT JOINT 1,
C THEN JOINT 2,3.
C (SIGMA-X,SIGMA-Y,TAU-XY) FOR (Z=-TBEN/2) AT JOINT 1,
C THEN JOINT 2,3.
C WHERE SIGMA IS NORMAL STRESS AND TAU IS SHEAR STRESS.
C EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
C CALLS FORMA SUBROUTINES ATXBA1,DCOS2,K2A1,K2B1,MULTA,ZZBOMB.
C LAST REVISION BY WA BENFIELD. MARCH 1976.

C SUBROUTINE ARGUMENTS
C CJ = INPUT MATRIX OF GLOBAL X,Y,Z COORDINATES AT TRIANGLE JOINTS.
C ROWS 1,2,3 CORRESPOND TO X,Y,Z COORDINATES.
C COLS 1,2,3 CORRESPOND TO JOINTS 1,2,3. SIZE(3,3).
C EJ = INPUT MATRIX OF EULER ANGLES (DEGREES) AT TRIANGLE JOINTS.
C ROWS 1,2,3 CORRESPOND TO GLOBAL X,Y,Z PERMUTATION.
C COLS 1,2,3 CORRESPOND TO JOINTS 1,2,3. SIZE(3,3).
C TMEM = INPUT EFFECTIVE MEMBRANE THICKNESS.
C TNEN = INPUT EFFECTIVE BENDING THICKNESS.
C E = INPUT YOUNG'S MODULUS OF ELASTICITY.
C ANU = INPUT POISSON'S RATIO. (E/2G)-1.
C NAMEK = INPUT TYPE OF STIFF MATRIX WANTED.
C = K1, USFS K2A1 FOR MEMBRANE, K2B1 FOR BENDING.
C NAMESST = INPUT OPTION FOR STRESS TRANSFORMATION.
C = 6H OR 6HNOSTRS, NO STRESS TRANS CALCULATED.
C S = OUTPUT STIFFNESS MATRIX (SAME AS GLOBAL LOAD TRANSFORMATION
C MATRIX). SIZE(18,18).
C TL = OUTPUT LOCAL LOAD TRANSFORMATION MATRIX. SIZE(18,18).
C TS = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(NRST,18).
C NRST = OUTPUT NUMBER OF ROWS IN STRESS TRANSFORMATION MATRIX.
C KCJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM.
C KEJ = INPUT ROW DIMENSION OF EJ IN CALLING PROGRAM.
C KS = INPUT ROW DIMENSION OF S IN CALLING PROGRAM. MIN=18.
C KTL = INPUT ROW DIMENSION OF TL IN CALLING PROGRAM. MIN=18.
C KTS = INPUT ROW DIMENSION OF TS IN CALLING PROGRAM. MIN=NRST.
C
C NERROR EXPLANATION
C 1 = SIZE LIMITATION EXCEEDED.
C 2 = NAMEK IMPROPERLY DEFINED.
C
C NRST = 18
C
C IF (KS * LT. 18 * OR * KTL * LT. 18 * OR * KTS * LT. NRST) GO TO 999
C DO 5 J=1,18
C DO 5 T=1,18
C TL(I,J) = 0.0
C 5 TS(I,J) = 0.0
C SL12 = SQRT((CJ(I,2)-CJ(I,1))**2 + (CJ(2,2)-CJ(2,1))**2
C * + (CJ(3,2)-CJ(3,1))**2)
C SL23 = SQRT((CJ(1,2)-CJ(1,1))**2 + (CJ(2,3)-CJ(2,2))**2
C * + (CJ(3,3)-CJ(3,2))**2)
C SL13 = SQRT((CJ(1,3)-CJ(1,1))**2 + (CJ(2,3)-CJ(2,1))**2
C * + (CJ(3,3)-CJ(3,1))**2)
C X3 = (SL13**2*SL12**2-SL23**2)/(2.0*SL12)
C Y3 = SQRT(SL13**2-X3**2)
C IF (NAMEK * EQ. 6HK1) GO TO 110
C
C NERROR=1
C
C GO TO 999
C
C
C 110 CALL K2A1 (SL12,X3,Y3,THEM,F,ANU,TL,T5,S,KTL,KTS,KS)
C CALL K2B1 (SL12,X3,Y3,TBEN,E,ANU,TL(10,10),TS(1,10),S,
C * KTL,KTS,KS)
C DO 111 I=1,9
C II = I+9
C DC 111 J=1,9
C 111 TS(I1,J) = TS(I,J)
C
C CALL DCOS2 (CJ,EJ,S,KCJ,KEJ,KS)
C CALL MULCA (TL,S,18,18,S,KTL,KKS)
C IF (NAMEST * EQ. 6H * OR * NAMEST * EQ. 6HNOSTRS) GO TO 210
C CALL MULCA (TS,S,NRST,18,18,KTS,KKS)
C 210 CALL ATXFA1 (S,TL,18,18,KS,KTL)
C RETURN
C
C 999 CALL ZZBOMB (SSTF2,NERROR)
C END
SUBROUTINE STF3 (CJ, EJ, TEM, TBEN, E, ANU, NAMEK, NAMEST, S, TL, TS, MRST, 
  * KJ, KS, KTL, KTS)
DIMENSION CJ(KCJ,1), EJ(KEJ,1), S(KS,1), TL(KTL,1), TS(KTS,1)
DIMENSION CW(3,3), EM(3,3), WI(16,18), 
  * IV1(18), IV2(18), IV3(18), IV4(18)
DATA KCW, KWI / 3,18 /
DATA IV1/ 1, 2, 3, 4, 5, 6, 7, 8, 9,10,11,12,13,14,15,16,17,18/, 
  * IV2/ 1, 2, 3, 4, 5, 6, 13,14,15,16,17,18,19,20,21,22,23,24/, 
  * IV3/ 1, 2, 3, 4, 5, 6, 7, 8, 9,10,11,12,19,20,21,22,23,24/, 
  * IV4/ 7, 8, 9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24/
C
SUBROUTINE TO CALCULATE FINITE ELEMENT...
C STIFFNESS MATRIX (SAME AS GLOBAL LOAD TRANSFORMATION MATRIX),
C LOCAL LOAD TRANSFORMATION MATRIX (NOT YET),
C STRESS TRANSFORMATION MATRIX (NOT YET),
C FOR A COMBINED MEMBRANE-BENDING QUADRILATERAL PLATE ELEMENT WITH
C UNRESTRAINED BOUNDARIES,
C STIFFNESS MATRIX IS IN GLOBAL COORDINATE DIRECTIONS.
C GLOBAL COORDINATE ORDER IS
C (U,V,W,P,Q,R) JOINT 1, THEN JOINT 2, 3, 4.
C WHERE U,V,W ARE TRANSLATIONS AND P,Q,R ARE ROTATIONS.
C GLOBAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT QUAD VERTICES IN
C GLOBAL COORDINATE DIRECTIONS TO DEFLECTIONS IN THE GLOBAL COORDINATE
C DIRECTIONS.
C ROW ORDER IN GLOBAL LOAD TRANSFORMATION MATRIX IS
C (PU,PV,PW,MP,MP,MR) JOINT 1, THEN JOINT 2,3,4.
C WHERE P IS FORCEx AND M IS MUMENT.
C LOCAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT QUAD VERTICES
C IN LOCAL COORDINATE SYSTEM TO DEFLECTIONS IN THE LOCAL COORDINATE
C DIRECTION.
C STRESS TRANSFORMATION MATRIX RELATES STRESS AT QUAD VERTICES IN LOCAL
C COORDINATE SYSTEM TO DEFORMATIONS IN THE GLOBAL COORDINATE DIRECTION.
C EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
C CALLS FORM SUBROUTINES STF2, PEVDO, ZZBOMR.
C DEVELOPED BY WA BENFIELD, RL WOHLER, FEBRUARY 1973.
C LAST REVISION BY WA BENFIELD, MARCH 1976.
C
SUBROUTINE ARGUMENTS
C CJ = INPUT MATRIX OF GLOBAL X,Y,Z COORDINATES AT QUAD JOINTS.
C ROWS 1,2,3 CORRESPOND TO X,Y,Z COORDINATES.
C COLS 1,2,3,4 CORRESPOND TO JOINTS 1,2,3,4. SIZE(3,4).
C EJ = INPUT MATRIX OF EULER ANGLES (DEGREES) AT QUAD JOINTS.
C ROWS 1,2,3 CORRESPOND TO GLOBAL X,Y,Z PERMUTATION.
C COLS 1,2,3,4 CORRESPOND TO JOINTS 1,2,3,4. SIZE(3,4).
C TEM = INPUT EFFECTIVE MEMBRANE THICKNESS.
C TBEN = INPUT EFFECTIVE BENDING THICKNESS.
C E = INPUT YOUNG'S MODULUS OF ELASTICITY.
C ANU = INPUT POISSON'S RATIO. (E/2G)-1.
C NAMEK = INPUT TYPE OF STIFF MATRIX WANTED.
C = K1, USES 4 TRIANGLES, OVERLAP AVERAGE.
C NAMEST = INPUT OPTION FOR STRESS TRANSFORMATION.
C = 6H OR 6HNOSS, NO STRESS TRANS CALCULATED.
C S = OUTPUT STIFFNESS MATRIX (SAME AS GLOBAL LOAD TRANSFORMATION
C MATRIX). SIZE(24,24).
C TL = OUTPUT LOCAL LOAD TRANSFORMATION MATRIX. SIZE(24,24).
C TS = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(NRST,24).
C NRST = OUTPUT NUMBER OF ROWS IN STRESS TRANSFORMATION MATRIX.
C KCJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM. MIN=3.
C KEJ = INPUT ROW DIMENSION OF EJ IN CALLING PROGRAM. MIN=3.
C KS = INPUT ROW DIMENSION OF S IN CALLING PROGRAM. MIN=24.
C KTL = INPUT ROW DIMENSION OF TL IN CALLING PROGRAM. MIN=24.
C KTS = INPUT ROW DIMENSION OF TS IN CALLING PROGRAM. MIN=NRST.
C
C NERROR EXPLANATION
C 1 = SIZE LIMITATION EXCEEDED.
C 2 = NAMEK IMPROPERLY DEFINED.
C
NRST = 24

IF (KS .LT. 24 .OR. KTL .LT. 24 .OR. KTS .LT. NRST) GO TO 999
DO 5 J=1,24
5 S(I,J) = 0.0
IF (NAMEK .EQ. '6HJ1') GO TO 110
GO TO 999

110 DO 200 I=1,3
   CW(I,1) = CJ(I,1)
   EW(I,1) = FJ(I,1)
   CW(I,2) = CJ(I,2)
   EW(I,2) = FJ(I,2)
   CW(I,3) = CJ(I,3)
   EW(I,3) = FJ(I,3)
   CALL REVPAD (*,W,I,IV1,IV2,V,S,18,18,24,24,18,KS)
DO 201 I=1,3
   CW(I,1) = CJ(' :11')
   EW(I,1) = FJ(I,i)
   CW(I,2) = CJ(I,3)
   EW(I,2) = EJ(I,3)
   CW(I,3) = CJ(I,4)
201 EW(I,3) = FJ(I,4)
   CALL REVPAD (*,W,I,IV3,IV4,V,S,18,18,24,24,18,KS)
DO 203 I=1,3
   CW(I,1) = CJ(I,1)
   EW(I,1) = FJ(I,1)
   CW(I,2) = CJ(I,2)
   EW(I,2) = EJ(I,2)
   CW(I,3) = CJ(I,4)
203 EW(I,3) = FJ(I,4)
   CALL REVPAD (*,W,I,IV3,IV4,V,S,18,18,24,24,18,KS)
DO 205 I=1,3
   CW(I,1) = CJ(I,2)
   EW(I,1) = EJ(I,2)
CW(I,2) = CJ(I,3)
EW(I,?) = EJ(I,3)
CW(I,3) = CJ(I,4)
205 EW(I,3) = EJ(I,4)
   CALL STF2 (CW, EW, TMEM, TBEN, E, ANU, NAMEN, NAMEST, W1, TL, TS, NRSTX,
   *       KCW, KCH, KW1, KTL, KTS)
   CALL REVADD (0.5, W1, IV4, IV4, S, 18, 18, 24, 24, 18, KS)
C
   DO 300 J=1,24
   DO 300 I=1,24
   300 TL(I,J) = 0.0
   RETURN
C
999 CALL ZZROMB (4HSTF3 ,NERROR)
END
SUBROUTINE STF3A (CJ,EJ,TH,G,NAMEN,NAMEST,S,TL,TS,NRST, 
    * 
    KJC,EKJ,KLS,KTL,KTS) 
    DIMENSION CJ(KJC,1), EJ(EKJ,1), S(KLS,1), TL(KTL,1), TS(KTS,1)
C
C SUBROUTINE TO CALCULATE FINITE ELEMENT STIFFNESS MATRIX (SAME AS GLOBAL LOAD TRANSFORMATION MATRIX), 
C LOCAL LOAD TRANSFORMATION MATRIX, 
C STRESS TRANSFORMATION MATRIX, 
C FOR A RECTANGULAR SHEAR PANEL ELEMENT WITH UNRESTRAINED BOUNDARIES. 
C STIFFNESS MATRIX IS IN GLOBAL COORDINATE DIRECTIONS. 
C LOCAL COORDINATE ORDER IS 
C (U,V,W) JOIN 1, THEN JOIN 2, 3, 4. 
C WHERE U,V,W ARE TRANSLATIONS. 
C GLOBAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT PANEL VERTICES IN 
C GLOBAL COORDINATE DIRECTIONS TO DEFLECTIONS IN THE GLOBAL COORDINATE 
C DIRECTIONS. 
C ROW ORDER IN GLOBAL LOAD TRANSFORMATION MATRIX IS 
C (PU,PV,PW) JOIN 1, THEN JOIN 2, 3, 4. 
C WHERE P IS FORCE. 
C LOCAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT PANEL VERTICES IN 
C LOCAL COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE 
C DIRECTIONS. 
C ROW ORDER IN LOCAL LOAD TRANSFORMATION MATRIX IS 
C (FX1,FX2,FX3,FX4, FY1,FY2,FY3,FY4, FZ1,FZ2,FZ3,FZ4) JOIN 1, THEN JOIN 2, 3, 4. 
C WHERE P IS FORCE. X GOES FROM 1 TO 2, Y GOES FROM 1 TO 4. 
C STRESS TRANSFORMATION MATRIX RELATES PANEL SHEAR STRESS (CONSTANT) IN 
C LOCAL COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORD DIRECTIONS. 
C EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION. 
C CALLS FORMA SUBROUTINES ATXBA1,DCOS2C,K3C1,MULTA2Z2ZCBMB. 
C DEVELOPED BY RL WHELM. APRIL 1974. 
C LAST REVISION BY WA BENFIELD. MARCH 1976. 
C
C SUBROUTINE ARGUMENTS 
C CJ = INPUT MATRIX OF GLOBAL X,Y,Z COORDINATES AT PANEL JOINTS. 
C ROWS 1/2/3 CORRESPOND TO X,Y,Z COORDINATES. 
C COLS 1/2/3/4 CORRESPOND TO JOINTS 1/2/3/4 SIZE(3,4). 
C EJ = INPUT MATRIX OF EULER ANGLES (DEGREES) AT PANEL JOINTS. 
C ROWS 1/2/3 CORRESPOND TO GLOBAL X,Y,Z PERMUTATION. 
C COLS 1/2/3/4 CORRESPOND TO JOINTS 1/2/3/4 SIZE(3,4). 
C TH = INPUT PANEL THICKNESS. 
C G = INPUT SHEAR MODULUS OF ELASTICITY. 
C NAMEK = INPUT TYPE OF STIF MATRIX WANTED. 
C = 1, USE K3C1. 
C NAMEST = INPUT OPTION FOR STRESS TRANSFORMATION. 
C = 6H IF GMNOSTRS NO STRESS TRANS CALCULATED. 
C S = OUTPUT STIFFNESS MATRIX (SAME AS GLOBAL LOAD TRANSFORMATION 
C MATRIX). SIZE(12,12). 
C TL = OUTPUT LOCAL LOAD TRANSFORMATION MATRIX. SIZE(6,12). 
C TS = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(1,12). 
C NPSST = OUTPUT NUMBER OF ROWS (1) IN STRESS TRANSFORMATION MATRIX. 
C KJC = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM. 
C KEJ = INPUT ROW DIMENSION OF EJ IN CALLING PROGRAM. 
C KLS = INPUT ROW DIMENSION OF S IN CALLING PROGRAM. MIN=12. 
C KTL = INPUT ROW DIMENSION OF TL IN CALLING PROGRAM. MIN=6. 
C KTS = INPUT ROW DIMENSION OF TS IN CALLING PROGRAM. MIN=1.
STF3A -- 2/2

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C  NERROR EXPLANATION
C  1 = SIZE LIMITATION EXCEEDED.
C  2 = NAMEK IMPROPERLY DEFINED.

C  NRST = 1
C
IF (KS .LT. 12 .OR. KTL .LT. & .OR. KTS .LT. NRST) GO TO 999
SL12 = SQRT((CJ(1,2)-CJ(1,1))**2 + (CJ(2,2)-CJ(2,1))**2
  + (CJ(3,2)-CJ(3,1))**2)
SL14 = SQRT((CJ(1,4)-CJ(1,1))**2 + (CJ(2,4)-CJ(2,1))**2
  + (CJ(3,4)-CJ(3,1))**2)
IF (NAMEK .EQ. 6HK1 ) GO TO 110

C  NERROR=2
C  GO TO 999

C  110 CALL K3C1 (SL12,SL14,TH,G,TL,TST,KTL,KTS) TL=K
C
CALL DCOS3C (CJ,EJ,S,KCJ,KEJ,KS) S=DC
CALL MULTA (TL,S,T12,KTL,KS)
IF (NAMEST .EQ. 6H .OR. NAMEST .EQ. 6HNOSTR) GO TO 210
CALL MULTA (TS,S,NRST,T12,KTS,KS)

C  210 CALL ATXEA1 (S,TL,E,T12,K,KS,KTL)
RETURN

C  999 CALL Z7PCMF (6HSTF3A ,NERROR)
END
SUBROUTINE TEGOM (CJ, JM, VL, DV, KCJ, IFBAD)
DIMENSION CJ(KCJ, 1), JM(1), DV(1)
DIMENSION RI2(3), RI3(3), RI4(3)
DATA EPS / 1.E-5 /
C
C SUBROUTINE TO DETERMINE THE VOLUME AND VOLUME CHANGE COEFFICIENTS OF
C A TETRAHEDRON.
C CALLS FORMA SUBROUTINES VCROSS, VDOT.
C DEVELOPED BY C. S. HOODLEY, FEBRUARY 1974.
C SUBROUTINE ARGUMENTS
C CJ = INPUT MATRIX OF JOINT COORDINATES, SIZE (3, N).
C JM = INPUT VECTOR OF JOINTS DEFINING A TETRAHEDRON, SIZE (4).
C VL = OUTPUT VOLUME OF TETRAHEDRON DEFINED BY JM.
C DV = OUTPUT VECTOR OF VOLUME CHANGE COEFFICIENTS.
C KCJ = INPUT ROW DIMENSION SIZE OF CJ IN CALLING PROGRAM, MIN = 3.
C IFBAD = OUTPUT
C = 0 THE TETRAHEDRON VERTICES ARE NOT NUMBERED ACCORDING
C TO THE ESTABLISHED CONVENTION, OR LIE IN A PLANE.
C
J1 = JM(1)
J2 = JM(2)
J3 = JM(3)
J4 = JM(4)
DC 5 I=1,3
RI2(I) = CJ(I, J2) - CJ(I, J1)
RI3(I) = CJ(I, J3) - CJ(I, J1)
RI4(I) = CJ(I, J4) - CJ(I, J1)
C
CALL VCROSS (RI2(1), RI3(1), RI4(I), VAMAG, VPMAG, VZMAG, SINAB)
CALL VDOT (DV(I), RI4, VAMAG, VPMAG, COSAB)
IF (VOL.EQ.EPS) IFBAD=0
VL = VOL/6.
C
CALL VCROSS (P14, P13, DV(4), VAMAG, VPMAG, VZMAG, SINAB)
CALL VCROSS (P13, RI2, DV(7), VAMAG, VPMAG, VZMAG, SINAB)
DC 10 I=1,3
10 DV(I) = -DV(I+3) - DV(I+6) - DV(I+9)
DC 15 I=1,12
15 DV(1) = DV(1)/6.
C
RETURN
END
SUBROUTINE TRNGL (XYZ,JDOF,EUL,NUTEL,NJ,
   * NUTMX,NUTKX,NUTBX,NULT,L,NUTST,
   * W,T,S,KX,KJ,K,E,KW)
DIMENSION XYZ(KX,1),JDOF(KJ,1),EUL(KE,1),W(KW,1),T(KW,1),S(KW,1)
DIMENSION CJ(3,3), EJ(3,3), IVI(18)
DATA NAMN /6HTRNL /, NRM,NRLT/18,18/, IBLNK/6H /*, KCJ/3/
DATA NIT,MCT/5,6/

C SUBROUTINE TO CALCULATE (ON OPTION) FINITE ELEMENT ...
C MASS MATRICES AND IVECS (ON NUTMX),
C STIFFNESS MATRICES (SAME AS GLOBAL LOAD TRANSFORMATION MATRICES)
C AND IVECS (ON NUTBX),
C UNIT LOAD BUCKLING MATRICES AND IVECS (ON NUTRX), (NOT YET)
C LOCAL LOAD TRANSFORMATION MATRICES AND IVECS (ON NULT),
C STRESS TRANSFORMATION MATRICES AND IVECS (ON NUTST),
C FOR COMBINED MEMBRANE-PENDING TRIANGLE PLATE ELEMENTS.
C MASS, STIFFNESS, BUCKLING MATRICES ARE IN GLOBAL COORDINATE
C DIRECTIONS.
C GLOBAL COORDINATE ORDER IS
C (UX,UY,UX,UX) JOINT 1, THEN JOINT 2, 3.
C WHERE UX,UY,UX ARE TRANSLATIONS AND UX,UY ARE ROTATIONS.
C IVEC GIVES ELEMENT DOF INTO GLOBAL DOF. EXAMPLES...
C IVEC(6)=E834 PLACES ELEMENT DOF 6 INTO GLOBAL DOF 834.
C IVEC(3)=0 OMITS ELEMENT DOF 3 FROM GLOBAL DOF. THIS CONSTRAINS
C ELEMENT DOF 3 TO ZERO MOTION.
C GLOBAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT TRNGL VERTICES IN
C GLOBAL COORDINATE TO DEFLECTIONS IN THE GLOBAL COORDINATE
C DIRECTIONS.
C ROW ORDER IN GLOBAL LOAD TRANSFORMATION MATRIX IS
C (PU,PU,PU,PU) JOINT 1, THEN JOINT 2, 3.
C WHERE P IS FORCE AND M IS MOMENT.
C LOCAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT TRNGL VERTICES IN
C LOCAL COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE
C DIRECTIONS.
C ROW ORDER IN LOCAL LOAD TRANSFORMATION MATRIX IS
C (P2,P2,PM,PM) JOINT 1 THEN 2, 3.
C WHERE P IS FORCE AND M IS MOMENT.
C STRESS TRANSFORMATION MATRIX RELATES STRESS AT TRNGL VERTICES IN LOCAL
C COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE DIRECTIONS.
C ROW ORDER IN STRESS TRANSFORMATION MATRIX IS
C (SIGMA-X,SIGMA-Y,TAU) FOR (Z=TBEN/2) AT JOINT 1,
C THEN JOINT 2, 3.
C (SIGMA-X,SIGMA-Y,TAU) FOR (Z=-TBEN/2) AT JOINT 1,
C THEN JOINT 2, 3.
C WHERE SIGM A IS NORMAL STRESS AND TAU IS SHEAR STRESS.
C DATA ARRANGEMENT ON NUTRX, NUTKX, NUTBX, NULT, NUTST FOR EACH
C FINITE ELEMENT IS (W,M,KL,LT,ST)
C WRITE (NUTRX) N,MEW,NFL,NP,NC,NAMFL,(IBLNK,I=1,5),
C ((W1,J),I=1,NR),J=1,NC),(IVEC(I),I=1,NC)
C CALLS FORMA SUBROUTINES MAS2, PAGEHD, STF2, ZBOME.
C LAST MODIFICATION BY RL WOHNEN. MAY 1976.
C
C******************************************************************************
INPUT DATA READ IN THIS SUBROUTINE FROM NUTEL. IF NUTEL = 5, DATA IS
READ FROM CARDS.

NAMEM,NAMEK,NAMET,NAMET,NAMET NAMEB
RD,E,ANU
TMASC,TMEMC,TEFNC
20 NEL,J1,J2,J3,TMASV,TMEMC,TENV
IF (J1 .EQ. 0) RETURN
GO TO 20

DEFINITION OF INPUT VARIABLES.

NAMEM = TYPE OF MASS MATRIX WANTED.
= M1, DIAGONAL LUMPED.
= M2, CONSISTENT.
= 6H, OR 6H=NO, NO MASS MATRIX CALCULATED.

NAMEK = TYPE OF STIFFNESS MATRIX WANTED.
= K1, QUADRATIC DISPLACEMENT FOR MEMBRANE, CUBIC
= K2, QUADRATIC DISPLACEMENT FOR BENDING.

NAMET = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES.
= 6H, OR 6H=NO, NO LOAD TRANSFORMATIONS CALCULATED.

NAMEST = IDENTIFICATION NAME FOR STRESS TRANSFORMATION MATRICES.
= 6H, OR 6H=NO, NO STRESS TRANSFORMATIONS CALCULATED.

NAMET = TYPE OF BUCKLING MATRIX WANTED.
= 6H, OR 6H=NO, NO BUCKLING MATRIX CALCULATED.

RO = MASS DENSITY.
E = YOUNG'S MODULUS OF ELASTICITY.
ANU = POISSONS RATIO. (E/2G)-1.
TMASC = EFFECTIVE MASS THICKNESS, (CONSTANT).
TMASV = EFFECTIVE MASS THICKNESS, (VARIABLE).

IF *E*, TMASC IS USED.

TMEMC = EFFECTIVE MEMBRANE THICKNESS, (CONSTANT).

IF *E*, TMEMC IS USED.

TENV = EFFECTIVE BENDING THICKNESS, (CONSTANT).

IF *E*, TENV IS USED.

NEL =FINITE ELEMENT NUMBER, FOR REFERENCE ONLY, NOT USED IN
CALCULATIONS. WRITTEN ON NUTMX, ETC.

J1 = JOINT NUMBER AT TRIANGLE VERTEX 1.
J2 = JOINT NUMBER AT TRIANGLE VERTEX 2.
J3 = JOINT NUMBER AT TRIANGLE VERTEX 3.

EXPLANATION OF INPUT FORMATS. NUMERER INDICATES CARD COLUMNS USED.
I = INTEGER DATA, RIGHT ADJUSTED.
F = DECIMAL POINT DATA, ANYWHERE IN FIELD. EXPONENT RIGHT ADJUSTED.
X = CAPD COLUMNS SKIPPED.

******************************************************************************************

SUBROUTINE ARGUMENTS (ALL INPUT)

XYZ = MATRIX OF JOINT GLOBAL X,Y,Z LOCATIONS. ROWS CORRESPOND
TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE JOINT
X,Y,Z LOCATIONS RESPECTIVELY. SIZE(NEL,3).

JDF = MATRIX OF JOINT GLOBAL DEGREES OF FREEDOM. ROWS CORRESPOND
TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE JOINT
TRACEMENT DOFS AND COLUMNS 4,5,6 CORRESPOND TO THE JOINT
ROTATION DOFS. SIZE(NJ,6).

EUL = MATRIX OF JOINT EULER ANGLES (DEGREES). ROWS CORRESPOND
TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE
GLOBAL X,Y,Z PERMUTATION. SIZE(NJ,3).

NUTEL = LOGICAL NUMBER OF TAPE CONTAINING ELEMENT INPUT DATA FOR
THIS SUBROUTINE. IF NUTEL = 5, DATA IS READ FROM CARDS.

NJ = NUMBER OF JOINTS OR ROWS IN MATRICES (XYZ), (JDOF), (EUL).

NUTMX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
MASS MATRICES AND IVECS ARE OUTPUT.
NUTMX MAY BE ZERO IF MASS MATRIX IS NOT FORMED.
USES FORTRAN READ, WRITE.

NUTKX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
STIFFNESS MATRICES (SAME AS GLOBAL LOADS TRANSFORMATION
MATRICES) AND IVECS ARE OUTPUT.
NUTKX MAY BE ZERO IF STIFFNESS MATRIX IS NOT FORMED.
USES FORTRAN READ, WRITE.

NUTBX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT UNIT LOAD
PUCKLING MATRICES AND IVECS ARE OUTPUT.
NUTBX MAY BE ZERO IF PUCKLING MATRIX IS NOT FORMED.
USES FORTRAN READ, WRITE.

NUTLT = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT LOCAL
LOAD TRANSFORMATION MATRICES AND IVECS ARE OUTPUT.
NUTLT MAY BE ZERO IF LOAD TRANSFORMATIONS ARE NOT FORMED.
USES FORTRAN READ, WRITE.

NUTST = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
STRESS TRANSFORMATION MATRICES AND IVECS ARE OUTPUT.
NUTST MAY BE ZERO IF STRESS TRANSFORMATIONS ARE NOT FORMED.
USES FORTRAN READ, WRITE.

W = MATRIX WORK SPACE. MIN SIZE(18,18).

T = MATRIX WORK SPACE. MIN SIZE(18,18).

S = MATRIX WORK SPACE. MIN SIZE(18,18).

KX = ROW DIMENSION OF XYZ IN CALLING PROGRAM.

KJ = ROW DIMENSION OF JDOF IN CALLING PROGRAM.

KE = ROW DIMENSION OF EUL IN CALLING PROGRAM.

KW = ROW DIMENSION OF W, T, AND S IN CALLING PROGRAM. MIN=18.

NERCOR EXPLANATION

1 = JOINT NUMBER GREATER THAN NUMBER OF JOINTS.

2 = MASS MATRIX FORMED, NUTMX .LE. ZERO.

3 = STIFFNESS MATRIX FORMED, NUTKX .LE. ZERO.

4 = Lr MATRlX FORMED, NUTLT .LE. ZERO.

5 = ST MATRIX FORMED, NUTST .LE. ZERO.

1001 FORMAT (5(6,1X))
1002 FORMAT (3(6X,10.0))
1003 FORMAT (4(6,1X,10.0))
2001 FORMAT (//32X 49HINPUT DATA FOR COMBINED MEMBRANE-BENDING TRIANGLE
* 15H PLATE ELEMENTS)
2002 FORMAT (//26X 49HINPUT DATA FOR COMBINED MEMBRANE-BENDING TRIANGLE
* 27H PLATE ELEMENTS (CONTINUED))
2003 FORMAT (/*
13X7MASS = A6, 13X7STIF = A6, 6X13HLOAD TRANS = A6,
* 5X1HSTRESS TRANS = A6, 5X1HPUCKLING = A6,
* / 13X4HPO = E10.3, 13X3HFE = F10.3,
* / 10XCHT(MASS) = E10.3, 12X4HNU = E10.3,
* / 52X15H(MEMBRANE) = E10.3,
* / 33X12HT(BENDING) = E10,3,
* /18X 7HELEMENT 5X 7HJOIN 1 5X 7HJOIN 2 5X 7HJOIN 3
* 5X 7HT(MASS) 6X 11HT(MEMBRANE) 5X 10HT(BENDING)
* /18X 6HNUMBEF 36X 3(5X 10H(VARIABLE))
2004 FORMAT (1FX 4(15,7X),3(E10,3,5X))
2005 FORMAT (15X 4(15,7X))
C
C READ AND WRITE FINITE ELEMENT DATA.
NLIN=1:
CALL PAGE+D:
WRITE (NO. 1, 'G01)
READ (NUTFL,1001) NAMEN,NAMEK,NAMELT,NAMEST,NAMEB
READ (MUTEL,1002) RO,E,ANU
READ (MUTEL,1002) TMASC,TMEMC,TBENC
WRITE (NOT, 2003) NAMEN,NAMEK,NAMELT,NAMEST,NAMEB,
C
20 READ (NUTEL,1003) NEL,J1,J2,J3,TMASV,TMEMV,TEENV
NO THIK = 1
IF (TMASV.LE.0. AND. TMEMV.LE.0. AND. TBENV.LE.0.) NO THIK=0
IF (J1.LE. 0) RETURN
NLIN = NLIN + 1
IF (NLIN .LE. 42) GO TO 30
CALL PAGE+D:
WRITE (NOT, 2002)
WRITE (NOT, 2003) NAMEN,NAMEK,NAMELT,NAMEST,NAMEB,
C
NLINE = 0
30 IF (NO THIK.EQ.1)
*WRITE (NOT,2004) NEL,J1,J2,J3,TMASV,TMEMV,TEENV
IF (NO THIK.EQ.0) WRITE (NOT, 2005) NEL,J1,J2,J3
NERRDR=1
IF (J1 .GT. NJ .OR. J2 .GT. NJ .OR. J3 .GT. NJ) GO TO 999
C
C SET THICKNESSES.
TMAS = TMASC
TMEM = TMEMC
TBEN = TBENC
IF (TMASV.GT.0.) TMAS=TMASV
IF (TMEMV.GT.0.) TMEM=TMEMV
IF (TBENV.GT.0.) TBEN=TBENV
C
C FORM FINITE ELEMENT COORDINATE LOCATIONS, EULER ANGLES, REVADD IVEC.
DO 42 I=I+3
CJ(I,1) = YYZ(J1,I)
CJ(I,2) = YYZ(J2,I)
CJ(I,3) = YYZ(J3,I)
EJ(I,1) = EUL(J1,I)
EJ(I,2) = EUL(J2,I)
EJ(I,3) = EUL(J3,I)
42 DO 44 I=I+3
IVI(I) = JDOF(J1,I)
IVI(I+6) = JDOF(J2,I)
44 IVI(I+12) = JDOF(J3,I)
C
C FORM MASS MATRIX (W).
TRNGL -- 5/5

IF (NAMFM .LE. 6H .OR. NAMEM .EQ. 6HNDMASS) GO TO 110
CALL MAS2 (CJ, EJ, TMAE, PO, NAMEM, W, T, S, KCJ, KCJ, KW, KW)

IF (NUTMX .LE. 0) GO TO 999
WRITE (NUTMX) NAMEM, NEL, NRW, NRW, NAMFL, (IBLNK, I = 1, 5),
* (W(I,J), I = 1, NRW, J = 1, NPW), (IV(I), I = 1, NRW)

C
C FORM STIFFNESS MATRIX (W), LOCAL LOAD TRANSFORMATION MATRIX (T),
C STRESS TRANSFORMATION MATRIX (S).
C
110 IF (NAMEK .EQ. 6H .OR. NAMEK .EQ. 6HNOSTIF) GO TO 20
CALL STF2 (CJ, EJ, TMAE, TBEN, F, APU, NAMEK, NAMEST, W, T, S, NRST,
* KCJ, KCJ, KW, KW, KM)

IF (NUTMX .LE. 0) GO TO 999
WRITE (NAMEK) NAMEK, NEL, NPW, NPW, NAMEL, (IBLNK, I = 1, 5),
* (W(I,J), I = 1, NRW, J = 1, NRW), (IV(I), I = 1, NRW)

115 IF (NAMFL .EQ. 6H .OR. NAMFL .EQ. 6HNOLOAD) GO TO 115

IF (NAMLT .LE. 0) GO TO 999
WRITE (NAMLT) NAMFL, NEL, NPLT, NRW, NAMEL, (IBLNK, I = 1, 5),
* (T(I,J), I = 1, NPLT, J = 1, NPW), (IV(I), I = 1, NPW)

115 IF (NAMEST .EQ. 6H .OR. NAMEST .EQ. 6HNOSTRS) GO TO 20

IF (NUTS .LE. 0) GO TO 999
WRITE (NUTS) NAMEST, NAMEK, NRST, NRW, NAMEL, (IBLNK, I = 1, 5),
* (S(I,J), I = 1, NRST, J = 1, NRW), (IV(I), I = 1, NRW)
GO TO 20

C
999 CALL ZZBOMS (6HTRNGL, NERROR)
END