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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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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 NAS8-31373. 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 Wikening, 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, JDOF, EUL, NUTEL, NJ, 
* NUTMX, NUTKX, NUTLT, NUTST, 
* W, T, S, KX, KJ, KE, KW) 
DIMENSION XYZ(KX,1), JDOF(KJ,1), EUL(KF,1), W(KW,1), T(KW,1), S(KW,1) 
DIMENSION C(J3,2), E(L3,2), IVEC(6) 
DATA NAMF, NAXIAL /, NRW, NRTL/6, 2/, IBLN/6H 
/3, KCJ/3. 
DATA NIT, NOT/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 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 OMKTS ELEMENT DOF 3 FROM GLOBAL DOF. THIS CONSTRFAINS 
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 (FP, 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, NUTK, NULIT, NUST FOR EACH FINITE 
C ELEMENT IS (W=Mx, Kx, Lx, ST) 
C WRITE (NUTMX) NAMF, NEL, NR, NC, NAMF, (IBLNK, I=1,5), 
C ( (W(I,J), I=1, NR), J=1, NC), (IVEC(I), I=1, NC) 
C CALLS FORMA SUBROUTINES MASIA, PAGEHO, STFIA, ZZBOMBO. 
C LAST REVISION BY WA EENFIELD. MARCH 1976. 
C
*********************************************************************** 
C INPUT DATA READ IN THIS SUBROUTINE FROM NUTEL. IF NUTEL = 5, DATA IS 
C READ FROM CARDS. 
C NAME, NAMEK, NAMET, NAMEST FORMAT (4(A6,4X) 
C RO, E 
C 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 NAME = 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 6HSTIF, 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 = YOUNG'S 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 = MATRICE 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 NULTT = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT LOCAL
AXIAL -- 3/4

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 KX = ROW DIMENSION OF XYZ IN CALLING PROGRAM.
C KJ = ROW DIMENSION OF JOOF IN CALLING PROGRAM.
C KE = ROW DIMENSION OF EUL IN CALLING PROGRAM.
C
C NEPRER 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, NUST .LE. ZERO.

1001 FORMAT (4(A6,4X))
1002 FORMAT (2(5X,E10.6))
1003 FORMAT (31F,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,
* //16X7THELEMENT 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 PAGEHD
WRITE (NCL,2001)
READ (NUTEL,1001) NAMEM,NAMEK,NAMET,LNAMEST
READ (NUTEL,1002) RO,E
WRITE (NCT,2002) NAMEM,NAMEK,NAMET,LNAMEST,RO,E
20 READ (NUTEL,1003) NFL,J1,J2,A1,A2
IF (J1 .LT. 0) RETURN
NLINE = NLINE + 1
IF (NLINE .LE. 42) GO TO 30
CALL PAGEHD
WRITE (NCL,2002)
WRITE (NCT,2003) NAMEM,NAMEK,NAMET,LNAMEST,RO,E
NLINE = 0
30 WRITE (NCL,2004) NFL,J1,J2,A1,A2
IF (J1 .GT. NJ .OR. J2 .GT. NJ ) GO TO 999
C
C FORM FINITE ELEMENT COORDINATE LOCATION, EULER ANGLES. REVADD IVEC.
DO 42 I=1,3
CJ(I,1) = XYZ(J1,1)
CJ(I,2) = XYZ(J2,1)
EJ(I,1) = FUL(J1,1)
EJ(I,2) = FUL(J2,1)
IV1(I) = JDCF(J1,1)
IV1(I+3) = JDCF(J2,1)
C
C FORM MASS MATRIX (W).
   IF (NAMEM .EQ. 6H) C@R. NAMEM .EQ. 6HNOWM A SS) GO TO 110
   CALL MAS1A (CJ,EJ,A1,A2,RO,NAMEM,W,KCJ,KCJ,KW)
   NERROR=2
   IF (NUTMX .LE. 0) GO TO 999
   WRITE (NUTMX) NAMEM,NEL,NFW,NRW,NAMEL,(IBLNK,I=1,3),
   * (((W(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) C@R. NAMEK .EQ. 6HNOWSTIF) GO TO 20
   CALL STF1A (CJ,EJ,A1,A2,ENAMEK,NAMEST,W,T,S,NRST,
   * KCJ,KCJ,KW,KW,KW)
   NERROR=3
   IF (NUTMX .LE. 0) GO TO 999
   WRITE (NUTMX) NAMEK,NEL,NRW,NRW,NAMEL,(IBLNK,I=1,5),
   * (((W(I,J),I=1,NRW),J=1,NRW),IV1(I),I=1,NRW)
   IF (NAMELT .EQ. 6H) C@R. NAMELT .EQ. 6HNOWLOAD) GO TO 115
   NERROR=4
   IF (NUTLT .LE. 0) GO TO 999
   WRITE (NUTLT) NAMELT,NEL,NRLT,NRW,NAMEL,(IBLNK,I=1,5),
   * (((T(I,J),I=1,NRLT),J=1,NRW),IV1(I),I=1,NRW)
115 IF (NAMEST .EQ. 6H) C@R. NAMEST .EQ. 6HNOWSTRS) GO TO 20
   NERROR=5
   IF (NUST .LE. 0) GO TO 999
   WRITE (NUST) NAMEST,NEL,NRST,NRW,NAMEL,(IBLNK,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,1)

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 WOHLEN. AUGUST 1973.
C LAST REVISION BY RL WOHLEN. SEPTEMBER 1973.

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 = 1./RL
Z(1,1) = C
Z(1,2) = -C
Z(2,1) = -C
Z(2,2) = C

RETURN
END
SUBROUTINE B1A2 (R**,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 TRANSITION AND TY IS ROTATION.
LAST REVISION BY RL WOHLER, SEPTEMBER 1973.

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 = .1
C2 = (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(I,J) = Z(I,J)

RETURN
END
DIMENSION XYZ(KX, 1), JDCF(KJ, 1), EUL(KE, 1), W(KW, 1), T(KW, 1), S(KW, 1)
DIMENSION CJJ(3, 3), EjJ(3, 2), IV1(12), TR(12, 12), TD(24, 24)
DIMENSION KODEK(4), KODEK(2), IFPIN(4), IV2(4)
DATA NAMEL / 6HEAP /
DATA NAM5/NULT/12, 12/, IBLNK/6H /, K CJ/3/, KTR/12/, KTD/24/
DATA NIT,NOT/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 UNIT LOAD BUCKLING MATRICES AND IVECS (ON NUTBX),
C LOCAL LOAD TRANSFORMATION MATRICES AND IVECS (ON NUTLT),
C STRESS TRANSFORMATION MATRICES AND IVECS (ON NUST),
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, O, R) JOINT 1, THEN JOINT 2
C WHERE U, V, W ARE TRANSLATIONS AND P, O, R ARE ROTATIONS.
C IVEC GIVES Element DOF INTO GLOBAL DCF. EXAMPLES ...
C IVEC(6)=834 PLACES Element DOF 6 INTO GLOBAL DOF 834.
C IVEC(3)=0 omits 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 System TO DEFORMATIONS IN THE GLOBAL Coordinate System.
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 DEFORMATIONS IN THE GLOBAL Coordinate System.
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 DEFORMATIONS IN THE GLOBAL Coordinate System.
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*CZ1/E1Y1, MY2*CZ2/E1Y2
C WHERE P IS Force and M IS MOMENT.
C DATA arrangement ON NUTMX, NUTKX, NUTRX, NULT, NUST FOR EACH
C Finite Element IS (W=M, K, B, LT, ST)
C WRITE (NUTMX) NAME, NEL, NR, NC, NAMEL, (IBLNK, I=1, 5),
C ((W(I,J), I=1, NR), J=1, NC), (IVEC(I), I=1, NC)
C Calls Forma Subroutines EUC1, EAS1, PAGEHD, STFB, ZZBOME.
C Last Revision BY RL WOHLER. APRIL 1976.
C
C*****************************************************************************

C INPUT DATA READ IN THIS SUBROUTINE FROM NUTEL. IF NUTEL = 5, DATA IS
INPUT DATA REQUIREMENTS

AXIAL TORSION BENDING BENDING
ALONG ABOUT ABOUT ABOUT
LOCAL X LOCAL X LOCAL Z LOCAL Y

MASS A,RO PI,RO A,RO A,RO
STIF, LOAD TRANS A,TF TJ,G E12,AS,EF,E,G E12,AS,EF,E,G
BUCKLING NONE NONE NONE NONE
STRESS TRANS SEE STIF STIF+R STIF-FY STIF+CZ

For no shear deformation in bending, set any of A (not if axial used), SF, or G (not if torsion is used) to zero. If bending stress transformation is wanted, A must not be zero.

DEFEINITION OF INPUT VARIABLES
NAME = TYPE OF MASS MATRIX WANTED.
  = M1, DIAGONAL LUMPED.
  = M2, CONSISTENT.
  = 63, CR 64-HOMASS, NO MASS MATRIX CALCULATED.
NAMEK = TYPE OF STIFFNESS MATRIX WANTED.
  = K1, CONSTANT FORCE FOR AXIAL, CONSTANT TORQUE FOR TORSION, CONSTANT SHEAR AND LINEAR MOMENT FOR BENDING.
  = 63, CR 64-HOSTIF, NO STIFFNESS MATRIX CALCULATED.
NAMELT = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES.
  = 63, CR 64-HNCLOAD, NO LOAD TRANSFORMATIONS CALCULATED.
NAMEST = IDENTIFICATION NAME FOR STRESS TRANSFORMATION MATRICES.
  = 63, CR 64-HNCST, NO STRESS TRANSFORMATIONS CALCULATED.
NAMEB = TYPE OF BUCKLING MATRIX WANTED.
  = F1, AXIAL ROD.
  = F2, BEAM.
  = 63, CR 64-HNBUCK, NO BUCKLING MATRIX CALCULATED.
KODEK = OPTION CODE FOR AXIAL, TORSION, BENDING Z, BENDING Y LOCAL STIFFNESS. IF BLANK, ALL FOUR ARE CALCULATED. SIZE(4).
KODEK(1)=A, LOCAL STIF MATRIX IS CALCULATED FOR AXIAL (ALONG LOCAL X-AXIS).
KODEK(2)=T, LOCAL STIF MATRIX IS CALCULATED FOR TORSION (ABOUT LOCAL X-AXIS).
KODEK(3)=EZ, LOCAL STIF MATRIX IS CALCULATED FOR BENDING (ABOUT LOCAL Z-AXIS).
KODEK(4)=FY, LOCAL STIF MATRIX IS CALCULATED FOR BENDING (ABOUT LOCAL Y-AXIS).
KODEK = OPTION CODE FOR BUCKLING IN LOCAL Y OR Z DIRECTION.
  IF BLANK, BOTH ARE CALCULATED. SIZE(2).
KODEK(1)=FY, LOCAL BUCKLING MATRIX IS CALCULATED FOR...
BAR -- 3/7

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

R0 = MASS DENSITY.
E = YOUNGS 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 END 1. LOCAL X-AXIS ORIGINATES AT J1.
J2 = JOINT NUMBER AT 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 END 1.
A2 = SAME AS A1 AT END 2.
PI1 = CROSS-SECTION POLAR AREA OF MOMENT OF INERTIA FOR MASS
CALCULATIONS AT END 1.
PI2 = SAME AS PI1 AT END 2.
TJ1 = CROSS-SECTION VALENTS TORSION CONSTANT (J) IN JG FOR
TORSION STIFFNESS AT END 1.
TJ2 = SAME AS TJ1 AT END 2.
BI21 = CROSS-SECTION AREA MOMENT OF INERTIA ABOUT LOCAL Z-AXIS
(FOR BENDING) AT END 1.
BI22 = SAME AS BI21 AT END 2.
BIY1 = CROSS-SECTION AREA MOMENT OF INERTIA ABOUT LOCAL Y-AXIS
( FOR BENDING) AT END 1.
BIY2 = SAME AS BIY1 AT 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=0.5 FOR A THIN WALLED CIRCULAR CYLINDER.

IFPY1 = PIN JOINT OPTION FOR LOCAL COORDINATE THETA Y AT END 1.
= 1H; MOMENT JOINT.
= 1HP; PIN JOINT.
IFPY2 = SAME AS IFPY1 AT END 2.
IFPZ1 = PIN JOINT OPTION FOR LOCAL COORDINATE THETA Z AT END 1.
= 1H; MOMENT JOINT.
= 1HP; PIN JOINT.
IFPZ2 = SAME AS IFPZ1 AT 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 END 1.
R2 = SAME AS R1 AT END 2.
CY1 = DISTANCE FROM LOCAL XZ PLANE TO OUTER FIBER FOR BENDING
STRESS CALCULATION AT END 1. LOCAL Y DIRECTION.
CY2 = SAME AS CY1 AT END 2.
CZ1 = DISTANCE FROM LOCAL XY PLANE TO OUTER FIBER FOR BENDING
STRESS CALCULATION AT END 1. LOCAL Z DIRECTION.
CZ2 = SAME AS CZ1 AT END 2.

EXPLANATION OF INPUT FORMATS. NUMBER INDICATES CARD COLUMNS USED.
I = INTEGER 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 CORDER 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. IF 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
        BUCKLING MATRICES AND IVECS ARE OUTPUT.
        NUTBX MAY BE ZERO IF BUCKLING MATRIX IS NOT FORMED.
        USES FORTRAN READ, WRITE.
NULTL = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT LOCAL
        LOAD TRANSFORMATION MATRICES AND IVECS ARE OUTPUT.
        NULTL 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(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.

NEPROC EXPLANATION
1 = JOINT NUMBER GREATER THAN NUMBER OF JOINTS.
2 = STIFFNESS MATRIX FORMED, NUTKX LE. ZERO.
3 = LOAD TRANSFORMATION MATRIX FORMED, NULTL 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,A2,A2,4X,A2,A2)
1002 FORMAT (3(5X,E10.0))
1003 FORMAT (4(5X,E10.0))
1004 FORMAT (20X,E10.0)
2001 FORMAT (//46X 27INPUT DATA FOR BAR ELEMENTS)
2002 FORMAT (//46X 39INPUT DATA FOR BAR ELEMENTS (CONTINUED))
2003 FORMAT (45X,8HKODEK = A1,A1,A2,A2, 4X 8HKODEB = A2,A2,
*                      / 10X7HM  = A6, 6X7HSTIF = A6, 6X13HLOAD TRANS = A6,
*                      / 3X15HSTRESS TRANS = A6, 3X11HBUCKLING = A6,
*                      / 12X4HRC = E10.3, 6X3HE = E10.3, 80X7HI I I I,
*                      / 32X3HP = E10.3, 80X7HF F F F,
*                      / 125X7HP P P P,
*                      / 1X7THELEMENT 2X5HJOINT 2X5HJOINT 3X3HREF 5X4HAREA
*                      / 7X5HPOLAR 5X7HTORSION 3X9H2 BENDING 2X9HY BENDING
*                      / 2X5HSHEAP 3X6HSTRESS 5X6HSTRESS 5X6HSTRESS 3X7HY Z Y Z
*                      / 1X6HNUMBER 5X1H1 6X1H2 4X5HPPOINT
*                      / 1X4 7HINEF'TIA 5X5HCONST 5X7HINEF'TIA
*                      / 4X7HINEF'TIA 3X6HFACTOR 5X1HR 9X2HCY 9X2HCZ 5X7H1 I 2 2 2/)
2004 FORMAT (1X I5, I8, I27, 1X 5E11.3, F7.3, 3E11.3, 4(I1X1))
2005 FORMAT (29X,5E11.3,7X,3E11.3)

C
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,NAMET,NAMEST,NAMEB,
*                      (KODEK(I),I=1,4),(KODEB(I),I=1,2)
READ (NUTEL,1002) RO,E,G
WRITE (NOT,2003) (KODEK(I),I=1,4),(KODEB(I),I=1,2),
*                      NAMEK,NAMET,NAMEST,NAMESB,RO,E,G
20 READ (NUTEL,1003) NEL,J1,J2,JREF,A1,P11,TJ1,BIZ1,BIY1, SF,
*                      IFP IN,IFTAPR
IF (J1 .LE. 0) RETURN
IF (IFTAPR .EQ. 1HT) READ (NUTEL,1004) A2,P21,TJ2,BIZ2,BIY2
IF (NAMEST .EQ. 6H: OR. NAMET .EQ. 6HNOSTRS) GO TO 25
READ (NUTEL,1004) R1,CY1,CZ1,R2,CY2,CZ2
25 NLINE = NLINE + 1
IF (IFTAPR .EQ. 1HT) NLINE=NLINE+1
IF (NLINE .LE. 42) GO TO 30
CALL PAGEHD
WRITE (NOT,2002)
WRITE (NOT,2003) (KODEK(I),I=1,4),(KODEB(I),I=1,2),
*                      NAMEK,NAMET,NAMEST,NAMESB,RO,E,G
NLINE = C
30 WRITE (NOT,2004) NEL,J1,J2,JREF,A1,P11,TJ1,BIZ1,BIY1, SF,
*                      R1,CY1,CZ1,IPIN
ERROR=1
IF (J1 .GE. NJ .CR. J2 .GE. NJ .CR. JREF .GE. NJ) GO TO 999
IF (IFTAPR .EQ. 1HT) WRITE (NOT,2005) A2,P21,TJ2,BIZ2,BIY2,R2,
*                      CY2,CZ2
C
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
PI1 = PI1
TJ2 = TJ1
RI2 = R1Z1
EIV2 = EIV1
R2 = R1
CY2 = CY1
CZ2 = CZ1
C
FORM PINING IVEC.
50 NPIN = 0
DO 55 I=1,C
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),
STRESS TRANSFORMATION MATRIX (S).
100 IF (NAMEK .EQ. 6H .OR. NAMEK .EQ. 6HNOSTIF) GO TO 110
   CALL STF18 (CJ,EJ,KODEK,A1,A2,TJ1,TJ2,BI21,BI22,BIY1,BIY2,R1,R2,
   CY1,CY2,CZ1,CZ2,ST,E,G,NAMEK,NAMEST,W,T,S,NRST,
   KCJ,KCJ,KW,KW)
C
C
PIN STIFFNESS MATRIX.
IF (NPIN .EQ. 0) GO TO 105
CALL DCOS18 (CJ,EJ,W,KCJ,KCJ,KW)
CALL TRANS (W,TR,NRW,NRW,KW,KTR)
CALL MULTA (T,TR,NRL,T,NRW,NRW,KW,KTR)
CALL SRED3 (T,IV2,T,TD,NRW,NPIN,1,KW)
CALL MULTA (TD,W,TR,NRW,NRW,KW,KTD,KW)
CALL MULTA (T,TD,NRW,NRW,KW,KTR,KTD)
CALL MULTA (T,W,NRL,T,NRW,KW,KW)
CALL ATXPA1 (W,T,NRW,NRW,KW,KW)
IF (NAMEST .EQ. 6H .OR. NAMEST .EQ. 6HNOSTSTRS) 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,NAMET,(irlnk,i=1,5),
* ((mi,j),i=1,nrw,j=1,nrw),( IVII(I),I=1,nrw)
IF (NAMELT .EQ. 6H .OR. NAMELT .EQ. 6HLOAD) GO TO 115
IF (NUTLT .LE. 0) GO TO 999
WRITE (NUTLT) NAMLT, NEL, NRLT, NRW, NAMEL, (IBLNK, I=1,5),
* ((T(I,J), I=1, NRLT), J=1, NRW), (IVI(I), I=1, NRW)
115 IF (NAMEST .EQ. 6H .OR. NAMEST .EQ. 6HNOSTRS) GO TO 110
NERROR=4
IF (NUTST .LE. 0) GO TO 999
WRITE (NUTST) NAMEST, NEL, NRST, NRW, NAMEL, (IBLNK, I=1,5),
* ((S(I,J), I=1, NRST), J=1, NRW), (IVI(I), I=1, NRW)
C
C FORM MASS MATRIX (W).
110 IF (NAMEM .EQ. 6H .OR. NAMEM .EQ. 6HNO MASS) GO TO 140
CALL MAS1B (CJ, EJ, AI, AZ, PI1, PI2, RO, NAMEM, W, T, KCJ, KCJ, KW, KW)
C
C PIN MASS MATRIX.
   IF (NPIN .GT. 0) CALL BTABA (W, TR, NRW, NRW, KW, KTR)
NERROR=5
IF (NUTMX .LE. 0) GO TO 999
WRITE (NUTMX) NAMEM, NEL, NRW, NRW, NAMEL, (IBLNK, I=1,5),
* ((W(I,J), I=1, NRW), J=1, NRW), (IVI(I), I=1, NRW)
C
C FORM UNIT LOAD BUCKLING MATRIX (W).
140 IF (NAMEB .EQ. 6H .OR. NAMEB .EQ. 6HNOBUCK) GO TO 20
CALL BUC1B (CJ, EJ, KODEB, NAMEB, W, S, KCJ, KCJ, KW, KW)
NERROR=6
IF (NUTPX .LE. 0) GO TO 999
WRITE (NUTPX) NAMEB, NEL, NRW, NRW, NAMEL, (IBLNK, I=1,5),
* ((W(I,J), I=1, NRW), J=1, NRW), (IVI(I), I=1, NRW)
GO TO 28
C
999 CALL Z2BOMB (6HBAR , NERROR)
END
SUBROUTINE RUCIB (CJ, EJ, KODEB, NAMER, 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 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 BIA1, BIA2, BTAB, DCOIS, Z2BOMB.
C DEVELOPED BY RL WOHLGEN. AUGUST 1973.
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 COL 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 NAMER = INPUT TYPE OF BUCKLING MATRIX WANTED.
C = P1, AXIAL ROD.
C = E2, BEAM.
C W = OUTPUT BUCKLING MATRIX. SIZE(12,12).
C = 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 NAMER.
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
PL = SQRT((CJ(1,2)-CJ(1,1))**2 + (CJ(2,2)-CJ(2,1))**2
     + (CJ(3,2)-CJ(3,1))**2)
KODEB = 1
KODEE = 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. 2HBEZ) KODEFB2 = 0
10 IF (NAMEB .EQ. 6HB1) GO TO 10
   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 (6HBUCIB, NERROR)
      END
SUBROUTINE DCOS1A (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
DX1,DX2
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,MULTR,ZIBOMB.
DEVELOPED BY RL Wohlen. 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.
COLUMNS 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.
COLUMNS 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
10 DO 10 J=1,6
10 Z(I,J) = 0.0
CALL EULEP(EJ(I,1),T,3)
CALL MULTR(P,T,1,3,3,1,3)
DO 22 J=1,3
22 Z(I,J) = T(1,J)
CALL EULEP(EJ(1,2),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 (6HDCOSIA,ERROR)
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
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, D11, D12, D21, D22, TY1, TY2
C WHERE DX, DY, DZ ARE TRANSLATIONS AND TX, TY, T2 ARE ROTATIONS.
C COLUMN ORDER (GLOBAL COORDINATE ORDER) OF DIRECTION COSINE MATRIX IS
C (UX, VY, WZ, PX, PY, PR) AND JOINT 1, THEN JOINT 2
C WHERE UX, VY, WZ ARE TRANSLATIONS AND PX, PY, PR ARE ROTATIONS.
C EULER ANGLE CONVENTION IS GLOBAL X, Y, Z PERMUTATION.
C CALLS FORMA SUBROUTINES EULEP, MULTB, ZBOMB.
C DEVELOPED BY RL WOHLLEN. FEBRUARY 1973.
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 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 = RX*PY - RZ*PX
OY = RZ*PX - RX*PZ
OZ = RX*PY - RY*PX
QL = SQRT(OX**2 + OY**2 + OZ**2)
W(1,1) = PX/PL

NERROR = 1
DCOS1B-- 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) = GZ/OL
W(3,1) = RX/RL
W(3,2) = PY/RL
W(3,3) = RZ/RL
DO 10 J=1,12
   10 I=1,12
10 : (I,J) = 0.0
   CALL EULEP (EJ(1,1),T,3)
   CALL MULTR (W,T,3,3,3,3,3)
   DC 22 J=1,3
      Z(1,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(1,2),T,3)
   CALL MULTR (W,T,3,3,3,3,3)
   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(3,J)
   24 Z(12,JP9) = T(2,J)
RETURN
999 CALL ZZBOMB (6DCOS1B,NERROR)
END
SUBROUTINE DCSOS2 (CJ,EJ,Z,KCJ,KEJ,KZ)

DIMENSION CJ(KCJ,1), EJ(KEJ,1), Z(KZ,1)

DIMENSION W(3,3), T(3,3)

SUBROUTINE TO CALCULATE FINITE ELEMENT...

DIRECT COSINE MATRIX

FOR A COMBINED MEMBRANE-PENDING TRIANGLE PLATE ELEMENT.

THE DIRECT 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 DIRECT COSINE MATRIX IS

(PX, DY, TZ) JOINT 1, THEN JOINT 2, 3, NEXT

(TZ, 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 DIRECT COSINE MATRIX IS

(U, V, W) JOINT 1, THEN JOINT 2, 3.

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

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

CALLS FORM SUBROUTINES EULER, MULT, ZIZZBOM.

DEVELOPED BY WA BENFIELD, FEBRUARY 1973.

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.

CALS 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.

CALS 1, 2, 3 CORRESPOND TO JOINTS 1, 2, 3. SIZE(3,3).

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

KCJ = INPUT NUMBER 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.

ERROR EXPLANATION

1 = DIMENSION SIZE LESS THAN 18.

IF (KZ .LT. 18) GO TO 999

IF (KZ .LT. 18) 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)

FX = PY*(CJ(2,3)-CJ(3,1)) - PZ*(CJ(2,3)-CJ(2,1))

RY = PZ*(CJ(1,3)-CJ(1,1)) - PX*(CJ(3,3)-CJ(1,1))

RZ = PX*(CJ(2,3)-CJ(2,1)) - PY*(CJ(1,3)-CJ(1,1))

RL = SQRT(FX**2 + RY**2 + RZ**2)

QX = FY*PZ - RZ*PY

LY = RZ*PX - PX*FY

QZ = PX*FY - FY*PX

CL = SQRT(CL**2 + QY**2 + QZ**2)

W(1,1) = PX/PL

W(1,2) = PY/PL
DCOS2  --  2/2

W(1,3) = PZ/PL
W(2,1) = QX/QL
W(2,2) = QY/QL
W(2,3) = QZ/QL
W(3,1) = RX/RL
W(3,2) = RY/RL
W(3,3) = RZ/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(1,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 = J2Z+JW
    Z(IZZ+1,JZ) = T(1,JW)
    Z(IZZ+2,JZ) = T(2,JW)
    Z(IZZ+3,JZ) = T(3,JW)
    JZ = J2Z+2
    Z(IZZ+4,JZ) = T(3,JW)
    Z(IZZ+5,JZ) = T(1,JW)
  50    Z(IZZ+6,JZ) = T(2,JW)
RETURN
C
999 CALL ZZSCME (6HDCOS2 ,NERRDR)
END
SUBROUTINE DCO3C (CJ,EJ,Z,KCJ,KEJ,KZ)
DIMENSION CJ(KCJ,1), EJ(KEJ,1), Z(KZ,1)
DIMENSION W(2,3), T(3,3)
C
C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C DIRECTION COSINE MATRIX
C FOR A RECTANGULAR SHEET 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,MULTIPLEZ.
C DEVELOPED BY RL WOLLEN. 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 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 NEPSRC. EXPLANATION
C 1 = DIMENSION SIZE TOO SMALL.
C
IF (KZ .LT. 4) CC TO 999
PX = CJ(1,1)-CJ(1,1)
PY = CJ(1,2)-CJ(2,1)
PZ = CJ(1,3)-CJ(3,1)
PL = SQRT(PX**2 + PY**2 + PZ**2)
CJ = 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 + CZ**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
C
CERROR=1
DO 10 J=1,12
50 DO 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 ZZGOMB (6,HDCOS3C,NERROR)
END
SUBROUTINE EULER (E, R, KR)
DIMENSION E(1), R(KR, 1)

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

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

C DIOR = ATAN2(1., 1.)/45.

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

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

C RETURN
END
SUBROUTINE FINAL (XYZ,JDOF,EUL,NUTEL,NJ,
  MUTM,NUTK,NULT,L,NUTL,NUTS,NUTE,V,LV,KV,
  KRX,KRZ,KRE,NUTM,NUTX,NUTY,NUT1,NUT2,NUT3)

DIMENSION XYZ(KRX,1), JDOF(KRX,1), EUL(KRE,1), V(1), LV(1)
DIMENSION W1(24,24), W2(24,24), W3(24,24)
DATA KW/24/, IELANK/6/
DATA NIT,NOT/5,6/

SUBROUTINE TO CALCULATE (ON OPTION) FINITE ELEMENT...  
ASEMBLED MASS MATRIX (ON MUTM). 
ASEMBLED STIFFNESS MATRIX (ON NUTK). 
ELEMENT LOCAL LOAD TRANSFORMATION MATRICES, IVECS (ON NULT), 
ELEMENT GLOBAL LOAD TRANSFORMATION MATRICES, IVECS (ON NUTX), 
ELEMENT STRESS TRANSFORMATION MATRICES, IVECS (ON NUTS), 
ELEMENT UNIT LOAD BUCKLING MATRICES, IVECS (ON NUT1). 
IVEC GIVES ELEMENT DOF INTO GLOBAL DOF. EXAMPLES...  
IVEC(6)=834 PLACES ELEMENT DOF 6 INTO GLOBAL DOF 834. 
IVEC(3)=6 OMITS ELEMENT DOF 2 FROM GLOBAL DOF. THIS CONSTRAINTS 
ELEMENT DOF 3 TO ZERO MOTION. 
DATA ARRANGEMENT ON MUTM, NUTK FOR THE ASSEMBLED MATRICES IS IN 
SPARSE (Y) FORMA SUBROUTINE FORMAT. 
DATA ARRANGEMENT ON NULT, NUTX, NUTS, NUTP FOR EACH FINITE 
ELEMENT (WRITTEN IN SUBROUTINE AXIAL, BAR, ETC) IS 
WRITE (NUTM) NAMEW,NEL,INF,NC,NAMEL (IBLANK,1,5), 
(CW1,I,J,I=1,INF,J=1,NC), (IVEC(I),I=1,NC) 
NAMEW = NAMELT,NAMEXX,NAMEST, OR NAMEB. 
NAMEL = AXIAL,PAP, ETC. 
LAST RECORD TO DENOTE TERMINATION IS, 
WRITE (NUTM) IELANK,(11,1=1,36) 
The FOLLOWING UTILITY TAPES USE BASIC FORTRAN READ, WRITE. DO NOT 
USE THESE TAPES IN SPARSE (Y) FORMA SUBROUTINES WHICH USE FORMA 
SUBROUTINES YIN, YOUT (BECAUSE THEY USE BUFFER IN, BUFFER OUT). 
NULT, NUTS, NUTX, NUTK, NUTE. 
The FOLLOWING UTILITY TAPES USE FORMA YIN, YOUT. 
NUTM, NUTK, NULT, NUTL, NUTS. 
CALLS FORMA SUBROUTINES AXIAL, BAR, FLUID, GRAVITY, PAGEHD, QUAD, 
RECTSP,TAPM, YRVAZ, ZI6CMB. 
LAST REVISION BY RL WOHLLEN. MAY 1976. 

***************************************************************************** 
INPUT DATA READ IN THIS SUBROUTINE FROM NUTEL. IF NUTEL = 5, DATA IS 
READ FROM CARDS. 
50 NAMEL FORMAT (A6) 
C IF (NAMEL .EQ. 6) RETURN RETURN 
C IF (NAMEL .EQ. 6AXIAL) CALL AXIAL (SEE SUBRT FOR INPUT) 
C IF (NAMEL .EQ. 6HFLUID) CALL FLUID (SEE SUBRT FOR INPUT) 
C IF (NAMEL .EQ. 6HGRAVITY) CALL GRAVITY (SEE SUBRT FOR INPUT) 
C IF (NAMEL .EQ. 6HQUAD) CALL QUAD (SEE SUBRT FOR INPUT) 
C IF (NAMEL .EQ. 6HRECTSP) CALL RECTSP (SEE SUBRT FOR INPUT) 
C IF (NAMEL .EQ. 6HTRNGL) CALL TRNGL (SEE SUBRT FOR INPUT) 
C GO TO 50 
C 
C DEFINITION OF INPUT VARIABLES.
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).

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

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 EQUIVALENTED TO VIKR*(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 NAMC.

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

NUTH = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ASSEMBLED MASS MATRIX IS OUTPUT IN SPARSE NOTATION.

NUTM MAY BE ZERO IF MASS MATRIX IS NOT FORMED.

USES FORTRAN READ, WRITE.

NUTK = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ASSEMBLED STIFFNESS MATRIX IS OUTPUT IN SPARSE NOTATION.

NUTK 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.

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.

NUTB = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT UNIT LOAD RUCKLING MATRICES AND IVECS ARE OUTPUT.

NUTB MAY BE ZERO IF RUCKLING MATRICES ARE NOT FORMED.

USES FORTRAN READ, WRITE.

V = VECTOR WORK SPACE.

LV = VECTOR WORK SPACE.

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

KR = ROW DIMENSION OF XYZ IN CALLING PROGRAM.

KJ = ROW DIMENSION OF JDOF IN CALLING PROGRAM.

KRE = ROW DIMENSION OF EUL IN CALLING PROGRAM.

NUTMX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT MASS MATRICES AND IVECS ARE STORED.

NUTMX MAY BE ZERO IF MASS MATRIX IS NOT FORMED.

USES FORTRAN READ, WRITE.
C NUTKX = LOGICAL NUMBER OF UTILITY Tape ON WHICH ELEMENT
STIFFNESS MATRICES (SAME AS GLOBAL LOADS TRANSFORMATION
MATRICES) AND IVECS 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
ERROR EXPLANATION
C 1 = NAMEL IMPROPERLY DEFINED.
C
1001 FORMAT (A6)
2001 FORMAT (/41X 25HJOINT DATA USED IN SUBROUTINE FINEL)
2002 FORMAT (/35X 47HJOINT DATA USED IN SUBROUTINE FINEL (CONTINUED))
2003 FORMAT (/16X .8HDEGREES OF FREEDOM
  *   1P9 2EPGLOBAL CARTESIAN COORDINATES
  *   12X 2HEULER ANGLES (DEGREES)
  *  /14X 11HTRANSATION 8X 8ROTATION
  *  /2X5HJOINT 6X1HV 5X1HV 'X1HP 5X1HQ 5X1HR
  *                    11X1HX 11X1HY 11X1HZ 14X1HM 10X1HY 10X1HZ /
2004 FORMAT (1X I5, 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 NUTEI
IF (NUTLT .GT. 0) REWIND NUTLT
IF (NUTST .GT. 0) REWIND NUTST
C
Determine size of final mass-stiffness matrix from the maximum dof
C number in JDOF.
NDOF = JDOF(1,1)
DO 35 I=1,NJ
DO 35 J=1,6
IF (JDOF(I,J) .GT. NDOD) NDOF=JDOF(I,J)
35 CONTINUE
C
PRINT joint dof, xyz coordinates, euler angles.
CALL PAGEHD
WRITE (NOT,2001)
WRITE (NOT,2003)
NLINE = 0
DO 40 IJ=1,NJ
NLINE = NLINE+1
IF (NLINE .LE. 42) GO TO 40
CALL PAGEHD
WRITE (NOT,2002)
WRITE (NOT,2003)
NLINE = 1
40 WRITE (NOT,2004) IJ, (JDOF(IJ,J), J=1,6), (XYZ(IJ,J), J=1,3),
  *               (EUL(IJ,J), J=1,3)
C
READ finite element type.
50 READ (NUTEX,1001) NAMEL
IF (NAMEL .EQ. 6HRETURN) GO TO 50C
IF (NAMEL .EQ. 6MAXIAL) GO TO 110
IF (NAMEL .EQ. 6HEAR) GO TO 140
IF (NAMEL .EQ. 6TRNGL) GO TO 150
IF (NAMEL .EQ. 6HEFLUID) GO TO 151
IF (NAMEL .EQ. 6HEQUC) GO TO 160
IF (NAMEL .EQ. 6HERECTSP) GO TO 162
IF (NAMEL .EQ. 6HGRAVITY) GO TO 171

NERROR=1
    GO TO 999

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

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

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

C GRAVITY ELEMENT.
171 CALL GRAVITY (XYZ, JDCF, EUL, NUTEL, NJ,
    * NUTKX,
    * 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 (NUTB .GT. 0) WRITE (NUTB) IBLANK, (II, I=1,30)
    IF (NUTLT .GT. 0) WRITE (NUTLT) 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 YZERO (NUTM, NDCF, NDCF)
    IF (NUTKX .GT. 0) CALL YZERO (NUTK, NDCF, NDCF)
IF (NUTMX .GT. 0) CALL YRVAD2 (NUTMX, NUTMX, NDOF, W1, KW, V, LV, KV,
   NUT1, NUT2, NUT3)
* RETURN

C 999 CALL ZZBOMB (6HF, FINEL, ERROR)
END
SUBROUTINE FLUID (XYZ, JDCF, EUL, NUTEL, NJ,
* NUTMX, NUTCX, NULTL, NUTST,
* W, T, S, KX, KJ, KE, KW)
DIMENSION XYZ(KX, 1), JDCF(KJ, 1), EUL(KE, 1), W(KW, 1),
* (KX, 1), (KJ, 1)
DIMENSION CJ(5, 8), EJ(3, 8), IVL(24), IVTET(12), JM(4, 16), VLT(10),
* DV(12), DIST(12, 12), TV(24)
DATA NRW, NIMST/24, 1/, IBLNK/6H /, IJST /0/
DATA NIT, NOT/ 56 /
DATA NAMET / FLUID /
DATA KCI / 2, JCJ / 4 /
DATA KDST / 12, IFBAD / 1 /
DATA JM/1, 2, 3, 4, 5, 6, 7, 8, 9, 10/
DATA IVL/1, 2, 3, 4, 5, 6, 7, 8 /
DATA IVTET/1, 2, 3, 4, 5, 6, 7, 8 /
DATA IVL(1), IVL(2), IVL(3), IVL(4), IVL(5), IVL(6), IVL(7), IVL(8) /
DATA IVTET(1), IVTET(2), IVTET(3), IVTET(4), IVTET(5), IVTET(6), IVTET(7) /
DATA IVTET(8), IVTET(9), IVTET(10), IVTET(11), IVTET(12), IVTET(13), IVTET(14), IVTET(15), IVTET(16) /
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 NUTCX), C PRESSURE TRANSFORMATION MATRICES AND IVECS (ON NUTST), 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 OMITS 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 HEIGHT IS NOT INCLUDED. C DATA ARRANGEMENT ON NUTMX, NUTCX, NUTST FOR EACH FINITE ELEMENT IS C (W=M, K, ST) C WRITE (NUTWX) NAMET, NEL, NP, NC, NAMET, (IBLNK, I=1, 5), C (J(1, J, I=1, MR), J=1, NC, IVEC(I), I=1, NC) C CALLS FORMA SUBROUTINES TEGEM, VCD, VDOT , ZBOMB. C DEVELOPED BY C S EDDLEY. 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, NAMELT, NAMET FORMAT (4(A6, 4X) C RC, EKM FORMAT (2(5X, E10)) C NZ, NEL, J1, J2, J3, J4, J5, J6, J7, J8 FORMAT (9I5) 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-IRROTATIONAL CONSISTENT MASS MATRIX.
C = M3, IRROTATIONAL MASS MATRIX.
C = 6P or 6HNASS, NO MASS MATRIX CALCULATED.

NAMEK = TYPE OF STIFFNESS MATRIX WANTED.
C = 1, LINEAR DISPLACEMENT ASSUMED.
C = 6H or 6HNOSTIF, NO STIFFNESS MATRIX CALCULATED.

NAMELT = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES, (NOT YET).
C NAMEST = IDENTIFICATION NAME FOR PRESSURE TRANSFORMATION MATRICES.
C = 6H or 6HNOSTRS, NO PRESSURE TRANSFORMATIONS CALCULATED.

NAME = TYPF STIFFNESS MATRIX WANTED.
C = KIT, LINEAR DISPLACEMENT ASSUMED.
C = 6HNOSTIF, NO STIFFNESS MATRIX CALCULATED.

C NAMELT = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES, (NOT YET).
C NAMEST = IDENTIFICATION NAME FOR PRESSURE TRANSFORMATION MATRICES.
C = 6H or 6HNOSTRS, NO PRESSURE TRANSFORMATIONS CALCULATED.

C RO = MASS DENSITY.
C BKM = 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 CLOCKWISE AS
VIEWED FROM OUTSIDE THE ELEMENT.
C J5 = JOINT NUMBER AT ELEMENT VERTEX 5. (USED FOR PENTAHEDRON AND
C HEXAHEDRON).
C J6 = JOINT NUMBER AT ELEMENT VERTEX 6. (USED FOR PENTAHEDRON AND
C HEXAHEDRON).
C FOR A PENTAHEDRON, FACE 1,2,3 MUST BE NUMBERED CLOCKWISE 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 CLOCKWISE 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.

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.

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.

NULTT = 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).

KK = ROW DIMENSION OF XYZ IN CALLING PROGRAM.
KJ = ROW DIMENSION OF JOEF IN CALLING PROGRAM.
KE = ROW DIMENSION OF EUL IN CALLING PROGRAM.


EXIT 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(5))
2001 FORMAT (//25X 38H INPUT DATA FOR FLUID (TETRA, PENTA, OR
* 21H HXAHEDRON) ELEMENTS)
2002 FORMAT (//20X 38H INPUT DATA FOR FLUID (TETRA, PENTA, OR
* 33H HXAHEDRON) ELEMENTS (CONTINUED))
2003 FORMAT (/12X7HMES = A6,13X7HSTIF = A6,6X13HLOAD TRANS = A5,
* 3X15HSRESS TRANS = A6, 3X
* / 15X4FRC = 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))
3001 FORMAT (51H ** ** ** ** UNCONVENTIONAL JOINT NUMBERING ** ** ** ** */
* 915)

C

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

3 NLINE = 0
CALL PAGEHD
WRITE (NOT,2001)
READ (NUTEL,1001) NAMFM,NAMFK,NAMELT,NAMEST
READ (NUTEL,1002) RO, BKM
WRITE (NOT,2003) NAMEM,NAMFK,NAMELT,NAMEST,
* RO, BKM
IF (YAMFM .NE. 6H33 ) GO TO 20
DO 2 I=1,12
  2 DIST(I,1) = 2.
C
20 READ (NUTEL,1003) NEL,J1,J2,J3,J4,J5,J6,J7,J8
    NERRDR=1
    IF (J1.LE.0 .AND. IFRAD.EQ.-1) GO TO 999
    IF (J1 .LE. 0) RETURN
    NLINE = NLINE + 1
    IF (NLINE .LE. 42) GO TO 30
    CALL PAGEHD
    WRITE (NOT,2002)
    WRITE (NOT,2003) NAMEM,NAMFK,NAMELT,NAMEST,
    * RO, BKM
    NLINE = 0
30 WRITE (NOT,2004) NEL,J1,J2,J3,J4,J5,J6,J7,J8
    NERRDR=2
    IF (J1.GT.NJ .OR. J2.GT.NJ .OR. J3.GT.NJ .OR. J4.GT.NJ) GO TO 999
    IF (J5.GT.NJ .OR. J6.GT.NJ .OR. J7.GT.NJ .OR. J8.GT.NJ) GO TO 999
C
C FORM FINITE 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 NCOL = 2*NJN
    DO 5 I=1,NCCL
      DO 5 J=1,NCCL
       WI(I,J) = 0.
       S(I,J) = 0.
       T(I,J) = 0.
      5
    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,I)
      EJ(I,1) = EUL(J1,I)
      EJ(I,2) = EUL(J2,I)
      EJ(I,3) = EUL(J3,I)
      EJ(I,4) = EUL(J4,I)
      IV1(I ) = JDOF(J1,I)
      IV1(I+3) = JDOF(J2,I)
      40
IVL(I+6) = JDCF(J3,I)
40 IVL(I+9) = JDCF(J4,I)
   IF (LR * EQ. 11) GO TO 50

C
DO 42 J=1,3
   CJ(J,5) = XYZ(J5,J)
   CJ(J,6) = XYZ(J6,J)
   EJ(J,5) = EUU(J5,J)
   EJ(J,6) = EUU(J6,J)
IVL(I+12) = JDCF(J5,I)
42 IVL(I+15) = JDCF(J6,I)
   IF (LP * EQ. 6) GO TO 50

C
DO 44 J=1,3
   CJ(J,7) = XYZ(J7,J)
   CJ(J,8) = XYZ(J8,J)
   EJ(J,7) = EUU(J7,J)
   EJ(J,8) = EUU(J8,J)
IVL(I+18) = JDCF(J7,I)
44 IVL(I+21) = JDCF(J8,I)

C
50 DO 52 L=1,LR
   LA = L
   IF (LR * EQ. 10) LA=L+6
   DO 52 I=1,4
      JNO = JM(1,LA)
      LI = 3*I - 2
      IVTFL(I) = 5*JNC - 2
      IVTFL(I+1) = 5*JNC - 1
   53 IVTFL(I+2) = 5*JNC

C
   CALL TEGEOM (CJ, JM(LA), VL(L), Dv, KJ, IFEAD)
   IF (IFBAD NE. 0) GO TO 51
   WRITE (NO7,3001) NEL, J1, J2, J3, J4, J5, J6, J7, J8
   IFBAD = -1
   51 SM = RO*VL(L)/16.0
   IF (NAMEE * EQ. 6HM3 ) SM=RO*VL(L)/20.0
   IF (LR * EQ. 1) SM = SM/2.
   CALL REVADD (15, Dv , IVTET, T, 12, LR, NCOL, I, KW)
52 CALL REVADD (SM, DIST, IVTET, IVTET, W, 12, 12, NCOL, NCOL, KDIST, KW)

C
   IF (NAMEE * NE. 6HM1 ) 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 * EQ. 1) GO TO 60
   DO 55 I=2, LR
      VL(I) = VL(I) + VL(I)
   DO 55 J=1, NCOL
      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
56   CALL EULE (E(J1, J), S(J1, J1), KW)
      IF (NAMEST .LT. 6H .OR. NAMEST .EQ. 6HNOSTIF) GO TO 90
      CALL PRESS (C, T, KJN, NCOL, KCJ, KW)
      CALL MULTI (T1, S, KJN, NCOL, NCOL, KW, KW)
90   CALL RTAP (W, S, NCOL, NCOL, KW, KW)
      CALL MULTI (TV, S, 1, NCOL, NCOL, 1, KW)
      BOV = EKM/TV(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 .OR. NAMEM .EQ. 6HNCMSS) GO TO 110
      NERROR = 3
      IF (NUTMX .LE. 0) GO TO 999
      WRITE (NUTMX) NAMEM, NEL, NCOL, NCOL, NAMEL, (I, I = 1, 5),
      *   ((W(I, J), I = 1, NCOL), J = 1, NCOL), (IVI(I), I = 1, NCOL)
C
110  IF (NAMEK .EQ. 6H .OR. NAMEK .EQ. 6HNOSTIF) GO TO 120
      NERROR = 4
      IF (NUTKX .LE. 0) GO TO 999
      WRITE (NUTKX) NAMEK, NEL, NCOL, NCOL, NAMEL, (I, I = 1, 5),
      *   ((S(I, J), I = 1, NCOL), J = 1, NCOL), (IVI(I), I = 1, NCOL)
C
120  IF (NAMEST .EQ. 6H .OR. NAMEST .EQ. 6HNOSTIF) GO TO 20
      NERROR = 5
      IF (NUTST .LE. 0) GO TO 999
      NJNP1 = NJN + 1
      CALL MULTI (T, S, 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, NCOL, NAMEL, (I, I = 1, 4),
      *(T(I, J), I = 1, NRST), J = 1, NCOL), (IVI(I), I = 1, NCOL)
      GO TO 20
C
999   CALL ZZBOMF (6HFLUID, NERROR)
      END
SUBROUTINE GRAVITY (XYZ, JDOF, EUL, NUTEL, NJ,
  * NUTXX,
  * W, T, S, KX, KJ, KE, KW)
DIMENSION XYZ(KK,1), JDOF(KJ,1), EUL(KE,1), W(KW,1),
  * (KW,1), S(KW,1)
DIMENSION CJJ(3,4), EJ(3,4), IVI(12), IVTRI(9), JM(3,4), GV(3), EV(3)
DATA IBLNK/6H /
DATA NIT, NJT/5, 6 /
DATA NAMEL/6HGRAVITY /
DATA KCJM/3 /
DATA JM/1, 2, 3, 1, 3, 4, 1, 2, 4, 4, 2, 3 /
C
C SUBROUTINE TO CALCULATE (ON OPTION) FINITE ELEMENT ...
C STIFFNESS MATRICES (SAME AS GLOBAL LOAD TRANSFORMATION MATRICES)
C AND IVECS (ON NUTXX),
C FOR GRAVITY ELEMENTS.
C STIFFNESS MATRICES ARE 9- GLOB-49-1T 4IR 090-58
C GLOBAL COORDINATE ORDER IS
C (U, V, W) JOINT 1, THEN JOINT 2, 3, (4).
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 OMITS ELEMENT DOF 3 FROM GLOBAL DOF. THIS CONSTRAINTS
C ELEMENT DOF 3 TO ZERO MOTION.
C DATA ARRANGEMENT ON NUTXX FOR EACH FINITE ELEMENT IS
C (W=K)
C WRITE (NUTXX) NAMEL, NEL, NR, NC, NAMEL, IBLNK, I=1,5,
C ((W(I,J), I=1, NP), J=1, NC), (IVEC(I), I=1, NC)
C CALLS FORMA SUBROUTINES KGRAV, MULTA, MULTB, VCGROSS, ZZBOMB.
C DEVELOPED BY C S GODLEY. 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 NAMEL, NAMEK FORMATT (2(A6,4X)
C RO FORMATT (5X,G10)
C (GV(I), I=1,3) FORMATT (3(5X,E10))
C 20 NEL, J1, J2, J3, J4 FORMATT (5I5)
C IF (J1 = 0) RETURN
C GO TO 20
C
C DEFINITION OF INPUT VARIABLES.
C NAMEL = TYPE OF MASS MATRIX WANTED.
C = 6H OR 6HNONMASS, NO MASS MATRIX CALCUATED.
C NAMEK = TYPE OF STIFFNESS MATRICES WANTED.
C = K1, LINEAR DISPLACEMENT ASSUMED.
C = 6H OR 6HNONSTIF, NO STIFFNESS MATRIX CALCUATED.
C RO = MASS DENSITY.
C GV = GRAVITY VECTOR.
C NEL = FINITE ELEMENT NUMBER, FOR REFERENCE ONLY, NOT USED IN
C CALCULATIONS, WRITTEN ON NUTXX.
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. (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 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 = NIT, DATA IS READ FROM CARDS.
C NJ = NUMBER OF JOINTS OR ROWS IN MATRICES (XYZ), (JDOF), (EUL).
C NUTX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
C STIFFNESS MATRICES (SAME AS GLOBAL LOADS TRANSFORMATION
C MATRICES) AND IVCS ARE OUTPUT.
C NUTX 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 XX = 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 NERD+0 EXPLANATION
C 1 = INPUT JOINT NUMBER EXCEEDS MAXIMUM ALLOWABLE NUMBER OF JOINTS.
C 2 = NUTX NOT POSITIVE.
C
1001 FORMAT (5(A6,4X))
1002 FORMAT (3(5X,E10.0))
1003 FORMAT (F15)
2001 FORMAT (//45X 'INPUT DATA FOR GRAVITY STIFFNESS (TRIANGLE OR
* (24+ QUADRILATERAL) ELEMENTS)
2002 FORMAT (//20X 'INPUT DATA FOR GRAVITY STIFFNESS (TRIANGLE OR
* (26+ QUADRILATERAL) ELEMENTS (CONTINUED))
2003 FORMAT (/12X7HMASS = A6,13X7HSTIF = A6,6X
* / 15X,4HRQ = E10.3, 13X5HGVX = E10.3, 13X5HGVY = E10.3,
* 13X5HGVZ = E10.3,
* //13X7HLEMENT 13X7HJOINT 1 13X7HJOINT 2 13X7HJOINT 3
* //13X7HJOINT 4
* /15X6HNUMBER)
2004 FORMAT (16X,9(15,15X))
C
C NLINE = 0
CALL PAGEHD
WRITE (NOT,2001)
READ (NUTFL,1001) NAMEM,NAMER
READ (NUTEL,10C2) R0
READ (NUTFL,1002) (GV(I),I=1,3)
WRITE (NOT,2003) NAMEM,NAMER,
* RC, (GV(I),I=1,3)
C
20 READ (NUTFL,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) NAMEM,NAMER,
* RC, (GV(I),I=1,3)
NLINE = 0
30 WRITE (NOT,2004) NEL,J1,J2,J3,J4
C
FORM FINITE ELEMENT COORDINATE 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
S(I,J) = 0
5 T(I,J) = 0
5 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) = 0UL(J1,I)
FJ(I,2) = 0UL(J2,I)
FJ(I,3) = 0UL(J3,I)
IV1(I) = JDCF(J1,I)
IV1(I+3) = JDCF(J2,I)
40 IV1(I+6) = JDCF(J3,I)
IF (LP .NE. 1) GO TO 50
C
DO 42 I=1,3
CJ(I,4) = XYZ(J4,I)
FJ(I,4) = 0UL(J4,I)
42 IV1(I+9) = JDCF(J4,I)
C
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 I=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 .GT. 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(1,J),T(J1,J1),KW) 
   CALL ETAHA (S,T,NCOL,NCOL,KW,KW) 
C
IF (NAMEK .EQ. '6H' .CR. NAMEK .EQ. '6HNDSTIF') GO TO 20 
   NERROR=2 
   IF (NUTKY .LE. 0) GO TO 999 
WRITE (NUTKY) NAMEK,NFL,NCOL,NCOL,NAMEL,(IBLNX,I=1,5), 
   *(S(I,J),I=1,NCOL),J=1,NCOL), (IVII(I),I=1,NCOL) 
C
GO TO 20 
C
999 CALL ZZBOMP (6HGRAVY,NERROR) 
END
SUBROUTINE KIA1 (A1,A2,RL,E,2,TS,KZ,KTS)
DIMENSION Z(KZ,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 X 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 DEVELOPED BY RL WOHLEN. SEPTEMBER 1972.
C LAST REVISION BY RL WOHLEN. SEPTEMBER 1973.
C
C SUBROUTINE ARGUMENTS
C A1 = INPUT CROSS-SECTION AREA AT ROD END 1.
C A2 = INPUT CROSS-SECTION AREA AT ROD END 2.
C RL = INPUT ROD LENGTH.
C E = INPUT YOUNG'S MODULUS OF ELASTICITY.
C Z = OUTPUT STIFFNESS MATRIX. SIZE(2,2).
C TS = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(2,2).
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=2.
C KTS = INPUT ROW DIMENSION OF TS IN CALLING PROGRAM. MIN=2.
C
S = A1*E/RL
R = A2/A1
IF (A*SR(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
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,RF,RL,E,G,Z,TS,K2,KTS)
DIMENSION Z(PZ,1), TS(KTS,1)
DATA EPS/3.0E-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*G. 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 D2 IS TRANSLATION AND TY IS ROTATION.
C  DEVELOPED BY RL WOHLN. FEBRUARY 1973.
C  LAST REVISION BY RL WOHLN. APRIL 1976.
C
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 SHEAR 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 PL = 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 BENDING FLEXIBILITY.
PP1 = F12/F11
REIM1 = PP1-1.
IF (ABS(REIM1) .LT. .01) GO TO 15
ERR = F11*P*PIM1
REILN = ALOG(ERR)
C
F11 = (0.5 - 1. * RBIM1 + RBILN/RBIM1**2) * (RL**3) / EBR
F12 = (1. - RBILN/RBIM1) * (RL**2) / EBR
F22 = RL* RBILN / EER
GO TO 20
15 F11 = RL**3 / (3.*E*B11)
F12 = RL**2 / (2.*E*B11)
F22 = RL/ (E*B11)
C SHEAR FLEXIBILITY
20 IF (SF*L-T.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(2,2) = Z(1,1)
Z(2,3) =-Z(1,3)
Z(2,4) =-Z(1,4)
Z(3,3) = 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+1
40 Z(I,J) = Z(J,I)
C
C STRESS TRANSFORMATION MATRIX.
DO 55 J=1,4
TS(1,J) = 0.*0
TS(2,J) = C.*0
IF (A1 .GT. 0.0) TS(1,J) = Z(1,J)/A1
IF (A2 .GT. 0.0) TS(2,J) = Z(2,J)/A2
TS(3,J) = Z(3,J)/C1/B11
55 TS(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 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 +/- CR - AS RIGHT HAND AXIS BETWEEN END FR. INTS 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 SUBROUTINE ARGUMENTS
C TJ1 = INPUT CROSS-SECTION SAINT VENANTS TORSION CONSTANT (J) IN JG
C AT ROD END 1. E.G., TJ1=5*PI*R1**4 FOR A SOLID CIRCULAR
C CYLINDER. TJ1=2*PI*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-1.0) .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
RETURN
END
DIMENSION Z(KZ,1),T(KT,1),R(KR,1)
DIMENSION XE(3),ET(3)

SUBROUTINE TO CALCULATE FINITE ELEMENT...

STIFFNESS MATRIX,
STRESS TRANSFORMATION MATRIX,
FOR A MEMBRANE TRIANGLE PLATE ELEMENT WITH UNRESTRAINED BOUNDARIES.
QUADRATIC DISPLACEMENT (LINEAR STRAIN) FIELD IS USED.
STIFFNESS MATRIX IS IN LOCAL COORDINATE SYSTEM.
STRESS TRANSFORMATION MATRIX RELATES STRESS AT TRIANGLE VERTICES
IN LOCAL COORDINATE SYSTEM TO DEFLECTIONS IN THE LOCAL SYSTEM.
ROW ORDER IN STRESS TRANSFORMATION MATRIX IS
(SIGMA-X,SIGMA-Y,TAU-XY) 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
(DX,DY,TZ) JOINT 1, THEN JOINT 2, 3.
WHERE DX,DY ARE TRANSLATION, AND TZ IS ROTATION.
CALLS FOPMA SUBROUTINES ETAEA AND MULTA.
DEVELOPED BY CS EDELLEY, WA EENFIELD, MARCH 1973.
LAST REVISION BY CS EDELLEY, 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.
E = INPUT YOUNG'S MODULUS OF ELASTICITY.
ANU = INPUT POISSON'S RATIO. (E/2G)-1.
Z = OUTPUT STIFFNESS MATRIX. SIZE(9,9).
T = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(9,9).
R = INPUT MATRIX WORK SPACE. SIZE(8,9).
KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=9.
KT = INPUT ROW DIMENSION OF T IN CALLING PROGRAM. MIN=9.
KR = INPUT ROW DIMENSION OF R IN CALLING PROGRAM. MIN=8.

DO 5 I=1,6
DO 5 J=1,6
5 T(I,J)=0.0
DO 10 I=1,6
DO 10 J=1,6
10 T(I,J)=0.0
IF (TH .LE. 0.0) RETURN
X22 = X2*X2
Y32 = Y3*Y3
X2Y3 = X2*Y3
SE1 = X3/X2
G = E/(2.*+2.*ANU)
DD = E*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) = D*D*F00/X22
Z(1,3) = D*D*F01/X22
Z(1,6) = D*N*F00/X2Y3
Z(1,8) = D*N*F10/X2Y3
Z(2,2) = D*C*F00/Y32
Z(2,3) = D*C*F10/Y32
Z(2,4) = 2.*D*D*F01/Y32
Z(2,5) = D*D*F00/X2Y3
Z(2,7) = 2.*D*D*F10/X2Y3
Z(2,8) = D*D*F01/X2Y3
Z(3,3) = D*D*F02/X22 + D*D*F20/Y32
Z(3,4) = 2.*D*D*F11/Y32
Z(3,5) = D*C*F10/X2Y3
Z(3,6) = D*N*F01/X2Y3
Z(3,7) = 2.*D*D*F20/X2Y3
Z(3,8) = D*N*F11/X2Y3 + D*D*F11/X2Y3
Z(4,4) = 4.*D*D*F02/Y32
Z(4,5) = 2.*D*D*F01/X2Y3
Z(4,7) = 4.*D*D*F11/X2Y3
Z(4,8) = 2.*D*D*F02/X2Y3
Z(5,5) = D*D*F00/X22
Z(5,7) = 2.*D*D*F10/X22
Z(5,8) = D*D*F01/X22
Z(6,6) = D*D*F00/Y32
Z(6,8) = D*D*F10/Y32
Z(7,7) = 4.*D*D*F20/X22
Z(7,8) = 2.*D*D*F11/X22
Z(8,8) = D*D*F20/Y32 + D*D*F02/X22

DC 20 I=1,8
DD 20 J=I,8
20 Z(I,J) = Z(I,J)

C
R(1,1) = -1.
R(1,3) = 1.
R(2,1) = 5*F1 - 1.
R(2,3) = -Y3
R(2,4) = -5*F1
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*F1
R(4,9) = -Y3
R(5,2) = -1.
R(5,3) = X2
R(5,5) = 1.
R(5,6) = -X2
R(6,2) = 5E1 - 1.
R(6,5) = -5E1
R(6,6) = X3
R(6,8) = 1.
R(6,9) = -X3
R(7,3) = -X2
R(7,6) = X2
P(8,3) = X2*(5E1 - 1)
R(5,6) = -X3
R(8,9) = X2

CALL BTABTA(Z,R,8,9,KZ,KR)

D11 = DC/TH
D12 = ANU/D11
D33 = 6
XE(1) = 0.
XE(2) = 1.
XE(3) = 5E1
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(K1,2) = D11*ET(1)/X2
T(K1,6) = D12/Y3
T(K1,9) = D12*XE(1)/Y3
T(K2,1) = D12/X2
T(K2,3) = D12*ET(1)/X2
T(K2,6) = E11/Y3
T(K2,9) = 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,9,8,9,KT,KR)

RETURN
END
SUBROUTINE K261 (X2,X3,Y3,TH,E,ANU,Z,TS,T,K2,KTS,KT)
DIMENSION Z(K2),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 FLEXING TRIANGLE PLATE ELEMENT WITH UNRESTRAINED 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 ROW 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.
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 (X2,Y2,Y3) JOINT 1, THEN JOINT 2, 3.
C WHERE DI IS TRANSLATION AND TX,TY ARE ROTATIONS.
C CALLS FORMA SUBROUTINES ETES A AND MULTA.
C DEVELOPED BY CS EDDLEY, MARCH 1973.
C LAST REVISION BY CS EDDLEY, 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 TS = OUTPUT LOCAL STRESS TRANSFORMATION MATRIX. SIZE(18,9).
C T = INPUT MATRIX WORK SP. CE. SIZE(10,10).
C K2 = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=9.
C KTS = INPUT ROW DIMENSION OF TS IN CALLING PROGRAM. MIN=18.
C KT = INPUT ROW DIMENSION OF T IN CALLING PROGRAM. MIN=10.

DO 10 I=1,9
DO 10 J=1,9
10 Z(I,J) = 0.0
DO 11 I=1,10
DO 11 J=1,10
11 TS(I,J) = 0.0
IF (TH .LT. 0.0) LF TURN

DO 12 I=1,10
DO 12 J=1,10
12 T(I,J) = 0.0
X22 = X2*X2
Y22 = Y2*Y2
X32 = X3*Y3
Y32 = Y3*Y3
K281 -- 2/5

\[ SE1 = X2/X2 \]
\[ SE2 = SE1 \times SE1 \]
\[ SE3 = SE2 \times SE1 \]
\[ SE4 = SE3 \times SE1 \]
\[ SEC1 = (1.0 + SE1)/3. \]
\[ SEC2 = SEC1 \times 2 \]
\[ SEC3 = SEC1 \times 2 \]
\[ G = E/(2.0 + 2.0 \times ANU) \]
\[ DD = (E+1)/(12.0 \times (1.0 - ANU)) \]
\[ DNU = DD \times ANU \]
\[ DG = (E+1)/(12.0) \]
\[ AL = DD/Y \]
\[ BE = DNU/(Y22+Y32) \]
\[ GA = D/DY34 \]
\[ DE = 4.0DG/(X22+Y32) \]

C

\[ T(1,1) = 1.0 \]
\[ T(2,1) = 1.0 \]
\[ T(3,1) = 1.0 \]
\[ T(4,1) = 1.0 \]
\[ T(5,1) = 1.0 \]
\[ T(6,1) = 1.0 \]
\[ T(7,1) = 1.0 \]
\[ T(7,2) = SE1 \]
\[ T(7,3) = 1.0 \]
\[ T(7,4) = SE2 \]
\[ T(7,5) = SE1 \]
\[ T(7,6) = 1.0 \]
\[ T(7,7) = SE3 \]
\[ T(7,8) = SE2 \]
\[ T(7,9) = SE1 \]
\[ T(7,10) = 1.0 \]
\[ T(8,1) = 1.0 \]
\[ T(8,2) = SE1 \]
\[ T(8,3) = 2.0 \]
\[ T(8,4) = SE2 \]
\[ T(8,5) = 2.0 \times SE1 \]
\[ T(8,6) = 2.0 \times SE1 \]
\[ T(9,2) = 1.0 \]
\[ T(9,3) = 2.0 \times SE1 \]
\[ T(9,4) = 1.0 \]
\[ T(9,5) = 2.0 \times SE2 \]
\[ T(9,6) = 2.0 \times SE1 \]
\[ T(9,7) = 1.0 \]
\[ T(10,1) = 1.0 \]
\[ T(10,2) = SEC1 \]
\[ T(10,3) = 1.0/5.0 \]
\[ T(10,4) = SEC2 \]
C

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

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
ALJ = T(L,J)
DC 17 J=1,10
T(L,J) = T(L,J)/ALJ
17 R(L,J) = F(L,J)/ALJ
DC 25 I=1,10
ALJEIG = T(I,JEIG)
IF (*. EQ. L) GO TO 25
DC 55 J=1,10
T(I,J) = T(I,J) - ALJEIG*T(L,J)
30 R(I,J) = F(I,J) - ALJEIG*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 55 I=1,10
DC 55 J=1,10
50 R(I,J) = T(I,J)

C

DC 25 I=1,10
R(I,2) = Y2*R(I,2)
R(I,3) = -Y2*R(I,3)
R(I,4) = Y2*R(I,4)
R(I,6) = -Y2*R(I,6)
R(I,8) = Y2*R(I,8)
20 R(I,9) = -Y2*R(I,9)

C

COEFF(1) = 1./3.
COEFF(2) = Y2/16.
COEFF(3) = -(X2+X5)/16.
COEFF(4) = 1./2.
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.
F02 = X2*Y3/12.

C

T(4,4) = 4.*AL*F00
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) = DF*F00
T(5,6) = 2.*DF*F10
T(5,7) = 2.*DF*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.*DF*F20
T(8,9) = 4.*EE*F11 + 4.*DF*F11
T(8,10) = 12.*FF*F02
T(9,9) = 4.*GA*F20 + 4.*DE*F02
T(9,10) = 12.*GA*F11
T(10,10) = 26.*GA*F02

C

DC 60 I=1,10
DC 60 J=1,10
60 T(J,1) = T(I,J)
CALL ETAFA (T, I, 10, 10, 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) = C.C
D11 = -6.*DD/((X2*TH)**2)
D21 = ANU*D11
D22 = -6.*DD/((Y3*TH)**2)
D12 = ANU*D22
D33 = -12.*DD/((X2*Y3)*TH**2)
XE(1) = C.
XE(2) = 1.
XE(3) = SE1
ET(1) = 0.
ET(2) = 0.
ET(3) = 1.
DO 75 I=1,3
K1 = 3*I - 2
K2 = K1 + 1
K3 = K1 + 2
T(K1,4) = 2.*D11
T(K1,6) = 2.*D12
T(K1,7) = 6.*D11*X(I)
T(K1,8) = 2.*D11*ET(I)
T(K1,9) = 2.*D12*X(I)
T(K1,10) = 6.*D12*ET(I)
T(K2,4) = 2.*D21
T(K2,6) = 2.*D22
T(K2,7) = 6.*D21*X(I)
T(K2,8) = 2.*D21*ET(I)
T(K2,9) = 2.*D22*X(I)
T(K2,10) = 6.*D22*ET(I)
T(K3,5) = D33
T(K3,8) = C.*G3*X(I)
75 T(K3,9) = 2.*D33*ET(I)
CALL MULTA (T, K, 9, 10, 9, 10, 10)
DO 77 I=1,9
IP9 = I + 9
DO 77 J=1,9
T(I,J) = T(I,J)
77 T(I,0,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
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,DX4, DY1,DY2,DY3,DY4
C WHERE DX, DY ARE TRANSLATIONS.
C DEVELOPED BY RL WOHLEN. 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(6,6).
C T = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(9,9).
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 C = TH*G/2.
C A = C*X3/Y3
C B = C*Y2/X2
C Z(1,1) = A
C Z(1,2) = A
C Z(1,3) = -A
C Z(1,4) = -A
C Z(1,5) = C
C Z(1,6) = -C
C Z(1,7) = -C
C Z(1,8) = C
C Z(2,1) = A
C Z(2,2) = A
C Z(2,3) = -A
C Z(2,4) = -A
C Z(2,5) = C
C Z(2,6) = -C
C Z(2,7) = -C
C Z(2,8) = C
C Z(3,1) = A
C Z(3,2) = A
C Z(3,3) = -C
C Z(3,4) = C
C Z(3,5) = -C
C Z(3,6) = C
C Z(3,7) = C
C Z(3,8) = -C
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) = F
Z(6,6) = B
Z(6,7) = B
Z(6,8) = -E
Z(7,7) = B
Z(7,8) = -F
Z(8,8) = F

C. SYMMETRIZE LOWER HALF.
   DD 10 J=1,8
   DC 10 I=J,F
   10 Z(I,J) = Z(J,I)

C
C STRESS TRANSFORMATION MATRIX.
   DD 20 J=1,6
   20 T(I,J) = 2.*Z(3,J)/(1+X3)

C
RETURN
FND
SUBROUTINE KGRAV (CJ, JM, EV, A, W, KW, KCJ)
DIMENSION CJ(KCJ, 1), JM(1), EV(I), W(KW, 1)
DIMENSION F(3, 4), R12(3), R13(3), VN(3), F(3, 3)
DATA KEF / 3 /

SUBROUTINE TO DERIVE STIFFNESS MATRIX FOR A TRIANGULAR GRAVITY ELEMENT.
CALLS SUBROUTINES MULTA, MULTB, VECROSS.
DEVELOPED BY C S EDDLEY. FEBRUARY 1974.
LAST REVISION BY C S EDDLEY. NOVEMBER 1974.

SUBROUTINE ARGUMENTS
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.

J1 = JM(1)
J2 = JM(2)
J3 = JM(3)
DO 5 I=1,9
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=1,2
8 F(I, J) = 1.
7 F(I, J) = 2.

CALL VECROSS (F12, F13, 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)

CALL MULTB (F, E, 3, 2, 0, KEF, KEF)
CALL MULTA (W, F, 3, 9, KW, KEF)
A = A*ACUM*ACUM*ACUM

RETURN
END
SUBROUTINE M1A1 (A1,A2,RL,RO,Z,KZ)
DIMENSION Z(KZ,1)

C C C C
C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C LUMPED MASS MATRIX
C FOR AN AXIAL ROD ELEMENT WITH UNRESTRAINED BOUNDARIES.
C ROD MAY BE LINFAFLY TAPERED OR UNIFORM.
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 DX1,DX2
C WHERE DX IS TRANSLATION.
C
C SUBROUTINE ARGUMENTS
C A1 = INPUT CROSS-SECTION AREA AT ROD END 1.
C A2 = INPUT CROSS-SECTION AREA 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 FOR DIMENSION OF Z IN CALLING PROGRAM. MIN=2.
C
W1 = A1*RL*RO/6.
W2 = A2*RL*RO/6.
Z(1,1) = Z(1,2) = 0.
Z(2,1) = C.
Z(2,2) = W1 + Z(2,2)

RETURN
END
SUBROUTINE M1A2 (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 TAPEFED 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 DEVELOPED BY RL WCHL'N. FEBRUARY 1973.
C LAST REVISION BY RL WCHL'N. 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
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(2,2) = W1 + 2.*W2
Z(4,4) = (A2*RO*RL**3)/24.

RETURN
END
SUBROUTINE MIE2 (A1,A2,RL,KO,Z,KZ)
DIMENSION Z(KZ,1)

C
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-2 PLANE
C WITH JOINT 1 AT THE ORIGIN, JOINT 2 ALONG THE POSITIVE X AXIS.
C LOCAL COORDINATE ORDER IS
C DZ1,DZ2,TY1,TY2
C WHERE DZ IS TRANSLATION AND TY IS ROTATION.
C DEVELOPED BY RL WOHLN. FEBRUARY 1973.
C LAST REVISION BY RL WOHLN. SEPTEMBER 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 RO = INPUT MASS DENSITY.
C Z = OUTPUT MASS MATRIX. SIZE(4,4).
C KZ = INPUT RCW DIMENSION OF Z IN CALLING PROGRAM. MIN=4.
C
C W1 = A1*RL*RO/E40.
C W2 = A2*RL*RO/E40.
C RL2 = RL**2
C Z(1,1) = 240.*W1 + 72.*W2
C Z(1,2) = 54.*W1 + 54.*W2
C Z(2,2) = 72.*W1 + 240.*W2
C Z(1,3) = -(30.*W1 + 14.*W2)*PL
C Z(1,4) = -(14.*W1 + 12.*W2)*RL
C Z(2,3) = -(12.*W1 + 14.*W2)*RL
C Z(2,4) = -(14.*W1 + 30.*W2)*RL
C Z(3,3) =  (5.*W1 + 3.*W2)*RL2
C Z(3,4) = -(3.*W1 + 3.*W2)*RL2
C Z(4,4) = ( 3.*W1 + 5.*W2)*RL2
C DO 10 J=1,4
C 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.
DEVELOPED BY RL WOHLLEN. FEBRUARY 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*PI2/RO/6.
W2 = PI2*PI2/RO/6.
Z(1,1) = 2*W2 + W2
Z(1,2) = 0.
Z(2,1) = 0.
Z(2,2) = W1 + 2*W2

RETURN
END
SUBROUTINE MIC, (PI1, PI2, RL, RO, Z, KZ)
DIMENSION Z(KZ, 1)

C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C CONSISTENT MASS MATRIX
C FOR A TORSION FLEX ELEMENT WITH UNRESTRAINED BOUNDARIES.
C ROD MAY BE LINEARLY TAPERED 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
C SUBROUTINE ARGUMENTS
C PI1 = INPUT CROSS-SECTION POLAR AREA MOMENT OF INERTIA AT ROD END 1.
C PI2 = 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 = PI1*RL*RO/12.
W2 = PI2*RL*RO/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 M2A1 (X2, Y3, TH, RC, Z, KZ)
DIMENSION Z(KZ, 1)
C
C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C LUMPED MASS MASS IS...
C FOR A MEMBRANE TRIANGLE PLATE ELEMENT WITH UNRESTRICTED 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, EY, T2) JOINT 1, THEN JOINT 2, 3.
C WHERE EX, EY ARE TRANSLATIONS AND T2 IS ROTATION.
C DEVELOPED BY W2 BENFIELD, FEBRUARY 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 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 * Y2
CM = (K0 * TH * AREA) / 3.0
DO 10 I = 1, 6
   DO 10 J = 1, 6
10 Z(I, J) = CM
DO 20 L = 1, 6
   DO 20 J = 1, 6
20 Z(I, J) = CM
RETURN
END
SUBROUTINE M2A2 (X2, X3, Y3, TH, PM, Z, T, R, KZ, KT, KR)
DIMENSION Z(KZ,1), T(KT,1), R(KR,1)

C
C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C CONSISTENT MASS MATRIX.
C FOR A MEMBRANE TRIANGLE PLATE ELEMENT WITH UNRESTRAINED SURFACES.
C QUADRATIC DISPLACEMENT (LINEAR STRAIN) FIELD IS USED.
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 ORDER IS
C (DX, DY, DZ) JOINT 1, THEN JOINT 2, 3.
C WHERE DX, DY ARE TRANSLATIONS AND DZ IS ROTATION.
C CALLED FROM SUBROUTINES ETELA.
C DEVELOPED BY CS BODLEY. MARCH 1973.
C LAST REVISION BY WA BENFIELD. 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 PM = INPUT MASS DENSITY.
C Z = OUTPUT MASS MATRIX. SIZE(9, 9).
C T = OUTPUT MATRIX WORK SPACE. SIZE(10, 10).
C R = OUTPUT MATRIX WORK SPACE. SIZE(10, 10).
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=9.
C KT = INPUT ROW DIMENSION OF T IN CALLING PROGRAM. MIN=10.
C KR = INPUT ROW DIMENSION OF R IN CALLING PROGRAM. MIN=10.

C SE1 = X2/X2
C SE2 = S[1]+SE1
C SE3 = S[2]+SE1
C SE4 = S[3]+SE1
C X2Y3 = X2*Y3*TH

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

C F00 = X2Y3/2.
C F10 = X2Y3*(1.0 + SE1)/6.
C F11 = X2Y3/6.
C F20 = X2Y3*(1.0 + SE1 + SE2)/12.
C F11 = X2Y3*(1.0 + 2.0*SE1)/24.
C F02 = X2Y3/12.
C F50 = X2Y3*(1.0 + SE1 + SE2 + SE3)/20.
C F21 = X2Y3*(1.0 + 2.0*SE1 + 3.0*SE2)/60.
C F12 = X2Y3*(1.0 + 3.0*SE1)/60.
C F62 = X2Y3/60.
C F40 = X2Y3*(1.0 + SE1 + SE2 + SE3 + SE4)/30.
C F51 = X2Y3*(1.0 + 2.0*SE1 + 3.0*SE2 + 4.0*SE3)/120.
C F22 = X2Y3*(1.0 + 3.0*SE1 + 6.0*SE2)/180.
\[ F_{13} = \times Y_{2} Y_{3} (1.4 \times \times S_{E1})/120. \]
\[ F_{04} = \times Y_{2} Y_{3} /30. \]
\[ T_{11} = F_{06} \]
\[ T_{12} = F_{10} \]
\[ T_{13} = F_{02} \]
\[ T_{14} = F_{03} \]
\[ T_{15} = F_{07} \]
\[ T_{16} = F_{01} \]
\[ T_{17} = F_{00} \]
\[ T_{18} = F_{01} \]
\[ T_{19} = F_{02} \]
\[ T_{20} = F_{03} \]
\[ T_{21} = F_{04} \]
\[ T_{22} = F_{05} \]
\[ T_{23} = F_{06} \]
\[ T_{24} = F_{07} \]
\[ T_{25} = F_{08} \]
\[ T_{26} = F_{09} \]
\[ T_{27} = F_{10} \]
\[ T_{28} = F_{11} \]
\[ T_{29} = F_{12} \]
\[ T_{30} = F_{13} \]
\[ T(J_{1}, J_{1}) = T(J_{1}, J_{1}) \]

\[ C \]
\[ F(1,1) = 1. \]
\[ R(2,1) = -1. \]
\[ R(2,4) = 1. \]
\[ P(3,1) = \times \times E1 - 1. \]
\[ \times (3,3) = -Y_{3} \]
\[ F(3,4) = -\times \times E1 \]
\[ P(3,7) = 1. \]
\[ R(3,9) = Y_{3} \]
\[ F(4,5) = Y_{3} \]
\[ P(4,6) = -Y_{3} \]
\[ R(5,2) = Y_{2} \times (1.4 \times \times E1) \]
\[ P(5,6) = Y_{2} \times \times E1 \]
\[ R(5,9) = -Y_{3} \]
\[ R(5,2) = 1. \]
\[ P(7,2) = -1. \]
\[ F(7,3) = Y_{2} \]
\[ P(7,1) = 1. \]
\[ R(7,6) = -Y_{2} \]
\[ P(6,2) = \times \times E1 - 1. \]
R{T,5} = -5EL
R{T,6} = X3
R{T,8} = 1.
F{T,0} = -Y3
F{T,3} = -X2
F{T,6} = X2
F{T,8} = Y2*(5EL - 1.)
R{(10,0)} = -X3
R{(10,6)} = X2

CALL RTAEA (T,F,10,9,K1,KP)
DC 40 I=1,5
DC 40 J=1,5
40 Z(I,J) = T(I,J)

C
RETURN
END
SUBROUTINE M281 (X2, Y3, TH, RO, Z, KZ)
DIMENSION Z(KZ,1)

SUBROUTINE TO CALCULATE FINITE ELEMENT...
LUMPED MASS MATRIX.
FOR A HINGED TRIANGLE PLATE ELEMENT WITH UNRESTRAINED BOUNDARIES.
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
(D2, TX, TY) JOINT 1, THEN JOINT 2, 3.
WHERE D2 IS TRANSLATION AND TX, TY ARE ROTATIONS.
DEVELOPED BY WA BINFIELD, FEBRUARY 1973.

SUBROUTINE ARGUMENTS
X2 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 2.
Y3 = INPUT LOCAL Y COORDINATE LOCATION OF JOINT 3.
TH = INPUT PLATE THICKNESS.
RO = INPUT MASS DENSITY.
Z = OUTPUT MASS MATRIX. SIZE(9,9).
KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=9.

AREA = 0.5*X2*Y3
CM = (RO*TH*AREA)/3.0
DO 10 I=1,9
DO 10 J=1,9
10 Z(I,J) = 0.0
DO 20 I=1,9
20 Z(I,I) = CM
RETURN
END
SUBROUTINE M2F2 (X2, Y3, TH, FHO, Z, T, P, KZ, KT, KR)
DIMENSION 2(KZ, 1), 1(KT, 1), P(KR, 1)
DIMENSION IVEC(10), GCEF(19)

C C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C C CONSISTENT MASS MATRIX.
C FOR A FENDING TRIANGLE PLATE ELEMENT WITH UNRESTRAINED BOUNDARIES.
C CUBIC DISPLACEMENT (LINEAR CURVATURE) FIELD IS USED.
C THIS IS NOT THE 'S' 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 BTAEX.
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 X3 = 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 T = INPUT MATRIX WORK SPACE SIZE(10, 10).
C P = INPUT MATRIX WORK SPACE SIZE(10, 10).
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=9.
C KT = INPUT ROW DIMENSION OF T IN CALLING PROGRAM. MIN=10.
C KR = INPUT ROW DIMENSION OF R IN CALLING PROGRAM. MIN=10.

C
C XI = X2/Y2
C SE1 = SE1 + XI
C SE2 = SE2 + XI
C SE4 = SE4 + XI
C SE5 = SE5 + XI
C SE6 = SE6 + XI
C SE1 = (1. + SE1)/3.
C SE2 = SE1*XI
C SE3 = SE1*XI

C DD 10 I=1,10
CD 10 J=1,10
10 T(I,J) = 0.

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

C
DO 5 J=1,10
DO 7 J=1,10
7 R(I,J) = 0.
5 R(I,1) = 1.
C
DC 100 L=1,16
JPEG = 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
JPEG = J
15 CONTINUE
IVEC(L) = JPEG
ALEDG = T(L,JPEG)
DC 17 J=1,10
T(L,J) = T(L,J)/A1JF1G

17 R(L,J) = R(L,J)/A1JB1G
DC 25 I = 1,10
A1JF1G = T(I,J)/A1JF1G
IF (I ≤ FC - L) GO TO 25
DC 30 J = 1,10
T(I,J) = T(I,J) - A1JB1G*T(L,J)
30 R(I,J) = R(I,J) - A1JB1G*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)
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*R(I,2)
R(I,3) = -X2*R(I,3)
R(I,4) = Y3*R(I,4)
R(I,5) = -X2*R(I,5)
R(I,6) = Y3*R(I,6)
R(I,7) = -X2*R(I,7)

20 R(I,9) = -X2*R(I,9)

C
CCE(F1) = 1.2,
CCE(F2) = 1.3,
CCE(F3) = -(X2*X3)/16.
CCE(F4) = 1.2,
CCE(F5) = 1.1,
CCE(F6) = (12*X2 - X3)/16.
CCE(F7) = 1.2,
CCE(F8) = 1.2,
CCE(F9) = -(12*X3 - X2)/16.

DO 60 I = 1,10
DO 60 J = 1,9
60 R(I,J) = R(I,J) + R(I,10)*CCEF(J)

C
DC 55 I = 1,10
DC 55 J = 1,10
55 T(I,J) = 0.

C
X2Y3 = Y2*Y3*TH*RHO
FCU = X2Y3/2.
F10 = X2Y3*(1. + SE1)/6.
FC1 = X2Y3/6.
F20 = Y2*Y3*(1. + SE1 + SE2)/12.
F11 = X2Y3*(1. + 2.*SE1)/24.
FC2 = X2Y3/12.
F30 = X2Y3*(1. + SE1 + SE2 + SE3)/20.
F21 = X2Y3*(1. + 2.*SE1 + 3.*SE2)/60.
F12 = X2Y3*(1. + 3.*SE1)/60.
FC3 = X2Y3/20.
\[ F_{40} = X2Y3*(1.0 + SE1 + SE2 + SE3 + SE4)/30. \]
\[ F_{31} = X2Y3*(1.0 + 2.0*SE1 + 3.0*SE2 + 4.0*SE3)/120. \]
\[ F_{22} = X2Y3*(1.0 + 3.0*SE1 + 6.0*SE2)/180. \]
\[ F_{13} = X2Y3*(1.0 + 4.0*SE1)/120. \]
\[ F_{04} = X2Y3/30. \]
\[ F_{50} = X2Y3*(1.0 + SE1 + SE2 + SE3 + SE4 + SE5)/42. \]
\[ F_{41} = X2Y3*(1.0 + 2.0*SE1 + 3.0*SE2 + 4.0*SE3 + 5.0*SE4)/210. \]
\[ F_{32} = X2Y3*(1.0 + 3.0*SE1 + 6.0*SE2 + 10.0*SE3)/420. \]
\[ F_{23} = X2Y3*(1.0 + 4.0*SE1 + 10.0*SE2)/420. \]
\[ F_{14} = X2Y3*(1.0 + 5.0*SE1)/210. \]
\[ F_{05} = X2Y3/42. \]
\[ F_{60} = X2Y3*(1.0 + SE1 + SE2 + SE3 + SE4 + SE5 + SE6)/56. \]
\[ F_{51} = X2Y3*(1.0 + 2.0*SE1 + 3.0*SE2 + 4.0*SE3 + 5.0*SE4 + 6.0*SE5)/336. \]
\[ F_{42} = X2Y3*(1.0 + 3.0*SE1 + 6.0*SE2 + 10.0*SE3 + 15.0*SE4)/840. \]
\[ F_{33} = X2Y3*(1.0 + 4.0*SE1 + 10.0*SE2 + 20.0*SE3)/1120. \]
\[ F_{24} = X2Y3*(1.0 + 5.0*SE1 + 15.0*SE2)/840. \]
\[ F_{15} = X2Y3*(1.0 + 6.0*SE1)/336. \]
\[ F_{06} = X2Y3/56. \]

\[ T_{(1,1)} = F_{00} \]
\[ T_{(1,2)} = F_{10} \]
\[ T_{(1,3)} = F_{01} \]
\[ T_{(1,4)} = F_{20} \]
\[ T_{(1,5)} = F_{11} \]
\[ T_{(1,6)} = F_{02} \]
\[ T_{(1,7)} = F_{30} \]
\[ T_{(1,8)} = F_{21} \]
\[ T_{(1,9)} = F_{12} \]
\[ T_{(1,10)} = F_{03} \]
\[ T_{(2,2)} = F_{20} \]
\[ T_{(2,3)} = F_{11} \]
\[ T_{(2,4)} = F_{20} \]
\[ T_{(2,5)} = F_{21} \]
\[ T_{(2,6)} = F_{12} \]
\[ T_{(2,7)} = F_{40} \]
\[ T_{(2,8)} = F_{31} \]
\[ T_{(2,9)} = F_{22} \]
\[ T_{(2,10)} = F_{13} \]
\[ T_{(3,3)} = F_{02} \]
\[ T_{(3,4)} = F_{21} \]
\[ T_{(3,5)} = F_{12} \]
\[ T_{(3,6)} = F_{03} \]
\[ T_{(3,7)} = F_{31} \]
\[ T_{(3,8)} = F_{22} \]
\[ T_{(3,9)} = F_{13} \]
\[ T_{(3,10)} = F_{04} \]
\[ T_{(4,4)} = F_{40} \]
\[ T_{(4,5)} = F_{31} \]
\[ T_{(4,6)} = F_{22} \]
\[ T_{(4,7)} = F_{50} \]
\[ T_{(4,8)} = F_{41} \]
\[ T_{(4,9)} = F_{32} \]
\[ T_{(4,10)} = F_{23} \]
\[ T_{(5,5)} = F_{22} \]
\[ T_{(5,10)} = F_{13} \]
\[
\begin{align*}
T(5,7) &= F41 \\
T(5,8) &= F32 \\
T(5,9) &= F23 \\
T(5,10) &= F14 \\
T(6,6) &= F64 \\
T(6,7) &= F22 \\
T(6,8) &= F23 \\
T(6,9) &= F14 \\
T(6,10) &= F05 \\
T(7,7) &= F66 \\
T(7,8) &= F51 \\
T(7,9) &= F42 \\
T(7,10) &= F23 \\
T(8,8) &= F47 \\
T(8,9) &= F33 \\
T(8,10) &= F24 \\
T(9,9) &= F24 \\
T(9,10) &= F15 \\
T(10,10) &= F06 \\
\end{align*}
\]

```
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
```
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 SHEAR 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 ORIG IN, 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,LY3,LY4
C WHERE DX, DY ARE TRANSLATIONS.
C DEVELOPED BY RL WOHLER. APRIL 1974.

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.

CM = RO*TH*X3*Y3/4.0
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,RA,YMEM,Z,KCJ,KEJ,KZ)

DIMENSION CJ(KCJ,1), EJ(KEJ,1), Z(1,1)

DIMENSION E1(3,3), E2(3,3), W(2,2)

SUBROUTINE TO CALCULATE FINITE ELEMENT...

MASS MATRIX

FOR AN AXIAL ROD ELEMENT WITH UNRESTRAINED BOUNDARIES.

ROD MAY BE LINEARLY TAPERED OR UNIFORM.

MASS MATRIX IS IN GLOBAL COORDINATE DIRECTIONS.

GLOBAL COORDINATE ORDER 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 FORA SUBROUTINES EULER,M1A1,M1A2,ZZBOMB.

DEVELOPED BY RL WOHLEN. 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.

RO = INPUT MASS DENSITY.

YMEM = INPUT TYPE OF MASS MATRIX WANTED.

= M1, LUMPED.

= M2, CONSISTENT.

Z = OUTPUT MASS MATRIX. SIZE(6,6).

KCJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM. MIN=3.

KEJ = INPUT ROW DIMENSION OF EJ IN CALLING PROGRAM. MIN=3.

KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=6.

NERROR EXPLANATION

1 = DIMENSION SIZE EXCEEDED (KZ).
2 = NAME IMPROPERLY DEFINED.

IF (KZ .LT. 6) GO TO 999

DC 5 J=1,6
DO 5 I=1,6
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)

IF (YMEM .EQ. 6MM1) GO TO 110
IF (YMEM .EQ. 6MM2) GO TO 126

GO TO 999

LUMPED,
110 CALL M1A1 (A1,A2,RL,RO,W,2)

DC 112 I=1,5
112 Z(I,1) = W(I,1)

NERROR=1

NERROR=2
DO 114 I=4,6
114 Z(I,J) = W(2,2)
RETURN
C
C CONSISTENT.
120 CALL MIA2 (A1,A2,RL,RO,W,2)
   DO 122 T=1,3
122 Z(I,1) = 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)
   DO 124 I=1,3
   DO 124 J=4,6
   Z(I,J) = W(1,2)*E2(I,J-3)
124 Z(J,1) = Z(1,J)
   DO 126 I=4,6
126 Z(I,1) = W(2,2)
RETURN
C
999 CALL ?ZBUMB (6HMAS1A,NERROR)
END.
SUBROUTINE MAS1B (CJ, EJ, A1, A2, PI1, PI2, RO, NAMEM, Z, W, KCJ, KEJ, KZ, KW)

DIMENSION CJ(KCJ,J), EJ(KEJ,1), Z(KZ,1), W(KW,1)

C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C MASS MATRIX
C FOR A COMBINED AXIAL-TORSION-BENDING BAR ELEMENT WITH UNRESTRAINED
C BOUNDARIES.
C BAR MAY BE LINEARLY TAPERED OR UNIFORM.
C MASS MATRIX IS IN GLOBAL COORDINATE DIRECTIONS.
C GLOBAL COORDINATE ORDER 1:
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 FOR SUBROUTINES BTABA, DCON1B, M1A1, M1A2, M1B1, M1B2, M1C1, M1C2, 2ZPOMR.
C DEVELOPED BY 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 BAR JOINTS.
C ROWS 1, 2, 3 CORRESPOND TO , , 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 A1 = INPUT CROSS-SECTION AREA AT BAR END 1.
C A2 = INPUT CROSS-SECTION AREA AT BAR END 2.
C PI1 = INPUT CROSS-SECTION POLAR AREA MOMENT OF INERTIA AT END 1.
C PI2 = INPUT CROSS-SECTION POLAR AREA MOMENT OF INERTIA AT 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(12, 12).
C W = OUTPUT WORK SPACE MATRIX. SIZE(12, 12).
C KCJ = INPUT FCCW DIMENSION OF CJ IN CALLING PROGRAM. MIN=3.
C KEJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM. MIN=3.
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=12.
C KW = INPUT ROW DIMENSION OF W IN CALLING PROGRAM. MIN=12.

NEPROP EXPLANATION
C 1 = DIMENSION SIZE EXCEEDED KZ, KW.
C 2 = NAMEM IMPROPERLY DEFINED.

IF (KZ .LT. 12 .OR. KW .LT. 12) GO TO 999
DC & J=1,12
DG & J=1,12
5 Z(I,J) = 0.0
RE = SQRT((CJ(1,2)-CJ(1,1)**2 + (CJ(2,2)-CJ(2,1)**2)
* + (CJ(3,2)-CJ(3,1)**2)
IF (NAMEM .EQ. 6)*M1 ) GO TO 110
IF (NAMEM .EQ. 6)*M2 ) TO TC 120

NERRR=1
GO TO 000.

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

110 CALL M1A1 (A1, A2, PL, RC, Z, KZ)
   CALL M1C1 (P11, P12, PL, RC, Z(3,3), KZ)
   CALL M1S1 (A1, A2, PL, RC, Z(5,5), KZ)
   CALL M1B1 (A1, A2, PL, RC, Z(9,9), KZ)
   GO TO 300

C AXIAL=M1A2 (LINEAR DISP), TORSION=M1C2 (LINEAR DISP),
C BENDING=M1B2 (CURVIC DISP).

120 CALL M1A2 (A1, A2, PL, RC, Z, KZ)
   CALL M1C2 (P11, P12, PL, RC, Z(3,3), KZ)
   CALL M1B2 (A1, A2, PL, RC, Z(5,5), KZ)
   DO 125 J=7,8
   DO 125 I=5,6
   Z(I,J) =-Z(I,J)
125 Z(I,J) =-Z(J,I)
   CALL M1B2 (A1, A2, PL, RC, Z(9,9), KZ)

C

300 CALL DCCS1F (CJ, EJ, W, KCJ, KEJ, KW)
   CALL HTABF (Z, W, 12, 12, KZ, KW)
   RETURN

C

999 CALL ZZPOMP (6, MAS1E, NERFOP)
   END
C SUBROUTINE TO CALCULATE FINITE ELEMENT...
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 WHERE U,V,W ARE TRANSLATIONS AND P,Q,R ARE ROTATIONS.
C FULLER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
C CALLS FROM SUBROUTINES EDATA, DC0S2,M2A1,M2A2,M2B1,M2B2,ZZBOMB.
C DEVELOPED BY WA FENNFIELD, FL WOHLEN. FEBRUARY 1973.
C LAST REVISION BY W. BENFIELD. MARCH 1976.
C
C SUBROUTINE Arguments
C CJ = INPUT MATRIX OF GLOBAL X,Y,Z COORDINATES AT TRIANGLE JOINTS.
C PWS 1,2,3 CORRESPOND TO X,Y,Z COORDINATES.
C CCLS 1,2,3 CORRESPOND TO JOINTS 1,2,3. SIZE(3,3).
C EJ = INPUT MATRIX OF EULER ANGLES (DEGREES) AT TRIANGLE JOINTS.
C PWS 1,2,3 CORRESPOND TO GLOBAL X,Y,Z PERMUTATION.
C CCLS 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 = INPUT 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.
C
C IF (KZ .LT. 16 .OR. KW1 .LT. 16 .OR. KW2 .LT. 16) GO TO 999
C D 5 =0.1,10
C DC 5 =1,10
5 12 = Z(J,J) = 0.*C
5 13 = SL12 = SQRT((CJ(1,2)-CJ(1,1)**2 + (CJ(2,2)-CJ(2,1)**2)
* + (CJ(3,2)-CJ(3,1)**2)
5 14 = SL23 = SQRT((CJ(1,2)-CJ(1,1)**2 + (CJ(2,3)-CJ(2,2)**2)
* + (CJ(3,3)-CJ(3,2)**2)
5 15 = SL13 = SQRT((CJ(1,3)-CJ(1,1)**2 + (CJ(7,3)-CJ(2,1)**2)
* + (CJ(3,3)-CJ(3,1)**2)
5 16 = X3 = (SL13**2+SL12**2-SL23**2)/(2.0*SL12)
NERROR=2

GO TO 999

C

MEMBRANE = M2A1 (LUMPED), BENDING = M2F1 (LUMPED).
110 CALL M2A1 (SL12,Y3,TMAS,EL,W1,KW1)
   CALL M2F1 (SL12,Y3,TMAS,PC,W1(10,10),KW1)
   DC IW=1,10
   IZ = IVFC(IW)
   115 Z(IZ,IZ) = W1(IW,IW)
   RETURN

C

MEMBRANE = 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 DCOS2 (CJ,EJ,W1,KCJ,KEJ,KW1)
   CALL RTAB2 (Z,W1,E1,E2,KZ,KW1)
   RETURN

C

999 CALL ZZLUMB (*HMAS2 ,NERROR)
END
SUBROUTINE MAS3 (CJ,EJ,TMAS,RC,NAMEM,Z,W1,2,KCJ,KEJ,KZ,KW1,KW2)
DIMENSION (JJKJ,1,EJ,IJEJ),ZIKZ,1),W1(KW1,1),W2(KW2,1)
DIMENSION CW(3,3), CW(3,3), IV1(18), IV2(18), IV3(18), IV4(18)
  "  W(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...

MASS MATRIX

FOR A COMBINED MEMBRANE-BENDING QUADLATERAL 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 FORMA SUBROUTINES MAS2,FFVADD,ZZPOMP.


LAST REVISION BY W.J. BENFIELD. MARCH 1976.

SUBROUTINE ARGUMENTS

CJ = INPUT MATRIX OF GLOBAL X,Y,Z COORDINATES AT QUAD JOINTS.
    ROWS 1,2,3,4 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 1,2,3,4 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.

NAMEM = 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 RW DIMENSION OF CJ IN CALLING PROGRAM. MIN=3.

KEJ = INPUT RW DIMENSION OF EJ IN CALLING PROGRAM. MIN=3.

KZ = INPUT RW DIMENSION OF Z IN CALLING PROGRAM. MIN=24.

KW1 = INPUT RW DIMENSION OF W1 IN CALLING PROGRAM. MIN=18.

KW2 = INPUT RW DIMENSION OF W2 IN CALLING PROGRAM. MIN=18.

NERRCR = ERROR BALANCING

1 = DIMENSION SIZE EXCEEDED (K2,KW1,KW2).
2 = NAMEM IMPROPERLY DEFINED.

NERRCR=1

IF (K2 .LT. 24 OR KW1 .LT. IF .OR. KW2 .LT. 18) GO TO 999
10 5 J=1,24
10 5 I=1,24
5 5 J=I,24
IF (NAMEM .EQ. '6FM1') GO TO 110
IF (NAMEM .EQ. '6HM2') GO TO 110
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)
   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,3)
   EW(I,2) = EJ(I,3)
   CW(I,3) = CJ(I,4)
   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,4)
   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,2)
   EW(I,1) = EJ(I,2)
   CW(I,2) = CJ(I,3)
   EW(I,2) = EJ(I,2)
   CW(I,3) = CJ(I,4)
   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 ZZG0M5 (SH,MAS3,NDERR)
SUPROUTINE 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 SUPROUTINE TO CALCULATE FINITE ELEMENT...
C
C MASS MATRIX
C FOR A RECTANGULAR SHEAR PANEL ELEMENT WITH UNRESTRAINED BOUNDARIES.
C MASS MATRIX IS IN GLOBAL COORDINATE DIRECTIONS.
C GLOBAL COORDINATE ORDER IS
C (U,V,W) JOURNT 1, THEN JOURNT 2, 3, 4.
C WHERE U,V,W ARE TRANSLATIONS.
C EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
C CALLS FORMA SUPROUTINES M3C1,Z3EOM.
C DEVELOPED BY RL WOHLER, APRIL 1974.
C LAST REVISION BY RL WOHLER, MAY 1976.
C
C SUPROUTINE 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 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=2.
C KW2 = INPUT ROW DIMENSION OF W2 IN CALLING PROGRAM. MIN=2.
C
C NERF0R 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   NERROR=1
C GO TO 999
C   NERROR=2
C
C LUMPED.
C 110 FO 112 J=1,12
C DC 112 J=1,12
C 112 Z(J,J+J) = 0.0
C CALL M3C1 (SL12,SL14,TMAS,RO,W1,W2)
C GO TO 115
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 (6HMAS3A , NERROR)
END
SUBROUTINE PRESS (CJ, T, NJN, NCOL, KCJ, KW)
DIMENSION CJ(KCJ,1), T(KW,1)
DIMENSION A(8,8), JNM(3,42), VN(3), C(3,9), IV(3), JV(19)

C
C *** SUBROUTINE TO CALCULATE FLUID ELEMENT PRESSURE TRANSFORMATION
C *** MORE DESCRIPTIVE COMMENT CARDS TO BE ADDED AT A LATER DATE.
C *** DEVELOPED BY CALL BOOLEY, OCTOBER 1974.
C LAST REVISION BY C S BOOLEY. 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, 1,3,6, 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 /

CALL ZER0 (T, NJN, NCOL, KW)
LC = 18
NTF = 24
IF (NJN * EC* 8) GO TO 5
LO = 4
NTF = 14
IF (NJN * EC* 6) GO TO 5
LO = 0
NTF = 4
5 CONTINUE

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))
20 C = SQRT(VN(1)*VN(1) + VN(2)*VN(2) + VN(3)*VN(3))
DC 25 I=1,3
25 VN(I) = VN(I)/AC
AC = AC/4.
IF (LOC * LT* 6) AC = 2.*AC
DO 30 I=1,2
IV(I) = JNM(1,LOC)
DC 30 J=1,9
J1 = 3*J - 3 + J
JL = (IV(I) - 1)*3 + J
30 JV(J1) = JL

DC 25 L=1,3
DC 25 L=1,2
IL = I + 3*(L - 1)
DO 35 J=1,3
   F = 1.
   IF (L .GE. J) F = 2.
35 C(J,IL) = F*VNI(I)
   CALL REVADD (AC,C,IV,JV,T,3,9,NJN,NCOL,3,KW)
   CONTINUE
C
   DO 40 I=1,NJN
   DO 40 J=1,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,A,NJN,B)
   CALL MULTF (A,T,NJN,B,NJN,NCOL,B,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 NUTXK),
- UNIT LOAD BUCKLING MATRICES and IVECS (IN NUTBX), (NOT YET)
- LOCAL LOAD TRANSFORMATION MATRICES and IVECS (IN NULTL), (NOT YET)
- STRESS TRANSFORMATION MATRICES and IVECS (IN NUTST), (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,G,P) joint 1, then joint 2, 3, 4.
WHERE U, V, W ARE TRANSLATIONS AND P, G, R ARE ROTATIONS.
IVEC GIVES ELEMENT DOF INTO GLOBAL DOF. EXAMPLES...
IVEC(6)=34 PLACES ELEMENT DOF 6 INTO GLOBAL DOF 34.
IVEC(3)=9 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
(PUP, PV, PW, MP, PK, MG) joint 1, then joint 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 NUTMXY, NUTXK, NUTEX, NUTLT, NUTST FOR EACH FINITE
ELEMENT IS (W=M,K,P,LT,L)
WRITE (NUTMX) NAME, NEL, NK, NC, NAMEL, IBLNK, I=1,5),
((W(I1,J1), I=1,1, NR), J=1, NC), IVEC(I1), I=1, NC)
CALLS FORMA SUBROUTINES MASS, PAGEHD, STF3, STZPMP.
DEVELOPED BY W. S. FENWICK, CS RODFLE, RL WHALEY. MARCH 1973.
LAST REVISION BY RL WHALEY. MAY 1976.

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

INPUT DATA READ IN THIS SUBROUTINE FROM NUTEL. IF NUTBL = 5, DATA IS
READ FROM CASES.

NAME=NAMK, NAMEF, NAMEST, NAMEE  FORMAT (5(A6,4X)
PC,E,NU  FORMAT (3I5,6E10)
TMAS, TMC, TMNC  FORMAT (3I5,6E10)
20 NEL, J1, J2, J3, J4, TMSV, TMCV, TMNCV  FORMAT (5I5,6E10)
IF (J1 .EQ. 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 6HNCMAS, 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 6HNCSTRES, NO STRESS TRANSFORMATIONS CALCULATED.
C NAMEB = TYPE OF BUCKLING MATRIX WANTED.
C = 6H OR 6HNCBUCK, NO BUCKLING MATRIX CALCULATED.
C R0 = MASS DENSITY.
C E = YOUNG'S MODULUS OF ELASTICITY.
C ANU = POISSON'S RATIO. (E/2G)-1.
C TMASC = EFFECTIVE MASS THICKNESS, CONSTANT.
C TMASV = EFFECTIVE MASS THICKNESS, VARIABLE.
C IF .LE. 0., TMASC IS USED.
C TMEMC = EFFECTIVE MEMBRANE THICKNESS, CONSTANT.
C TMEMV = EFFECTIVE MEMBRANE THICKNESS, VARIABLE.
C IF .LE. 0., TMEMC IS USED.
C TECNC = EFFECTIVE ENDING THICKNESS, CONSTANT.
C TEENV = EFFECTIVE ENDING THICKNESS, VARIABLE.
C IF .LE. 0., TECNC IS USED.
C NEL = FINITE ELEMENT NUMBER. FOR REFERENCE ONLY, NOT USED IN
C CALCULATIONS. 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 JOIF = 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 CLOTH 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 IF ROWS IN MATRICES (XYZ), (JOIF), (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 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(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 JOINTS IN CALLING PROGRAM.
C KE = ROW DIMENSION OF EUL IN CALLING PROGRAM.

C 1 = JOINT NUMBER GREATER THAN NUMBER OF JUNITS.
C 2 = MASS MATRIX FORMED, NUTMX .LE. ZER0.
C 3 = STIFFNESS MATPIY FORMED, NUTKX .LE. ZER0.
C 4 = LT MATRIX FORMED, NUTLT .LE. ZER0.
C 5 = ST MATRIX FORMED, NUTST .LE. ZER0.

C 1001 FORMAT (5(A6,4X))
C 1002 FORMAT (3(E16,F10.0))
C 1003 FORMAT (5(I1,3E15.6))
C 2001 FORMAT (/25X 40H INPUT DATA FOR COMBINED MEMBRANE-BENDING
C * 29H QUADRILATERAL PLATE ELEMENTS)
C 2002 FORMAT (/25X 40H INPUT DATA FOR COMBINED MEMBRANE-BENDING
C * 41H QUADRILATERAL PLATE ELEMENTS (CONTINUED))
C 2003 FORMAT (/ 13X7HMASS = A6, 13X7HSTIF = A6, 6X13HLOAD TRANS = A6,
C * 5X15HSTRESS TRANS = A6, 3X11HBUCKLING = A6,
C * / 15X4HFO = E10.3, 13X2HE = E10.3,
C * / 15X4HT(MASS) = E10.3, 12X4HNU = E10.3,
C * / 32X13HT(MEMBRANE) = E10.3,
C * / 32X12HT(BENDING) = E10.3,
C * / 12X 7H-ELEMENT 5X 7H-JOINT 1 5X 7H-JOINT 2 5X 7H-JOINT 3
C * 5X 7H-JOINT 4 5X 7H-JOINT 5X 7H-JOINT 3 6X 11HT(MEMBRANE)
C * 5X 10HT(BENDING)
C * / 12X SNHNUME = 48X 3(5X 10H(VARIABLE 1))
C 2004 FORMAT (12X 5(I5,T7X),5(I16,E5X))
C 2005 FORMAT (12X 5(I5,T7X))

C READ AND WRITE FINITE ELEMENT DATA.
NLINE = 0
CALL PAGE4C
WRITE (NOT,2001)
READ (NUTFL,1001) NAMEM,NAMEK,NAMELT,NAMEST,NAMEB
READ (NUTEL,1062) RC,E,ANU
READ (NUTEL,1062) TMASC,TMEMC,TEENC
WRITE (NOT,2003) NAMEM,NAMEK,NAMELT,NAMEST,NAMER,
* RC,E,TMASC,ANU,TMEMC,TEENC
20 READ (NUTEL,1063) NEL,J1,J2,J3,J4,TMASV,TMEMV,TEENV
NC THIK = 1
IF (TMASV.LE.0.0 .AND. TMEMV.LE.0.0 .AND. TEENV.LE.0.0) NC THIK=0
IF (J1.LE.0) RETURN
NLINE = NLINE + 1
IF (NLINE.LE.40) GC TO 30
CALL PAGE4C
WRITE (NOT,2002)
WRITE (NOT,2003) NAMEM,NAMEK,NAMELT,NAMEST,NAMER,
* RC,E,TMASC,ANU,TMEMC,TEENC
NLINE = 0
30 IF (NC THIK.GE.1)
*WRITE (NOT,2004) NEL,J1,J2,J3,J4,TMASV,TMEMV,TEENV
IF (NC THIK.EQ.0) WRITE (NOT,2005) NEL,J1,J2,J3,J4
C
C SET THICKNESSES.
TMAS = TMASC
TMEM = TMEMC
TEEN = TEENC
IF (TMASV.GT.0.0) TMAS=TMASV
IF (TMEMV.GT.0.0) TMEM=TMEMV
IF (TEENV.GT.0.0) TEEN=TEENV
C
C FORM FINITE ELEMENT COORDINATE LOCATIONS, EULER ANGLES, REVADD IVEL.
DO 42 I=1,3
CJ(I,1) = YYZ(J1,I)
CJ(I,2) = YYZ(J2,I)
CJ(I,3) = YYZ(J3,I)
CE(I,1) = CE(I)
CE(I,2) = CE(I)
CE(I,3) = CE(I)
42 EJ(I,4) = JL(J4,I)
DO 44 I=1,4
IV(1) = JDCF(J1,I)
IV(1+I) = JDCF(J2,I)
IV(1+2I) = JDCF(J3,I)
IV(1+4I) = JDCF(J4,I)
C
C FORM MASS MATRIX (W).
IF (AMS.EQ.6H .OR. NAMEM.EQ.6H) 6HCMMASS) GO TO 110
CALL MAT4C (CJ,EJ,TMAS,FL,NAMEM,W,1.,KCJ,KCJ,KW,KW)
NEKRCR=2
IF (NUTMX.LE.0) GC TO 99
WRITE (NUTMX) NAMEM,NEL,NPW,NFX,NAMEL,(1FLNK,I=1,2)
C FORM STIFFNESS MATRIX (W), LOCAL LOAD TRANSFORMATION MATRIX (T),
C STRESS TRANSFORMATION MATRIX (S).
110 IF (NAMEK .EQ. 6H) OR (NAMEK .EQ. 6HNOSTIF) GO TO 20
   CALL STF3 (CJ,EJ,TEMN,TEEN,E,ANU,NAMEK,NAMET,W,T,S,NRS1,
   * KLI,KCJ,KW,KW,KW)
   NERROR=3
   IF (NUTKD .LE. 0) GO TO 999
   WRITE (NUTKD) NAMEK,NFL,REW,REW,REW,NAMET,(IELNK,I=1,5),
   * ((W(I,J),I=1,REW),J=1,REW),(IVI(I),I=1,REW)
   IF (NAMELT .EQ. 6H) OR (NAMELT .EQ. 6HNOLOAD) GO TO 115
   NERRCK=4
   IF (NUTLT .LE. 0) GO TO 999
   WRITE (NUTLT(L)) NAMELT,MLE,LRLT,REW,NAMET,(IELNK,I=1,5),
   * ((T(I,J),I=1,REW),J=1,REW),(IVI(I),I=1,REW)
115 IF (NAMET .EQ. 6H) OR (NAMET .EQ. 6HNOSTIF) GO TO 20
   NERROP=5
   IF (NUTST .LE. 0) GO TO 999
   WRITE (NUTST) NAMEST,MEL,NRS,T,NPW,NAMET,(IBLNK,I=1,5),
   * ((S(I,J),I=1,NRS),J=1,NPW),(IVI(I),I=1,NPW)
   GO TO 20
C 999 CALL ZZPOMP (CHCUAD ,NERROR)
END
SUBROUTINE RECTSP (XYZ, JD0F, EUL, NUTFL, NJ, 
               NUTMX, NTKX, NULT, NUST, 
               Wt, T, S, K, K, KE, KH)

* DIMENSION XYZ(KK,1), JD0F(KJ,1), EUL(KF,1), N(KW,1), T(IKW,1), S(IKW,1)
* DIMENSION CJ(3,4), EJ(3,4), IV1(12)
* DATA NAMEL/6FECFSP/, NFW, NLMT/12,3/ , IBNLK/9/ , KCJ/3/
* DATA NIT, NCUT/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 NUTLT),
C LOCAL LOAD TRANSFORMATION MATRICES AND IVECS (ON NULT),
C STRESS TRANSFORMATION MATRICES AND IVECS (ON NUST),
C FOR RECTANGULAR SHEAR PANEL ELEMENTS.
C KAT'S, STIFFNESS MATRICES ARE IN GLOBAL COORDINATE DIRECTIONS.
C GLOBAL COORDINATE ORDER IS
C (U, V, W) JOINT 1, THEN JOINT 2, 3, 4,
C WHERE U, V, W ARE TRANSLATIONS.
C IVEC GIVES ELEMENT DOF INTO GLOBAL DOF. EXAMPLES...
C IV1(6)=634 PLACES ELEMENT DOF 6 INTO GLOBAL DOF 834.
C IV1(3)=6 PLACES ELEMENT DOF 3 FROM GLOBAL DOF. THIS CONSTRAINS
C ELEMENT DOF 3 TO ZERO MOTION.
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) JOINT 1, THEN JOINT 2, 3, 4,
C WHERE P IS FORCE.
C LOCAL LOAD TRANSFORMATION MATRICES RELATES LOAD AT PANEL VERTICES IN
C LOCAL COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE
C DIRECTIONS.
C STRESS TRANSFORMATION MATRICES RELATES PANEL SHEAR STRESS (CONSTANT)
C IN LOCAL COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE
C DIRECTIONS.
C DATA ARRANGEMENT ON NUTMX, NUTKX, NULT, NUST FOR EACH FINITE
C ELEMENT IS (U=K, LT, ST)
C WRITE (NUTMX) NAMEN, NEL, NR, NC, NAMEL.(JBLNK, I=1, 5),
C IF (J1,J2,J3,J4) (W(J), J=1, 5, NP), J=1, NC, (IVEC(I), I=1, NC)
C CALLS FORMA SUBROUTINES MAS3A, PAGEMD, STF3A, Z2EDMR.
C DEVELOPED BY PL WOHLF, APRIL 1974.
C LAST REVISION BY WA BINFIEL, MARCH 1976.
C
C ***********************************************************************
C INPUT DATA READ IN THIS SUBROUTINE FROM NULFEL. IF NUFEL = 5, DATA IS
C READ FROM CPDS.
C NAMEN, NAMEK, NAMELT, NAMEST FORMAT (4(A6,4X)
C PC, 6 FORMAT (215X, E10))
C TMAS, ISTF FORMAT (215X, E10)
C 20 NEL, J1, J2, J3, J4
C IF (.T., PC, 0) RETURN
C GO TO 20
C
C DEFINITION OF INPUT VARIABLES.
C NAMEN = TYPE OF MASS MATRIX WANTED.
C = M1, DIAGONAL LUMPED.
C = M2, CONSISTENT.
C = 6H OR 6H+MASS, NO MASS MATRIX CALCULATED.
C NAMEK = TYPE OF STIFFNESS MATRIX WANTED.
C = K1, LINEAR DISPLACEMENT (CONSTANT STRAIN).
C = 6H OR 6H+STIF, NO STIFFNESS MATRIX CALCULATED.
C NAMELT = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES.
C = 6H OR 6H+LOAD, NO LOAD TRANSFORMATIONS CALCULATED.
C NAMEST = IDENTIFICATION NAME FOR STRESS TRANSFORMATION MATRICES.
C = 6H OR 6H+STIPS, NO STRESS TRANSFORMATIONS CALCULATED.
C RD = MASS DENSITY.
C G = SMPL MODULUS OF ELASTICITY.
C TMAS = EFFECTIVE MASS THICKNESS.
C TSTF = EFFECTIVE STIFFNESS THICKNESS.
C NEL = FINITE ELEMENT NUMBER, FOR REFERENCE ONLY, NOT USED IN CALCULATIONS. WRITTEN ON NUTMX, ETC.
C J1 = JOINT NUMBER AT PANEL VERTEX 1.
C J2 = JOINT NUMBER AT PANEL VERTEX 2.
C J3 = JOINT NUMBER AT PANEL VERTEX 3.
C J4 = JOINT NUMBER AT PANEL VERTEX 4.

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

SUBROUTINE ARGUMENTS (ALL INPUT)
C XYZ = MATRIX OF JOINT GLOAL X,Y,Z LOCATIONS. ROWS CORRESPOND TO JOINT NUMBERS. COLUMNS 1,2,3 EACH ROW CORRESPOND TO THE JOINT X,Y,Z LOCATIONS RESPECTIVELY. SIZE(NJ,3).
C JDOF = MATRIX OF JOINT GLOAL DEGREES OF FREEDOM. ROWS CORRESPOND TO JOINT NUMBERS. COLUMNS 1,2,3 EACH COLUMN 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 EACH COLUMN 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 = 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 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 STIFFNESS MATRICES (SAME AS GLOBAL LOADS TRANSFORMATION MATRICES) AND IVECS ARE OUTPUT.
C NUTKX MAY BE ZERO IF STIFFNESS MATRIX IS NOT FORMED.
C USES FORTRAN READ, WRITE.
C NULT = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT LOCAL LOAD TRANSFORMATION MATRICES AND IVECS ARE OUTPUT.
C NULT MAY BE ZERO IF LOAD TRANSFORMATIONS ARE NOT FORMED.
C USES FORTRAN READ, WRITE.
C NUST = 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 FCPTRAN 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 KK = ROW DIMENSION OF XYZ IN CALLING PROGRAM.
C KJ = ROW DIMENSION OF JOOF 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 NERRCR EXPLANATION
C 1 = INPUT JOINT NUMBER EXCEEDS MAXIMUM ALLOWABLE NUMBER OF JOINTS.
C 2 = NUTMX NON POSITIVE.
C 3 = NUTKX NON POSITIVE.
C 4 = NULTLX NON POSITIVE.
C 5 = NUTST NON POSITIVE.
C
C 1001 FORMAT (4(A6,4X))
C 1002 FORMAT (2(5X,E10.0))
C 1003 FORMAT (515)
C 2001 FORMAT (//3EX 47H INPUT DATA FCP RECTANGULAR SHEAR PANEL ELEMENTS)
C 2002 FORMAT (//32X 47H INPUT DATA FOR RECTANGULAR SHEAR PANEL ELEMENTS
C * 12H (CONTINUED))
C 2003 FORMAT (/ 14X7H MASS = A0, 14X7HSTIF = A6, 11X7HLOAD TRANS = A6,
C * 8X15HSTRESS TRANS = A6,
C * / 16X4HRO = E10.3, 14X3HGG = E10.3,
C * / 11X9HT(MASS) = E10.3, 8X9HT(STIF) = E10.3,
C * //18X7H ELEMENT 13X7HJOINT 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 PAGEFD
C WRITE (NCT,2061)
C READ (NUTFL,1001) NAMEM,NAMENK,NAMETL,NAMEST
C READ (NUTFL,1002) RO,G
C READ (NUTFL,1062) TMAS,TSTF
C WRITE (NCT,2063) NAMEM,NAMENK,NAMETL,NAMEST,RO,G,TMAS,TSTF
C 20 READ (NUTFL,1063) NEL,J1,J2,J3,J4
C IF (J1 .LE. G) RETURN
C NLINE = NLINE + 1
C IF (NLINE .LE. 42) GO TO 30
C CALL PAGEFD
C WRITE (NCT,2002)
C WRITE (NCT,2003) NAMEM,NAMENK,NAMETL,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.
C DO 42 I=1,3
C CJ(I,1) = YZ(J1,1)
C FORM MASS MATRIX (W).*
   IF (NAMFM .EQ. 6H) ** CF. NAMFM .EQ. 6HNCMASS GO TO 110
   CALL MAS3A (CJ,EJ,TMAS,RO,NAMFM,W,T,S,KCJ,KCJ,KW,KW,KW)
      NERROR=2
   END IF
   WRITE (NUTMX) NAMFM,NFL,NRW,NRW,NAMEL,(IBLNK,I=1,5),
      *((W(I,J),I=1,NRW),J=1,NRW),(IV1(I),I=1,NRW)
   C FORM STIFFNESS MATRIX (W), LOCAL LOAD TRANSFORMATION MATRIX (I),
   STRESS TRANSFORMATION MATRIX (S).*
C 110 IF (NAMFK .EQ. 6H) ** CF. NAMFK .EQ. 6HNOSTIF GO TO 20
   CALL STF3A (CJ,EJ,TSTF,G,NAMFK,NAMEST,W,T,S,NRST,
      * KCJ,KCJ,KW,KW,KW)
      NERROR=3
   END IF
   WRITE (NUTKX) NAMFK,NEL,NRW,NRW,NAMEL,(IBLNK,I=1,5),
      *((W(I,J),I=1,NRW),J=1,NRW),(IV1(I),I=1,NRW)
   IF (NAMELT .EQ. 6H) ** CF. NAMELT .EQ. 6HNOLOAD GO TO 115
      NERROR=4
   END IF
   WRITE (NULTK) NAMELT,NEL,NRKL,NRW,NAMEL,(IBLNK,I=1,5),
      *((W(I,J),I=1,NRKL),J=1,NRW),(IV1(I),I=1,NRW)
C 115 IF (NAMEST .EQ. 6H) ** CF. NAMEST .EQ. 6HNOSTRS GO TO 20
      NERROR=5
   END IF
   WRITE (NUTST) NAMEST,NEL,NRST,NPW,NAMEL,(IBLNK,I=1,5),
      *((W(I,J),I=1,NRST),J=1,NPW),(IV1(I),I=1,NPW)
   GO TO 20
C 999 CALL ZEROM (6HRECTSP,NERROR)
END
SUBROUTINE STF1A (CJ, EJ, A1, A2, E, NAMEK, NAMEST, S, TL, TS, NRST,
*          KCIJ, KEJ, KS, KTL, KTS)
   DIMENSION C(J(KEJ,1)), EJKE(J,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 AN AXIAL ROD ELEMENT WITH UNRESTRICTED BOUNDARIES.
C  ROD MAY BE LINEARLY TAPERED OR UNIFORM.
C  STIFFNESS 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  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 POD 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
C  WHERE PX IS AXIAL FORCE.
C  PX1(-), PX2(+) IS TENSION. PX1(+), PX2(-) IS COMPRESSION.
C  STRESS TRANSFORMATION MATRIX RELATES STRESS AT POD 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  EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
C  CALLS FORMA SUBROUTINES ATXBAI, DCOS1A, K1A1, MULTA, ZZ60MB.
C DEVELOPED BY RL WOHLFELD. SEPTEMBER 1972.
C LAST REVISION BY WA BENFIELD. MARCH 1976.

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 POD 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 POD END 1.
C A2 = INPUT CROSS-SECTION AREA AT POD END 2.
C E = INPUT YOUNGS MODULUS OF ELASTICITY.
C NAMEK = INPUT TYPE OF STIFF MATRIX WANTED.
C = K1, CONSTANT AXIAL FORCE ASSUMED.
C NAMEST = 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(6,6).
C TL = OUTPUT LOCAL LOAD TRANSFORMATION MATRIX. SIZE(NRST,6).
C TS = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(NRST,6).
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=6.
KTL = INPUT ROW DIMENSION OF TL IN CALLING PROGRAM, MIN=2.
KTS = INPUT ROW DIMENSION OF TS IN CALLING PROGRAM, MIN=NRST.

ERROR EXPLANATION
1 = SIZE LIMITATION EXCEEDED.
2 = NAMEK IMPROPERLY DEFINED.

NRST = 2
IF (KS .LT. 6 .OR. KTL .LT. 2 .OR. KTS .LT. NRST) GO TO 999
PL = SCPT((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) TL=K

CALL DCOS1A (CJ, EJ, A, KCJ, KEJ, KS)
CALL MULTA (TL, S, 2, 2, 6, KTL, KS)
IF (NAMEST .EQ. 6P .OR. NAMEST .EQ. 6HNOST) GO TO 210
CALL MULTA (TS, S, NRST, 2, 6, KTS, KS)
210 CALL ATXBA1 (S, TL, 2, 6, KS, KTL) RETURN

999 CALL ZZROMR (6HSTF1A, NERROR)
END
SUBROUTINE STF18 (CJ,LJ,KODE,A1,A2,TJ1,TJ2,R121,B122,B1Y1,B1Y2,
  *  K1,R2,CY1,CY2,CZ1,CZ2,SF,E,G,NAMEK,NAMET,
  *  S,TL,TS,NST,KCJ,KEJ,KS,KTL,KTS)
  .DIMENSION CJ(KCJ,1),EJ(KEJ,1),KODE(1),S(KS,11),TL(KTL,1),TS(KTS,1)

  SUBROUTINE TO CALCULATE FINITE ELEMENT...
  STIFFNESS MATRIX (SAME AS GLOBAL LOAD TRANSFORMATION MATRIX),
  LOCAL LOAD TRANSFORMATION MATRIX,
  STRESS TRANSFORMATION MATRIX,
  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.
  LOCAL 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 DEFLECTIONS IN THE GLOBAL COORDINATE
  DIRECTIONS.
  ROW ORDER IN GLOBAL LOAD TRANSFORMATION MATRIX IS
  (PU,PV,PW,MP,MPQ,MR) 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 DEFLECTIONS IN THE GLOBAL COORDINATE DIRECTIONS.
  ROW ORDER IN LOCAL LOAD TRANSFORMATION MATRIX IS
  PX1, PX2, MX1, MX2, PY1, PY2, M21, M22, P21, P22, MY1, MY2
  WHERE P IS FORCE AND M IS MOMENT.
  STRESS TRANSFORMATION MATRIX RELATES STRESS AT BAR ENDS IN LOCAL
  COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE DIRECTIONS.
  ROW ORDER IN STRESS TRANSFORMATION MATRIX IS
  PX1/1, PX2/2, MX1*1/TJ1, MX2*2/TJ2, 
  PY1/1, PY2/2, M21*CY1/E121, M22*CY2/B122, 
  P21/1, P22/2, MY1*CY1/E1Y1, MY2*C22/B1Y2
  WHERE P IS FORCE AND M IS MOMENT.
  EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
  CALLS FORMA SUBROUTINES ATXPAI,DCOSIB,KIA,KIB1,KIC1,MULTA,ZZBOMB.
  LAST REVISION BY RL WOHLKEN. APRIL 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
  MATRIX 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).

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).
KODE(4)=6Y, LOCAL STIFFNESS MATRIX IS CALCULATED
FOR BENDING (ABOUT LOCAL Y-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
      JC AT BAR END 1.
TJ2 = INPUT SAME AS TJ1 AT BAR END 2.
B121 = INPUT CROSS-SECTION AREA MOMENT OF INERTIA ABOUT LOCAL
       Z-AXIS (FOR BENDING) AT BAR END 1.
B122 = INPUT SAME AS B121 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.
K1 = 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.
C21 = INPUT DISTANCE FROM XY PLANE TO OUTER FIBER FOR BENDING
     STRESS CALCULATION AT BAR END 1. LOCAL Z DIRECTION.
C22 = INPUT SAME AS C21 AT BAR END 2.
SF = INPUT 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=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 MATRICES WANTED.
      = K1, USES K1A1 FOR AXIAL, K1C1 FOR TORSION,
      K1B1 FOR BENDING.
NAMEST = INPUT OPTION FOR STRESS TRANSFORMATION.
      = 6H OR 6HNCSTRS , 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.

NAMEK = INPUT TYPE OF STIFFNESS MATRICES WANTED.
      = K1, USES K1A1 FOR AXIAL, K1C1 FOR TORSION,
      K1B1 FOR BENDING.
NAMEST = INPUT OPTION FOR STRESS TRANSFORMATION.
      = 6H OR 6HNCSTRS , 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.

NAMEK = INPUT TYPE OF STIFFNESS MATRICES WANTED.
      = K1, USES K1A1 FOR AXIAL, K1C1 FOR TORSION,
      K1B1 FOR BENDING.
NAMEST = INPUT OPTION FOR STRESS TRANSFORMATION.
      = 6H OR 6HNCSTRS , 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.

NAMEK = INPUT TYPE OF STIFFNESS MATRICES WANTED.
      = K1, USES K1A1 FOR AXIAL, K1C1 FOR TORSION,
      K1B1 FOR BENDING.
NAMEST = INPUT OPTION FOR STRESS TRANSFORMATION.
      = 6H OR 6HNCSTRS , 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.

NAMEK = INPUT TYPE OF STIFFNESS MATRICES WANTED.
      = K1, USES K1A1 FOR AXIAL, K1C1 FOR TORSION,
      K1B1 FOR BENDING.
NAMEST = INPUT OPTION FOR STRESS TRANSFORMATION.
      = 6H OR 6HNCSTRS , 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.
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).
110 IF (KODEA .EQ. 1) CALL K1A1 (A1,A2,RL,F,TL,T5,KTL,KTS)
   IF (KODET .EQ. 1) CALL K1C1 (T1,J1,J2,R1,R2,RL,G,T63,TS3,3,3,TS3,3,3, 
   * KTL,KTS)
   IF (KODEBZ .EQ. 1) CALL K1B1 (B1Z1,B1Z2,GY1,CY2,A1,A2,SL,EL,G, 
   * TL5,TS5,5,KTL,KTS)
   DO 115 J=7,8
   DO 115 I=5,6
   TL(I,J) =-TL(I,J)
   TS(I,J) =-TS(I,J)
   TL(J,I) =-TL(J,I)
   115 TS(J,J) =-TS(J,J)
   IF (KODEBY .EQ. 1) CALL K1B1 (B1Y1,B1Y2,CZ1,CZ2,A1,A2,SL,EL,G, 
   * TL9,TS9,9,KTL,KTS) TL=K
C
CALL DCOS18 (CJ,EJ,S,K,JC,KFJ,KS)
CALL MULTA (TL,S,12,12,12,12,KTL,KS)
IF (NAMEST .EQ. 6H0) OR (NAMEST .EQ. 6H0NSTRS) GO TO 210
CALL MULTA (TS,S,9R5,12,12,KTS,KS)
210 CALL ATXEA1 (S,TL,12,12,KS,KTL)
RETURN
C
999 CALL ZZECME (G,HSTF18,MERROR)
END
SUBROUTINE STF2 (CJ,EJ,TMEM,TEN,E,ANU,NAM,NAMEST,S,TL,TS,NRST, *
  K,KEJ,KS,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,Q,R) JOINT 1, THEN JOINT 2, 3.
  C WHERE U,V,W ARE TRANSLATIONS AND P,Q,R ARE ROTATIONS.
  C GLOBAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT TRIANGLE 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, MQ, MR) JOINT 1, THEN JOINT 2,3.
  C WHERE P IS FORCE AND M IS MOMENT.
  C LOCAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT TRIANGLE 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, PM) JOINT 1 THEN 2,3, NEXT
  C (PZ, MX, MY) JOINT 1 THEN 2,3.
  C WHERE P IS FORCE AND M IS MOMENT.
  C STRESS TRANSFORMATION MATRIX RELATES STRESS AT TRIANGLE VERTICES IN LOCAL
  C COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE DIRECTIONS.
  C ROW ORDER IN STRESSES TRANSFORMATION MATRIX IS
  C (SIGMA-X, SIGMA-Y, TAU-XY) FOR (Z=TEN/2) AT JOINT 1,
  C THEN JOINT 2,3.
  C (SIGMA-X, SIGMA-Y, TAU-XY) FOR (Z=-TEN/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 FORM SUBROUTINES ATXBAI,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 JOINTS 1,2,3. SIZE(3,3).
  C TMEM = INPUT EFFECTIVE membrane thickness.
  C TEN = 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 STIF MATRIX WANTED.
  C = K1, USFS K2A1 FOR membrane, K2B1 FOR BENDING.
  C NAMEST = 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=N RST.
C
C NERROR EXPLANATION
C 1 = SIZE LIMITATION EXCEEDED.
C 2 = NAMEK IMPROPERLY DEFINED.

C NRST = 18
C
IF (KS *LT. 18 *OR* KTL *LT. 18 *OR* KTS *LT. NRST) GO TO 990
DO 5 J=1,18
DO 5 I=1,18
5 TL(I,J) = 0.0
5 TS(I,J) = 0.0
5 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(1,2))**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)
Y3 = SQRT(SL13**2-X3**2)
IF (NAMEK *EQ. 6HK1) GO TO 110
GO TO 990

C MEMBRANE = KZ2A1 (BODLEY, RENFIELD), FENDING = KZB1 (BODLEY).

110 CALL KZ2A1 (SL12,X3,Y3,TLM,F,ANUS,TL,TS,S,KTL,KTS,KS)
CALL KZB1 (SL12,X3,Y3,TBN,E,ANUS,TL(10,10),TS(1,10),S,
* KTL,KTS,KS)
DO 111 I=1,9
II = I+9
DC 111 J=1,9
111 TS(I,J) = TS(I,J)
C
CALL DCOS2 (CJ,EJ,S,KCJ,KEJ,KS)
CALL MUTA (TL,S,18,18,E,KTL,KS)
IF (NAMEST *EQ. 6H *OR* NAMEST *EQ. 6HNOSTRS) GO TO 210
CALL MUTA (TS,S,NRST,18,18,KTS,KS)
210 CALL ATXPA1 (S,TL,18,18,KS,KTL)
RETURN
C
999 CALL ZZBOMB (5HSTF2,NERROR)
END
SUBROUTINE STF3  
* SUBROUTINE TO CALCULATE FINITE ELEMENT...
* STIFFNESS MATRIX (SAME AS GLOBAL LOAD TRANSFORMATION MATRIX),
* LOCAL LOAD TRANSFORMATION MATRIX (NOT YET),
* STRESS TRANSFORMATION MATRIX (NOT YET),
* FOR A COMINED MEMBRANE-BENDING QUADRILATERAL PLATE ELEMENT WITH
* UNRESTRAINED BOUNDARIES.
* STIFFNESS 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.
* GLOBAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT QUAD VERTICES IN
* GLOBAL COORDINATE DIRECTIONS TO DEFLECTIONS IN THE GLOBAL COORDINATE
* DIRECTION.
* ROW ORDER IN GLOBAL LOAD TRANSFORMATION MATRIX IS
* (PU,PV,PW,MP,MN,MR) JOINT 1, THEN JOINT 2,3,4.
* WHERE P IS FORCE AND M IS MOMENT.
* LOCAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT QUAD VERTICES IN
* LOCAL COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE
* DIRECTION.
* STRESS TRANSFORMATION MATRIX RELATES STRESS AT QUAD VERTICES IN LOCAL
* COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE DIRECTION.
* EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
* CALLS FORMA SUBROUTINES STF2,PEVAD,ZZBMR.
* LAST REVISION BY WA BENFIELD. MARCH 1976.
* 
* SUBROUTINE ARGUMENTS
* CJ = INPUT NUMPY 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).
* TMEM = INPUT EFFECTIVE MEMBRANE THICKNESS.
* TBN = INPUT EFFECTIVE PENDING THICKNESS.
* E = INPUT YOUNG'S MODULUS OF ELASTICITY.
* ANU = INPUT POISSONS RATIO. (E/2G)-1.
* NAMEK = INPUT TYPE OF STIF MATRIX WANTED.
* = K1, USES 4 TRIANGLES, OVERLAP AVERAGE.
* NAMEST = INPUT OPTION FOR STRESS TRANSFORMATION.
* = 6H OR 6HNOSTR, NO STRESS TRANS CALCULATED.
* S = OUTPUT STIFFNESS MATRIX (SAME AS GLOBAL LOAD TRANSFORMATION
* MATRIX). SIZE(24,24).
* TL = OUTPUT LOCAL LOAD TRANSFORMATION MATRIX. SIZE(24,24).

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 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
NERROK 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
DO 5 I=1,24
5 S(I,J) = 0.0
IF (NAMEK .LT. 6) GO TO 110

GO TO 999

NERROK=1

DO 200 I=1,3
CWI(I,1) = CJI(I,1)
EWI(I,1) = EJI(I,1)
CWI(I,2) = CJI(I,2)
EWI(I,2) = EJI(I,2)
CWI(I,3) = CJI(I,3)

200 EW(I,3) = EJI(I,3)
CALL SFT2 (CWI, EW, TMFM, TLEN, E, ANU, NAMEK, NAMEST, W1, TL, TS, NRSTX, *
            * KCW, KCW, W1, KTL, KTS)
CALL REVAMD (.5, W1, IV1, IV1, S, 18, 18, 24, 24, 18, KS)
DO 201 I=1,3
CWI(I,1) = CJI(·:·1)
EWI(I,1) = EJI(I,1)
CWI(I,2) = CJI(I,3)
EWI(I,2) = EJI(I,3)
CWI(I,3) = CJI(I,4)

201 EW(I,2) = EJI(I,4)
CALL SFT2 (CWI, EW, TMFM, TBN, F, ANU, NAMEK, NAMEST, W1, TL, TS, NRSTX, *
            * KCW, KCW, W1, KTL, KTS)
CALL REVAMD (.5, W1, IV2, IV2, S, 18, 18, 24, 24, 18, KS)
DO 203 I=1,3
CWI(I,1) = CJI(I,1)
EWI(I,1) = EJI(I,1)
CWI(I,2) = CJI(I,2)
EWI(I,2) = EJI(I,2)
CWI(I,3) = CJI(I,4)

203 EW(I,3) = EJI(I,4)
CALL SFT2 (CWI, EW, TMFM, TBN, F, ANU, NAMEK, NAMEST, W1, TL, TS, NRSTX, *
            * KCW, KCW, W1, KTL, KTS)
CALL REVAMD (.5, W1, IV3, IV3, S, 18, 18, 24, 24, 18, KS)
DO 205 I=1,3
CWI(I,1) = CJI(I,2)
EWI(I,1) = EJI(I,2)
CW(1,2) = CJ(I,3)
EW(I,?) = EJ(I,3)
CW(I,3) = CJ(I,4)
EW(I,3) = EJ(I,4)

CALL STF2 (CW, EW, TEMEM, TBEN, E, ANU, NAMEK, NAMEST, W1, TL, TS, NRSTX,
*                 KCW, KCW, KW1, KTL, KTS)
CALL REVADD (1.5, W1, IV4, IV4, S, 18,18,24,24, 18, KS)

C
DO 300 J=1,24
DO 300 I=1,24
TL(I,J) = 0.0
300 TS(I,J) = 0.0
RETURN
C
999 CALL ZZROMB (4HSTF3 ,NERROR)
END
SUBROUTINE STF3A (CJ,EJ,TH,G,NAMEK,NAMEST,S,TL,TS,NRST, *
  KCJ,KEJ,KS,KTL,KTS)
  DIMENSION CJ(KCJ,1), EJ(KEJ,1), S(KS,1), TL(KTL,1), TS(KTS,1)
C
SUBROUTINE TO CALCULATE FINITE ELEMENT...
STIFFNESS MATRIX (SAME AS GLOBAL LOAD TRANSFORMATION MATRIX),
LOCAL LOAD TRANSFORMATION MATRIX,
STRESS TRANSFORMATION MATRIX,
FOR A RECTANGULAR SHEET PANEL ELEMENT WITH UNRESTRAINED BOUNDARIES.
STIFFNESS MATRIX IS IN GLOBAL COORDINATE DIRECTIONS.
GLOBAL COORDINATE ORDER IS
(U,V,W) JOINT 1, THEN JOINT 2, 3, 4.
WHERE U,V,W ARE TRANSLATIONS.
GLOBAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT PANEL VERTICES IN
GLOBAL COORDINATE DIRECTIONS TO DEFLECTIONS IN THE GLOBAL COORDINATE
DIRECTIONS.
ROW ORDER IN GLOBAL LOAD TRANSFORMATION MATRIX IS
(PX,PY,PZ) JOINT 1, THEN JOINT 2, 3, 4.
WHERE P IS FORCE.
LOCAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT PANEL VERTICES IN
LOCAL COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE
DIRECTIONS.
ROW ORDER IN LOCAL LOAD TRANSFORMATION MATRIX IS
FX,FY,FZ,FX,FZ,FY,FY,FZ,FZ,FY,FY,FZ.
WHERE P IS FORCE. X GOES FROM 1 TO 2, Y GOES FROM 1 TO 4.
STRESS TRANSFORMATION MATRIX RELATES PANEL SHEAR STRESS (CONSTANT) IN
LOCAL COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORD DIRECTIONS.
EUCLER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
CALLS FORMA SUBROUTINES ATXBA1,DCOS3G,KSC1,MULTA,ZZCBMB.
DEVELOPED BY RL WHELEN, APRIL 1974.
LAST REVISION BY WA BENFIELD, MARCH 1976.
C
SUBROUTINE ARGUMENTS
C
CJ = INPUT MATRIX OF GLOBAL X,Y,Z COORDINATES AT PANEL JOINTS.
ROWS 1,2,3 CORRESPOND TO X,Y,Z COORDINATES.
CCS 1,2,3,4 CORRESPOND TO JOINTS 1,2,3,4. SIZE(3,4).
EJ = INPUT MATRIX OF EUCLER ANGLES (DEGREES) AT PANEL JOINTS.
ROWS 1,2,3 CORRESPOND TO GLOBAL X,Y,Z PERMUTATION.
CCS 1,2,3,4 CORRESPOND TO JOINTS 1,2,3,4. SIZE(3,4).
TH = INPUT PANEL THICKNESS.
G = INPUT SHEAR MODULUS OF ELASTICITY.
NAMEK = INPUT TYPE OF STIFF MATRIX WANTED.
  = 1, USE KSC1.
NAMEST = INPUT OPTION FOR STRESS TRANSFORMATION.
  = 6H, USE HMDSTRT *NO STRESS TRANS CALCULATED.
S = OUTPUT STIFFNESS MATRIX (SAME AS GLOBAL LOAD TRANSFORMATION
MATRIX). SIZE(12,12).
TL = OUTPUT LOCAL LOAD TRANSFORMATION MATRIX. SIZE(6,12).
TS = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(1,12).
NPST = OUTPUT NUMBER OF ROWS (1) IN STRESS TRANSFORMATION MATRIX.
KCJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM.
KEJ = INPUT ROW DIMENSION OF EJ IN CALLING PROGRAM.
KS = INPUT ROW DIMENSION OF S IN CALLING PROGRAM. MIN=12.
KTL = INPUT ROW DIMENSION OF TL IN CALLING PROGRAM. MIN=6.
KTS = INPUT ROW DIMENSION OF TS IN CALLING PROGRAM. MIN=1.
C  NEFORTH EXPLANATION
C  1 = SIZE LIMITATION EXCEEDED.
C  2 = NAMEK IMPROPERLY DEFINED.
C
NRST = 1

IF (KS .LT. 12 .OR. KTL .LT. KS) 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  NERROR=2
GO TO 999

C 110 CALL K3C1 (SL12,SL14,TH,G,TL,TS,KTL,KTS)  TL=K
C
CALL DCONS (CJ,EC,KE,KS)
CALL MULTA (TL,SE,12,KTL,KS)
IF (NAMEST .EQ. 6H .OR. NAMEST .EQ. 6HNOSTR) GO TO 210
CALL MULTA (TS,ST,NRST,A,12,KTS,KS)
210 CALL ATXEA1 (S,TL,EC,12,KS,KTL)
RETURN

C 999 CALL Z7POMF (6HSTF3A,NERROR)
END
SUBROUTINE TEGFOM (CJ, JM, VL, DV, KCJ, IFBAD)
DIMENSION CJ(KCJ,1), JM(1), DV(1)
DIMENSION R12(3), R13(3), R14(3)
DATA EPS / 1.E-5 /

C
C SUBROUTINE TO DETERMINE THE VOLUME AND VOLUME CHANGE COEFFICIENTS OF
C A TETRAHEDRON.
C CALLS FORM SUBROUTINES VCROSS, VDOT.
C DEVELOPED BY C S HODLEY, FEBRUARY 1974.
C LAST REVISION BY R A PHILIPPIUS, AUGUST 1974.
C
SUBROUTINE ARGMENTS
C CJ = INPUT MATRIX OF JOINT COORDINATES. SIZE(3,8).
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 P/N 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)
DO 5 I=1,2
R12(I) = CJ(I,J2) - CJ(I,J1)
R13(I) = CJ(I,J3) - CJ(I,J1)
R14(I) = CJ(I,J4) - CJ(I,J1)
5 CONTINUE
C
CALL VCROSS (R12,R13,DV(10),VAMAG,VPNAME,VZMAG,SINAB)
CALL VDOT (DV(10),R14,VCL,VAMAG,VPNAME,COSAB)
IF (VOL.E.EPS) IFBAD = 0
VL = VOL/6.
C
CALL VCROSS (R13,R14,DV(4),VAMAG,VPNAME,VZMAG,SINAB)
CALL VCROSS (R14,R12,DV(7),VAMAG,VPNAME,VZMAG,SINAB)
DO 10 I=1,3
10 DV(I) = -DV(I+3) - DV(I+6) - DV(I+9)
DO 15 I=1,12
15 DV(I) = DV(I)/6.
C
RETURN
END
SUBROUTINE TRNGL (XYZ, JDOF, EUL, NUTEL, NJ,
  * NUTMX, NUTKX, NUTBX, NULT, NUST,
  * W, T, S, KX, KJ, KE, 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 NAMS(6) = 'TRNGL', 'NRW', 'NRLT/18, 18/', 'IBLNK/6H', '/', 'KCJ/3/
DATA NIT, IOT(5), 0/

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 NUTBX),
C UNIT LOAD BUCKLING MATRICES AND IVECS (ON NUTBX), (NOT YET)
C LOCAL LOAD TRANSFORMATION MATRICES AND IVECS (ON NULT),
C STRESS TRANSFORMATION MATRICES AND IVECS (ON NUST),
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 (U, V, W, P, M, R) JOINT 1, THEN JOINT 2, 3.
C WHERE U, V, W APE TRANSLATIONS AND P, M, R APE 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 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 DIRECTIONS TO DEFLECTIONS IN THE GLOBAL COORDINATE
C DIRECTIONS.
C ROW ORDER IN GLOBAL LOAD TRANSFORMATION MATRIX IS
C (PU, PV, PW, NP, NG, NK) 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, MX, MY) 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-X IS NORMAL STRESS AND TAU IS SHEAR STRESS.
C DATA ARRANGEMENT ON NUTMX, NUTKX, NUTBX, NULT, NUST FOR EACH
C FINITE ELEMENT IS (W, M, K, T, S, LT, ST)
C WRITE (NUTWX) N, MEX, NFX, NP, NC, NAMFL, (IBLNK, I=1, 5),
C (((W(1, J), I=1, NR), J=1, NC), (IVEC(I), I=1, NC)
C CALLS FORMA SUBROUTINES MSA2, PAGEHD, STF2, ZZBOME.
C LAST REVISION BY RL WOHLEN. MAY 1976.
C
INPUT DATA READ IN THIS SUBROUTINE FROM NUTEL. IF NUTEL = 5, DATA IS READ FROM CARDS.

NAMEF, NAMEK, NAMELT, NAMEST, NAMEB
R0, E, ANU
TMASc, TMEMC, TBENC
20 N1, J2, J3, TMASV, TMEMV, TBENV
IF (J1 .EQ. 0) RETURN
GO TO 20

DEFINITION OF INPUT VARIABLES.
NAMEF = TYPE OF MASS MATRIX WANTED.
  = M1, DIAGONAL LUMPED.
  = M2, CONSISTENT.
NAMEK = TYPE OF STIFFNESS MATRIX WANTED.
  = K1, QUADRATIC DISPLACEMENT FOR MEMBRANE, CUBIC DISPLACEMENT FOR BENDING.
NAMELT = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES.
  = 6H OR 6HNOLOAD, NC LOAD TRANSFORMATIONS CALCULATED.
NAMEST = IDENTIFICATION NAME FOR STRESS TRANSFORMATION MATRICES.
  = 6H OR 6HNOSTFS, NC STRESS TRANSFORMATIONS CALCULATED.
NAMEB = TYPE OF BUCKLING MATRIX WANTED.
  = 6H OR 6HNOBUCK, NO BUCKLING MATRIX CALCULATED.
RO = MASS DENSITY.
E = YOUNG'S MODULUS OF ELASTICITY.
ANU = POISSON'S RATIO, (E/2G)-1.
TMASc = EFFECTIVE MASS THICKNESS, (CONSTANT).
TMASV = EFFECTIVE MASS THICKNESS, (VARIABLE).
IF .LE. 0., TMASc IS USED.
TMEMC = EFFECTIVE MEMBRANE THICKNESS, (CONSTANT).
TMEMV = EFFECTIVE MEMBRANE THICKNESS, (VARIABLE).
IF .LE. 0., TMEMc IS USED.
TBENC = EFFECTIVE BENDING THICKNESS, (CONSTANT).
TBENV = EFFECTIVE BENDING THICKNESS, (VARIABLE).
IF .LE. 0., TBENC 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. NUMER 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 (NJ, 3).
JDDF = MATRIX OF JOINT GLOBAL DEGREES OF FREEDOM. ROWS CORRESPOND TO JOINT NUMBERS. COLUMNS 1, 2, 3 CORRESPOND TO THE JOINT TRANSFORMATION Dofs AND COLUMNS 4, 5, 6 CORRESPOND TO THE JOINT
**TRNLGL -- 3/5**

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 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 NUTBX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT UNIT LOAD
C PULLING MATRICES AND IVECS ARE OUTPUT.
C NUTBX MAY BE ZERO IF PULLING MATRIX IS NOT FORMED.
C USES FORTRAN READ, WRITE.
C NUTEX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT UNIT LOAD
C PULLING MATRICES AND IVECS ARE OUTPUT.
C NUTEX MAY BE ZERO IF PULLING 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 WOPK SPACE. MIN SIZE(18, 18).
C T = MATRIX WORK SPACE. MIN SIZE(18, 18).
C S = MATRIX WOPK SPACE. MIN SIZE(18, 18).
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=18.

NEROR 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.

1001 FORMAT (5(6,E4.4))
1002 FORMAT (3(5X,E10.4))
1003 FORMAT (4(5X,E10.4))
2001 FORMAT (/32X'49HINPUT DATA FOR COMBINED MEMBRANE-BENDING TRIANGLE
* 15H PLATE ELEMENTS)
2002 FORMAT (/32X'49HINPUT DATA FOR COMBINED MEMBRANE-BENDING TRIANGLE
* 27H PLATE ELEMENTS (CONTINUED))
2003 FORMAT (/ 13X7=MASs = A6, 13X7=STIF = A6, 6X13HLOAD TRANS = A6,
* 5X13HPUL = A6, 3X13HPULLING = A6,
* 15X4HPO = E10.3, 13X3HE = F10.3,
* 10X4HT(MASS) = E10.3, 12X4HNU = E10.3,
* 5X4HT(MEMBRANE) = E10.3,
* / 33x12ht(bending) = e10.3,  
* /18x 7helement 5x 7hjoint 1 5x 7hjoint 2 5x 7hjoint 3  
* 5x 7ht(mass) 6x 11ht(membrane) 5x 10ht(bending)  
* / 18x 6hnumbeP 36x 3(5x 10h(variable) ) 
2004 format (1Fx 4(15,7fX),3(e10.3,5X)) 
2005 format (1fx 4(15,7fX)) 
C 
C READ AND WRITE FINITE ELEMENT DATA. 
NLINE = 1: 
CALL PAGEFD 
WRITE (NO1,3601) 
READ (NUTEL,1001) NAMEM,NAMEK,NAMELT,NAMEST,NAMEB 
READ (NUTEL,1002) RO,ET,ANU 
READ (NUTEL,1002) TMAK,TMEMC,TBENC 
WRITE (NO,2003) NAMEM,NAMEK,NAMELT,NAMEST,NAMEB, 
* 
20 READ (NUTEL,1003) NEL,J1,J2,J3,TMASV,TMEMV,TEENV 
NO THIK = I 
IF (TMASV.LE.0. AND. TMEMV.LE.0. AND. TBENV.LE.0.) NO THIK=0 
IF (J1.LE.0.) RETURN 
NLINE = NLINE + 1 
IF (NLINE.LE.42) GO TO 30 
CALL PAGEFD 
WRITE (NO,2002) 
WRITE (NO,2003) NAMEM,NAMEK,NAMELT,NAMEST,NAMEB, 
* 
NLINE = 0 
30 IF (NO THIK .EQ.1) WRITE (NO,2004) NEL,J1,J2,J3,TMASV,TMEMV,TEENV 
IF (NO .THIK .EQ.0) WRITE (NO,2005) NEL,J1,J2,J3 
NERRD=1 
C 
C SET THICKNESSSES. 
TMAS = TMAK 
TMEM = TMEMC 
TBEN = TBENC 
IF (TMASV.GT.0.) TMAS=TMASV 
IF (TMEMV.GT.0.) TMEM=TMEMV 
IF (TBENV.GT.0.) TBEN=TEENV 
C 
C FORM FINITE ELEMENT COORDINATE LOCATIONS, EULER ANGLES, REVADD IVEC. 
DO 42 I=1,3 
CJ(I,1) = YZ(J1,I)  
CJ(I,2) = XY(J2,I)  
CJ(I,3) = XY(J3,I)  
EJ(I,1) = FUL(J1,I)  
EJ(I,2) = FUL(J2,I)  
42 EJ(I,3) = FUL(J3,I)  
DO 44 I=1,6 
IVI(I) = JD0F(J1,I)  
IVI(I+6) = JD0F(J2,I) 
44 IVI(I+12) = JD0F(J3,I) 
C 
C FORM MASS MATRIX (W). 

IF (NAMFM .LE. 6) GO TO 110
CALL MAS2 (CJ,EJ,TMAS,PO,NAMFM,W,T,S,KCJ,KCJ,KW,KW)

IF (NLRTX .LE. 0) GO TO 999
WRITE (NLMX) NAMFM,NEL,MRW,MRW,NAML,NB,(IBLNK, I=1,5),
            (W(I,J), I=1,MRW),J=1,MRW,(IV1(I), I=1,MRW)
C FORM STIFFNESS MATRIX (W), LOCAL LOAD TRANSFORMATION MATRIX (T),
C STRESS TRANSFORMATION MATRIX (S).
110 IF (NAMEK .EQ. 6) GO TO 20
    CALL STF2 (CJ,EJ,TMEM,BLF,F,ANU,NAMEK,NAMES,T,S,NSST,
                  KCJ,KCJ,KW,KW)

IF (NLTX .LE. 0) GO TO 999
WRITE (NLTX) NAMEK,NEL,NPT,MRW,MRW,NAME,S,(IBLNK, I=1,5),
            (W(I,J), I=1,MRW),J=1,MRW,(IV1(I), I=1,MRW)
115 IF (NAMEST .EQ. 6) GO TO 115
    WRITE (NLTS) NAMEST,NEL,NSST,MRW,MRW,NAME,S,(IBLNK, I=1,5),
            (S(I,J), I=1,NSST),J=1,MRW,(IV1(I), I=1,MRW)
115 IF (NLTS .LE. 0) GO TO 999
    WRITE (NLTS) NAMEST,NEL,NSST,MRW,MRW,NAME,S,(IBLNK, I=1,5),
            (S(I,J), I=1,NSST),J=1,MRW,(IV1(I), I=1,MRW)
GO TO 20

999 CALL ZZBOM2 (6HTRNLG, NERROR)
END