(NASA-CR-144320) EXPANSION AND IMPROVEMENT OF THE FORMA SYSTEM FOR RESPONSE AND LOAD ANALYSIS, VOLUME 2C: LISTINGS, FINITE ELEMENT FORMA SUBROUTINES (MARTIN MARIETTA UNCLASS CORPORATIONS) 119 P HC $5.90 CSCL 134 63/39 43038

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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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Author:
Richard L. Wohlen

Approved:

Richard L. Wohlen
Program Manager

Prepared for: National Aeronautics and Space Administration
George C. Marshall Space Flight Center
Huntsville, Alabama 35812

MARTIN MARIETTA CORPORATION
Denver Division
Denver, Colorado 80201
foreword

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

This report is published in seven volumes:

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

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

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

The FORMA method has advantageous features such as:

1. subroutines in the library have been used extensively for many years and as a result are well checked out and debugged;
2. method will work on any computer with a FORTRAN IV compiler;
3. incorporation of new subroutines is no problem;
4. basic FORTRAN statements may be used to give extreme flexibility in writing a program.

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

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

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

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

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

The subroutines are given in alphabetical order with numbers coming before letters.
SUBROUTINE AXIAL (XYZ, JDOF, EUL, NUTEL, NJ,
* NUTMX, NUTX, 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(J3,2), IV(6)
DATA Namel/6MAXIAL/,. NRW,NRLT/6,2/,. IBLNK/6H/,. KCJ/3/.
DATA NIT, NC/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 NUTMX),
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 OMITS ELEMENT DOF 3 FROM GLOBAL DOF. THIS CONSTRains
C ELEMENT DOF 3 TO ZERO MOTION.
C GLOBAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT ROD ENDS IN GLOBAL
C COORDINATE DIRECTIONS TO DEFLECTIONS IN THE GLOBAL COORDINATE
C DIRECTIONS.
C ROW ORDER IN GLOBAL LOAD TRANSFORMATION MATRIX IS
C (PU, PV, PW) JOINT 1, THEN JOINT 2.
C WHERE P IS FORCE.
C LOCAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT ROD ENDS IN LOCAL
C COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE
C DIRECTIONS.
C ROW ORDER IN LOCAL LOAD TRANSFORMATION MATRIX IS
C PX1, PX2
C WHERE PX IS AXIAL FORCE.
C PX1(-), PX2(+) IS TENSION, PX1(+), PX2(-) IS COMPRESSION.
C STRESS TRANSFORMATION MATRIX RELATES STRESS AT ROD ENDS IN LOCAL
C COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE DIRECTIONS.
C ROW ORDER IN STRESS TRANSFORMATION MATRIX IS
C SIGMA-X1, SIGMA-X2
C WHERE SIGMA IS NORMAL STRESS.
C SX1(-), SX2(+) IS TENSION, SX1(+), SX2(-) IS COMPRESSION.
C DATA ARRANGEMENT ON NUTMX, NUTX, NUTLT, NUTST FOR EACH FINITE
C ELEMENT IS (W=MK, LT, ST)
C WRITE (NUTMX) NAMEN, 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 SUPROUTINES MASIA, PAGEHO, STFIA, Z2BOMB.
C LAST REVISION BY WA EENFIELD. MARCH 1976.
C
C***************************************************************************
C INPUT DATA READ IN THIS SUBROUTINE FROM NUTEL. IF NUTEL = 5, DATA IS
C READ FROM CARDS.
C NAMEI, NAMEK, NAMELT, NAMEST FORMAT (4(A6,4X)
C RO, E FORMAT (2(5X, E10))
C 20 NEL,J1,J2,A1,A2
C IF (J1 .EQ. 0) RETURN
C GO TO 20
C
C DEFINITION OF INPUT VARIABLES.
C NAMEM = TYPE OF MASS MATRIX WANTED.
C = M1, DIAGONAL LUMPED.
C = M2, CONSISTENT.
C = M3 OR 6HNONMASS, NO MASS MATRIX CALCULATED.
C NAMEK = TYPE OF STIFFNESS MATRIX WANTED.
C = K1, CONSTANT AXIAL FORCE ASSUMED.
C = K2 OR 6HINSTIF, NO STIFFNESS MATRIX CALCULATED.
C NAMELT = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES.
C = K3 OR 6HNLLOAD, NO LOAD TRANSFORMATIONS CALCULATED.
C NAMEST = IDENTIFICATION NAME FOR STRESS TRANSFORMATION MATRICES.
C = K4 OR 6HNSSTRS, NO STRESS TRANSFORMATIONS CALCULATED.
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 D = DECIMAL POINT DATA, ANYWHERE IN FIELD. EXPONENT RIGHT ADJUSTED.
C X = CARD COLUMNS SKIPPED.
C
C******************************************************************************
C SUBROUTINE ARGUMENTS (ALL INPUT)
C XYZ = MATRIX OF JOINT GLOBAL X,Y,Z LOCATIONS. ROWS CORRESPOND TO JOIN.
C TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE JOINT.
C JDOF = MATRIX OF JOINT GLOBAL DEGREES OF FREEDOM. ROWS CORRESPOND TO.
C 1 TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE JOINT.
C TRANSITION DOFS AND COLUMNS 4,5,6 CORRESPOND TO THE JOINT.
C EUL = MATRIX OF JOINT EULER ANGLES (DEGREES). ROWS CORRESPOND TO.
C 1 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 NUTXX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEME.
C STIFFNESS MATRICES (SAME AS GLOBAL LOADS TRANSFORMATION.
C MATRICES) AND IVFCS ARE OUTPUT.
C NUTXX 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.

NUTLT MAY BE ZERO IF LOAD TRANSFORMATIONS ARE NOT FORMED.

USES FORTRAN READ, WRITE.

NUTST = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT

STRESS TRANSFORMATION MATRICES AND IVECS ARE OUTPUT.

NUTST MAY BE ZERO IF STRESS TRANSFORMATIONS ARE NOT FORMED.

USES FORTRAN READ, WRITE.

W = MATRIX WORK SPACE.  MIN SIZE(6,6).

T = MATRIX WORK SPACE.  MIN SIZE(6,6).

S = MATRIX WORK SPACE.  MIN SIZE(6,6).

KX = ROW DIMENSION OF XYZ IN CALLING PROGRAM.

KJ = ROW DIMENSION OF JDOF IN CALLING PROGRAM.

KE = ROW DIMENSION OF ELEMENT IN CALLING PROGRAM.


NEPHER EXPLANATION

1 = JOINT NUMBER GREATER THAN NUMBER OF JOINTS.

2 = MASS MATRIX FORMED, NUTMX LE ZERO.

3 = STIFFNESS MATRIX FORMED, NUTKX LE ZERO.

4 = LT MATRIX FORMED, NUTLT LE ZERO.

5 = ST MATRIX FORMED, NUTST LE ZERO.

1001 FORMAT (4(A6,E4X))

1002 FORMAT (2(5X,E10.6))

1003 FORMAT (31F,4E10.0)

2001 FORMAT (//46X 29H INPUT DATA FOR AXIAL ELEMENTS)

2002 FORMAT (//40X 41H INPUT DATA FOR AXIAL ELEMENTS (CONTINUED))

2003 FORMAT (/ 16X7MASS = A6, 9X7STIF = A6, 9X13LOAD 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)

READ AND WRITE FINITE ELEMENT DATA.

NLINE = 0

CALL PAGEHD

WRITE (NET,1001) NAMEM,NAMEK,NAMELT,NAMEST

READ (NET,1002) RO,E

WRITE (NET,1003) NAMEM,NAMEK,NAMELT,NAMEST,RO,E

20 READ (NET,1003) NEL,J1,J2,A1,A2

IF (J1 .LE. 0) RETURN

NLINE = NLINE + 1

IF (NLINE .LE. 42) GO TO 30

CALL PAGEHD

WRITE (NET,1002)

WRITE (NET,1003) NAMEM,NAMEK,NAMELT,NAMEST,RO,E

NLINE = 0

30 WRITE (NET,1004) NEL,J1,J2,A1,A2

IF (J1 .GT. NJ .OR. J2 .GT. NJ ) GO TO 999

C FORM FINITE ELEMENT COORDINATE LOCATIONS, EULER ANGLES, REVADD IVEC.

DO 42 I=1,3
C
C FORM MASS MATRIX (W).
    IF (NAMEM .EQ. 6H
         *CR. NAMEM .EQ. 6HNDOMASS) GO TO 110
    CALL MASM1A (CJ, EJ, A1, A2, RD, 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
         *OR. NAMEK .EQ. 6HNDOSTIF) GO TO 20
    CALL STF1A (CJ, EJ, A1, A2, E, NAMEK, NAMEST, W, T, S, NRST,
                 *
                    KCJ, KCJ, KW, KW, KW)
                 NERROR=3
    IF (NUTMX .LE. 0) GO TO 999
    WRITE (NUTMX) NAMEK, NEL, 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
         *OR. NAMELT .EQ. 6HNDNLOAD) GO TO 115
                 NERROR=4
    IF (NULTX .LE. 0) GO TO 999
    WRITE (NULTX) NAMELT, NEL, NRTL, NRW, NAMEL, (IBLNK, I=1, 5),
                 *
                    ((T(I,J), I=1, NRTL), J=1, NRW), (IV1(I), I=1, NRW)
115 IF (NAMEST .EQ. 6H
         *OR. NAMEST .EQ. 6HNDOSTRS) GO TO 20
                 NERROR=5
    IF (NUSTX .LE. 0) GO TO 999
    WRITE (NUSTX) 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

999 CALL ZZBOME (6HAXIAL, NERROR)
END
SUBROUTINE RIA1 (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 TRANSFORMATION.
C DEVELOPED BY RL WOHLEN. AUGUST 1973.
C LAST REVISION BY RL WOHLEN. SEPTEMBER 1973.
C
C SUBROUTINE ARGUMENTS
C RL = INPUT ROD LENGTH.
C Z = OUTPUT BUCKLING MATRIX. SIZE(2,2).
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=2.
C
C C = 1/RL
Z(1,1) = C
Z(1,2) = -C
Z(2,1) = -C
Z(2,2) = C

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

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

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

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

RETURN
END
SUBROUTINE BAR (XYZ, JDCF, EUL, NUTEL, NJ, 
* NUTMX, NUTKX, NUTAX, NULT, NUST, 
* W1, T, K1, KJ, KE, KW)
DIMENSION XYZ(KX,1), JDCF(KJ,1), EUL(KE,1), W(KW,1), T(KW,1), S(KW,1)
DIMENSION CJ(3,3), EJ(3,2), IV1(12), TR(12,12), TD(24,24)
DIMENSION KODEK(4), KODEB(2), IFPIN(4), IV2(4)
DATA NAMEL / 6HEAP / 
DATA NW,NRLT/12,12/, IBLNK/6H /, KCJ/3/, KTR/12/, KTD/24/
DATA NIT,NCT/5,6/

C C SUBROUTINE TO CALCULATE (ON OPTION) FINITE ELEMENT ...
C C MASS MATRICES AND IVECS (ON NUTMX),
C C STIFFNESS MATRICES (SAME AS GLOBAL LOAD TRANSFORMATION MATRICES)
C C AND IVECS (ON NUTKX),
C C UNIT LOAD BUCKLING MATRICES AND IVECS (ON NUTBX),
C C LOCAL LOAD TRANSFORMATION MATRICES AND IVECS (ON NUTLT),
C C STRESS TRANSFORMATION MATRICES AND IVECS (ON NUTST)
C C FOR COMBINED AXIAL-TORSION-ENDING BAR ELEMENTS.
C C MASS, STIFFNESS, BUCKLING MATRICES ARE IN GLOBAL COORDINATE
C DIRECTIONS.
C C GLOBAL COORDINATE ORDER FOR EACH ELEMENT IS
C (U, V, W, P, Q, R) JOINT 1, THEN JOINT 2
C WHERE U, V, W ARE TRANSLATIONS AND P, Q, R ARE ROTATIONS.
C IVEC GIVES ELEMENT DOF INTO GLOBAL DOF. EXAMPLES...
C IVEC(6)=834 PLACES ELEMENT DOF 6 INTO GLOBAL DOF 834.
C IVEC(3)=0 OOMITS ELEMENT DOF 3 FROM GLOBAL DOF. THIS CONSTRAINTS
C ELEMENT DOF 3 TO ZERO MOTION.
C C GLOBAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT BAR ENDS IN GLOBAL
C COORDINATE TO DEFLECTIONS IN THE GLOBAL COORDINATE
C DIRECTIONS.
C C ROW ORDER IN GLOBAL LOAD TRANSFORMATION MATRIX IS
C (PU, PV, PW, MP, MQ, MR) JOINT 1, THEN JOINT 2.
C C WHERE P IS FORCE AND M IS MOMENT.
C C LOCAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT BAR ENDS IN LOCAL
C COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE DIRECTIONS.
C C ROW ORDER IN LOCAL LOAD TRANSFORMATION MATRIX IS
C PX1, PX2, MX1, MX2, FY1, PY2, MZ1, MZ2, PZ1, PZ2, MY1, MY2
C C WHERE P IS FORCE AND M IS MOMENT.
C C STRESS TRANSFORMATION MATRIX RELATES STRESS AT BAR ENDS IN LOCAL
C COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE DIRECTIONS.
C 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/BIY2
C C WHERE P IS FORCE AND M IS MOMENT.
C C DATA ARRANGEMENT ON NUTMX, NUTKX, NUTAX, NULT, NUST FOR EACH
C FINITE ELEMENT IS (W=M, K, E, L, T, S)
C WRITE (NUTMX) NAME, NEL, NR, NC, NAMEL(I=1,5),
C ((M(I,J), I=1,NR), J=1,NC), (IVEC(I), I=1,NC)
C CALLS FORM SUBROUTINES EUCIE, MASIE, PAGEH, STFIB, ZPBOMP.
C DEVELOPED BY WA EENFIELD, CS BOODLEY, RL WOHLER. FEBRUARY 1973.
C LAST REVISION BY RL WOHLER. APRIL 1976.
C
C******************************************************************************
C INPUT DATA READ IN THIS SUBROUTINE FROM NUTEL. IF NUTEL = 5, DATA IS
READ FROM CARDS.

NAME=NAME, NAME=N1, NAME=N2, NAME=E, NAME=E, NAME=E, NAME=E.

(KODEK(I), I=1,4), (KODEK(I), I=1,2)

ROF, E, C

20 NEL, J1, J2, KEF, A1, P11, T11, 6121, B11Y1, SF, IPY1, IPY2, IPY3, IPY4, IPTAPR

IF (J1 = FC, 0) RETURN

IF (IFTARK = EQ, EQ, A2, P12, T12, B12, B12Y2) FORMAT (20X, 5E10)

30 IF (NAMEST = EQ, 6H, OR, NAMEST = EQ, EQ, 6HNS1RS) GO TO 20

R1, CY1, CZ, R2, CY2, CZZ

GO TO 20

INPUT DATA REQUIREMENTS

AXIAL TORSION BENDING BENDING

ALONG ABOUT ABOUT ABOUT

LOCAL X LOCAL X LOCAL Z LOCAL Y

MASS A, RC, PI, RO, A, PO, A, RO

STIFF, LOAD TRANS A, E, T1, G, E12, A, SF, E, G, E12, A, SF, E, G

BUCKLING NONE NONE NONE

STRESS TRANS SE STIF, R STIF+CY, STIF+G2

FOR NO SHEAR DEFORMATION IN BENDING, SET ANY OF A (NOT IF AXIAL USED), SF, OP G112NT IF TORSION IS USED) TO ZERO. IF BENDING STRESS TRANSFORMATION IS WANTED, A MUST NOT BE ZERO.

DEFINITION OF INPUT VARIABLES.

NAME = TYPE OF MASS MATRIX WANTED.

N1 = DIAGONAL LUMPED.

N2 = CONSISTENT.

6H = CR 6H-NOMASS, NO MASS MATRIX CALCULATED.

NAMEK = TYPE OF STIFFNESS MATRIX WANTED.

K1 = CONSTANT FORCE FOR AXIAL, CONSTANT TORQUE FOR TORSION.

K2 = CONSTANT SHEAR AND LINEAR MOMENT FOR BENDING.

6H = CR 6H-STIF, NO STIFFNESS MATRIX CALCULATED.

NAMELT = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES.

6H = CR 6H-LOAD, NO LOAD TRANSFORMATIONS CALCULATED.

NAMEST = IDENTIFICATION NAME FOR STRESS TRANSFORMATION MATRICES.

6H = CR 6H-NS1RS, NO STRESS TRANSFORMATIONS CALCULATED.

NAMEBE = TYPE OF BUCKLING MATRIX WANTED.

E1 = AXIAL RCO.

E2 = BEAM.

6H = CR 6H-CP, NO BUCKLING MATRIX CALCULATED.

KODEK = OPTION CODE FOR AXIAL, TORSION, BENDING 2, BENDING Y LOCAL

KODEK(I)=A, LOCAL STIF MATRIX IS CALCULATED FOR AXIAL

LOCAL X-AXIS). KODEK(I)=A, LOCAL STIF MATRIX IS CALCULATED FOR AXIAL

LOCAL X-AXIS).

KODEK(3)=E2, LOCAL STIF MATRIX IS CALCULATED FOR BENDING LOCAL Z-AXIS).

KODEK(4)=Fy, LOCAL STIF MATRIX IS CALCULATED FOR BENDING 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
DEFLECTION IN LOCAL Y DIRECTION.

R0 = MASS DENSITY.
E = YOUNG'S MODULUS OF ELASTICITY.
G = SHEAR MODULUS OF ELASTICITY.
NEL = FINITE ELEMENT NUMBER, FOR REFERENCE ONLY, NOT USED IN CALCULATIONS. WRITTEN ON NUTMX, ETC.
J1 = JOINT NUMBER AT BAR END 1. LOCAL X-AXIS ORIGINATES AT J1.
J2 = JOINT NUMBER AT BAR END 2. LOCAL X-AXIS GOES FROM J1 TO J2.
JREF = REFERENCE POINT. LOCAL Z-AXIS IS DEFINED BY VECTOR (J1,J2) CROSSED INTO VECTOR (J1,JREF). LOCAL Y-AXIS LIES IN XY PLANE DEFINED BY J1,J2,JREF.
A1 = CROSS-SECTION AREA AT BAR END 1.
A2 = SAME AS A1 AT BAR END 2.
P11 = CROSS-SECTION POLAR AREA MOMENT OF INERTIA FOR MASS CALCULATIONS AT BAR END 1.
P12 = SAME AS P11 AT BAR END 2.
TJ1 = CROSS-SECTION PRINCIPAL VENANTS TORSION CONSTANT (J) IN JG FOR TORSION STIFFNESS AT BAR END 1.
TJ2 = SAME AS TJ1 AT BAR END 2.
B121 = CROSS-SECTION AREA MOMENT OF INERTIA ABOUT LOCAL Z-AXIS (FOR BENDING) AT BAR END 1.
B122 = SAME AS B121 AT BAR END 2.
B1Y1 = CROSS-SECTION AREA MOMENT OF INERTIA ABOUT LOCAL Y-AXIS (FOR BENDING) AT BAR END 1.
B1Y2 = SAME AS B1Y1 AT BAR END 2.
SF = SHAPE FACTOR (K) FOR SHEAR IN KAG.
   USE SF=0.0 FOR NO SHEAR DEFORMATION IN BENDING.
   SF=1.0 FOR A SOLID CIRCULAR CYLINDER.
   SF=0.5 FOR A THIN WALLED CIRCULAR CYLINDER.
IFPY1 = PIN JOINT OPTION FOR LOCAL COORDINATE THETA Y AT BAR END 1.  
   = 1H, MOMENT JOINT.
   = 1HP, PIN JOINT.
IFPY2 = SAME AS IFPY1 AT BAR END 2.
IFPZ1 = PIN JOINT OPTION FOR LOCAL COORDINATE THETA Z AT BAR END 1.  
   = 1H, MOMENT JOINT.
   = 1HP, PIN JOINT.
IFPZ2 = SAME AS IFPZ1 AT BAR END 2.
IFTAPR = OPTION FOR TAPERED EAR.
   = 1H, CONSTANT SECTION PROPERTIES.
   = 1HT, LINEAR TAPER SECTION PROPERTIES.
R1 = DISTANCE FROM LOCAL X-AXIS TO OUTER FIBER FOR TORSION STRESS CALCULATION AT BAR END 1.
R2 = SAME AS R1 AT BAR END 2.
CY1 = DISTANCE FROM LOCAL XZ PLANE TO OUTER FIBER FOR BENDING STRESS CALCULATION AT BAR END 1. LOCAL Y DIRECTION.
CY2 = SAME AS CY1 AT BAR END 2.
CZ1 = DISTANCE FROM LOCAL XY PLANE TO OUTER FIBER FOR BENDING STRESS CALCULATION AT BAR END 1. LOCAL Z DIRECTION.
CZ2 = SAME AS CZ1 AT BAR END 2.

EXPLANATION OF INPUT FORMATS. NUMBER INDICATES CARD COLUMNS USED.
I = INTEGER DATA, RIGHT ADJUSTED.
E = DECIMAL POINT DATA, ANYWHERE IN FIELD. EXPONENT RIGHT ADJUSTED.
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 NUMBER. COLUMNS 1,2,3 CORRESPOND TO THE JOINT
      TRANSLATION DOPS AND COLUMNS 4,5,6 CORRESPOND TO THE JOINT
      ROTATION DOFS. SIZE(NJ,6).
EUL = MATRIX OF JOINT EULER ANGLES (DEGREES). ROWS CORRESPOND
      TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE
      GLOBAL X,Y,Z PERMUTATION. SIZE(NJ,3).
NUTEL = LOGICAL NUMBER OF TAPE CONTAINING ELEMENT INPUT DATA FOR
      THIS SUBROUTINE. IF NUTEL = 5, DATA IS READ FROM CARDS.
NJ = NUMBER OF JOINTS. ALL 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,E5.0,5A1))
1004 FORMAT (20X,6E10.0)
2001 FORMAT (/'46X 27HINPUT DATA FOR BAR ELEMENTS/)
2002 FORMAT (/'46X 39HINPUT DATA FOR BAR ELEMENTS (CONTINUED)/)
2003 FORMAT (45X,8HKODEK = A1,A1,A2,A2, 4X 8HKODEB = A2,A2,
* 10X7HMMASS = A6, 6X7HSTIF = A6, 6X13HLOAD TRANS = A6,
* 3X15HSTRESS TRANS = A6, 3X11HBUCKLING = A6,
* 12X4HRC = E10.3, 6X3HE = E10.3, 80X7MI I I I,
* 32X3HG = E10.3, 80X7HF F F F,
* 125X7HP P P P,
* 1X7THELEMEN 2X5HJOINT 2X5HJOINT 3X3IHEF 5X4HAREA
* 7X5HPOLAR 5X7HTORSION 3X9H2 BENDING 2X9H2 BENDING
* 2X5HSHEAP 3X6HSTRESS 5X6HSTRESS 5X6HSTRESS 3X7HY Z Y Z
* 1X6HNUMBER 5X1HI 6X1H2 4X5HPPOINT
* 14X 7HNEPTIA 5X5HCONST 5X7HINERTIA
* 4X7HINERTIA 3X6HFACCTOR 5X1HR 9X2HCY 9X2HCZ 5X7HI I 2 2/1)
2004 FORMAT (1X I5, I8, 2I7, 1X 5E11.3, F7.3, 3E11.3, 4(1X,A1))
2005 FORMAT (29X,5E11.3,7X,3E11.3)

C READ AND WRITE FINITE ELEMENT DATA-
R1 = 0.0
CY1 = 0.0
CZ1 = 0.0
NLINE = 0
CALL PAGEPD
WRITE (NOT,2001)
READ (NUTEL,1001) NAMEK,NAMESL,NAMESM,NAMESN
* (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),
* NAMEN,NAMESL,NAMESM,NAMESN,RO,E,G
20 READ (NUTEL,1003) NEL,J1,J2,JREF,A1,P11,T1J1,B1Z1,B1Y1,GF,
* IFIPN,IFTAPR
IF (J1 .LE. 0) RETURN
IF (IFTAPR .EQ. 1HT) READ (NUTEL,1004) A2,P12,T2J2,B2Z2,B2Y2
IF (NAMESP .EQ. 6HR OR. NAMESM .EQ. 6HNOSTRS) GO TO 25
READ (NUTEL,1004) R1,CY1,CZ1,R2,CY2,CZ2
25 NLINE = NLINE + 1
IF (IFTAPK .EQ. 1HT) NLIN=NLIN+1
IF (NLINE .LE. 42) GO TO 30
CALL PAGEPD
WRITE (NOT,2002)
WRITE (NOT,2003) (KODEK(I),I=1,4), (KODEB(I),I=1,2),
* NAMEN,NAMESL,NAMESM,NAMESN,RO,E,G
NLINE = C
30 WRITE (NOT,2004) NEL,J1,J2,JREF,A1,P11,T1J1,B1Z1,B1Y1,GF,
* R1,CY1,CZ1,IFIPN
NERROR=1
IF (J1 .GT. NJ .CR. J2 .GT. NJ .CR. JREF .GT. NJ) GO TO 999
IF (IFTAPR .EQ. 1HT) WRITE (NOT,2005) A2,P12,T2J2,B2Z2,B2Y2,R2,
* CY2,CZ2
C FORM FINITE ELEMENT COORDINATE LOCATIONS, EULER ANGLES, REVADD IVEC.
DC 42 I=1,3
C FORM DATA FOR UNIFORM ELEMENT.
IF (IFTAPR .EQ. 1HT) GO TO 50
A2 = A1
PI2 = PI1
TJ2 = TJ1
RI2 = RI1
BI2 = BI1
RI2 = RI1
C2 = C1
C FORM PINING IVEC.
50 NPIN = 0
DO 55 I=1,Y
IF (IFPIN(I) .NE. 1HP) GO TO 55
NPIN = NPIN + 1
IF (I .EQ. 1) IV2(NPIN) = 11
IF (I .EQ. 2) IV2(NPIN) = 7
IF (I .EQ. 3) IV2(NPIN) = 12
IF (I .EQ. 4) IV2(NPIN) = 8
55 CONTINUE
C FORM STIFFNESS MATRIX (W), LOCAL LOAD TRANSFORMATION MATRIX (T),
C STRESS TRANSFORMATION MATRIX (S).
100 IF (NAMEK .EQ. 6H .OR. NAMEK .EQ. 6HNOSTIF) GO TO 110
CALL STFB (CJ,EJ,KODEK, A2, A2, TJ1, TJ2, BI2, BI2, BIY1, BIY2, RI1, RI2,
* CJ, CY2, C2, CW2, SF, E, G, NAMEK, NAMEST, W, T, S, NRST,
* CJ, KC2, KW, KW, KW)
C C PIN STIFFNESS MATRIX.
IF (NPIN .EQ. 0) GO TO 105
CALL DCOS1B (CJ, EJ, W, CJ, KCJ, KW)
CALL TRANS (W, TR, NRW, NRW, KW, KTR)
CALL MUTA (TR, NRW, NRW, NRW, KW, KTR)
CALL SEDR (TR, NRW, NRW, NRW, KW, KTR)
CALL MUTA (TR, NRW, NRW, NRW, KTR, KTD)
CALL MUTA (TR, NRW, NRW, NRW, KTR, KTD)
CALL ATXP1 (W, TR, NRW, NRW, KW, KTR)
IF (NAMEST .EQ. 6H .OR. NAMEST .EQ. 6HNOSTRS) GO TO 105
CALL MUTA (ST, NRST, NRW, NRW, KW, KTR)
105 NERROR=2
IF (NUTKX .LE. 0) GO TO 999
WRITE (NUTKX) NAMEK, NEL, NRW, NRW, NAMEK, (IRLNS, J=1, 5),
* ((W(I,J), I=1, NRW), J=1, NRW), (IV1(I), I=1, NRW)
IF (NAMEST .EQ. 6H .OR. NAMEST .EQ. 6HNOLOAD) GO TO 115
IF (NUMLT .LE. 0) GO TO 999
WRITE (NUMLT) NAMELT, NEL, NRTL, NRW, NAMEL, (IBLNK, I=1, 5),
* ((T(I,J), I=1, NRTL), J=1, NRW), (IVL(I), I=1, NRW)
115 IF (NAMEST .EQ. 6H .OR. NAMEST .EQ. 6NO) GO TO 110

IF (NUTST .LE. 0) GO TO 999
WRITE (NUTST) NAMEST, NEL, NRSN, NRW, NAMEL, (IBLNK, I=1, 5),
* ((S(I,J), I=1, NRSN), J=1, NRW), (IVL(I), I=1, NRW)
C
C FORM MASS MATRIX (W).
110 IF (NAME .EQ. 6H .OR. NAME .EQ. 6NO) GO TO 140
CALL MAS18 (CJ, EJ, A1, A2, PI1, PI2, R0, NAMEH, W, T, KCJ, KCE, KW)
C
C PIN MASS MATRIX.
IF (NPIN .GT. 0) CALL BTAU (W, TR, NRW, NRW, KW, KTR)

IF (NUTMX .LE. 0) GO TO 999
WRITE (NUTMX) NAMEP, NEL, NRW, NRW, NAMEL, (IBLNK, I=1, 5),
* ((W(I,J), I=1, NRW), J=1, NRW), (IVL(I), I=1, NRW)
C
C FORM UNIT LOAD BUCKLING MATRIX (W).
140 IF (NAMEB .EQ. 6H .OR. NAMEB .EQ. 6NO) GO TO 20
CALL BUC (CJ, EJ, KODEP, NAMEP, W, S, KCE, KCW, KW)

IF (NUTFX .LE. 0) GO TO 999
WRITE (NUTFX) NAMEB, NEL, NRW, NRW, NAMEL, (IBLNK, I=1, 5),
* ((W(I,J), I=1, NRW), J=1, NRW), (IVL(I), I=1, NRW)
GO TO 2G
C
999 CALL 2ZBOMB (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
WHERE U,V,W ARE TRANSLATIONS AND P,Q,R ARE ROTATIONS.
C EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
C CALLS FORMA SUBROUTINES B1A1, B1A2, BTAB, DCOSIB, ZZBOMB.
C DEVELOPED BY RL WOHNEN. 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 COLS 1,2 CORRESPOND TO JOINTS 1,2. SIZE(3,2).
C KODEB = INPUT OPTION CODE FOR LOCAL Y, LOCAL Z BUCKLING.
C IF BLANK, BOTH ARE CALCULATED. SIZE(2).
C KODEB(1)=BY, LOCAL BUCKLING MATRIX IS CALCULATED
C FOR LOCAL Y DIRECTION.
C KODEB(2)=EZ, LOCAL BUCKLING MATRIX IS CALCULATED
C FOR LOCAL Z DIRECTION.
C NAMEB = INPUT TYPE OF BUCKLING MATRIX WANTED.
C =P1, AXIAL RCD.
C =E3, BEAM.
C Z = OUTPUT BUCKLING MATRIX. SIZE(12,12).
C W = OUTPUT WORK SPACE MATRIX. SIZE(12,12).
C KCJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM.
C KEJ = INPUT ROW DIMENSION OF EJ IN CALLING PROGRAM.
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=12.
C KW = INPUT ROW DIMENSION OF W IN CALLING PROGRAM. MIN=12.
C
C NERROR EXPLANATION
C 1 = DIMENSION SIZE EXCEEDED.
C 2 = IMPROPERLY DEFINED NAMEB.
C
IF (KZ .LT. 12) OR (KW .LT. 12) GO TO 999
DO 5 J=1,12
5 Z(I,J) = 0.0
RL = SQRT((CJ(1,2)-CJ(1,1))**2 + (CJ(2,2)-CJ(2,1))**2
* + (CJ(3,2)-CJ(3,1))**2)
KODEB1 = 1
KODEB2 = 1
IF (KODEB(1).EQ.2) .AND. KODEB(2).EQ.2H ) GO TO 10
IF (KODEP(1) .NE. 2HBY) KODEBY = 0
IF (KODEB(2) .NE. 2HBZ) KODEFBZ = 0
10 IF (NAMEB .EQ. 6HB1) GO TO 110
    IF (NAMEB .EQ. 6HB2) GO TO 120
    GO TO 999
110 IF (KODERY .EQ. 1) CALL B1A1 (RL, Z(5, 5), KZ)
    IF (KODEPZ .EQ. 1) CALL B1A1 (RL, Z(9, 9), KZ)
    GO TO 300
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 IF (KODEPZ .EQ. 1) CALL B1A2 (RL, Z(9, 9), KZ)
300 CALL DCOS1B (CJ, EJ, W, KCJ, KEJ, KW)
    CALL PTABA (Z, W, 12, 12, KZ, KW)
    RETURN
999 CALL ZZBOMB (6HBUC1B, NERROR)
END
SUBROUTINE DCOSIA (CJ, EJ, Z, KCJ, KEJ, KZ)
DIMENSION CJ(KCJ,1), EJ(KEJ,1), Z(KZ,1)
DIMENSION P(3), T(3,3)
C
C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C DIRECTION COSINE MATRIX
C FOR AN AXIAL ROD ELEMENT.
C THE DIRECTION COSINE MATRIX RELATES LOCAL COORDINATE DISPLACEMENTS
C TO GLOBAL COORDINATE DISPLACEMENTS.
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 ROW ORDER (LOCAL COORDINATE ORDER) OF DIRECTION COSINE MATRIX IS
C DX1,DX2
C WHERE DX IS TRANSLATION.
C COLUMN ORDER (GLOBAL COORDINATE ORDER) OF DIRECTION COSINE MATRIX IS
C (U,V,W) JOINT 1, THEN JOINT 2.
C WHERE U,V,W ARE TRANSLATIONS.
C EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
C CALLS FORMA SUBROUTINES EULER,MULTR,Elizabeth.
C DEVELOPED BY RL WOHLEN. SEPTEMBER 1972.
C LAST REVISION BY WA BENFIELD. MARCH 1976.
C
C SUBROUTINE ARGUMENTS
C CJ = INPUT MATRIX OF GLOBAL X,Y,Z COORDINATES AT ROD JOINTS.
C ROWS 1,2,3 CORRESPOND TO X,Y,Z COORDINATES.
C COLS 1,2 CORRESPOND TO JOINTS 1,2. SIZE(3,2).
C EJ = INPUT MATRIX OF EULER ANGLES (DEGREES) AT ROD JOINTS.
C ROWS 1,2,3 CORRESPOND TO GLOBAL X,Y,Z PERMUTATION.
C COLS 1,2 CORRESPOND TO JOINTS 1,2. SIZE(3,2).
C Z = OUTPUT DIRECTION COSINE MATRIX. SIZE(2,6).
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=2.
C
C NERPRR EXPLANATION
C 1 = DIMENSION SIZE LESS THAN 2.
C
IF (KZ .LT. 2) 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)
P(1) = PX/PL
P(2) = PY/PL
P(3) = PZ/PL
DO 10 I=1,2
DO 10 J=1,6
10 Z(I,J) = G.0
CALL EULEP (EJ(1,1),T,3)
CALL MULTR (P,T, 1,3,3, 1,3)
DO 22 J=1,3
22 Z(I,J) = T(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 (6HDCOS1A, NERROR)
END
SUBROUTINE DCOSIS (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, DY1,DY2, T21,T22, DZ1,DZ2,TY1,TY2
C WHERE DX,Y,Z ARE TRANSLATIONS AND TX,TY,TZ ARE ROTATIONS.
C COLUMN ORDER (GLOBAL COORDINATE ORDER) OF DIRECTION COSINE MATRIX IS
C (UX,VW,WV) JOIN 1, THEN JOIN 2
C WHERE UX,V,W ARE TRANSLATIONS AND P,Q,R ARE ROTATIONS.
C EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
C CALLS FORMA SUBROUTINES EULP,MULTB,ZBOMB.
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 1,2,3 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
NERROR = 1
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(3,1)-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(2,1)-CJ(2,1)) - PY*(CJ(1,3)-CJ(1,1))
RL = SQRT(PX**2 + RY**2 + RZ**2)
QX = RY*RZ - RX*PX
QY = RZ*PX - RX*PY
QZ = RX*PY - RX*PX
QL = SQRT(QX**2 + QY**2 + QZ**2)
W(1,1) = PX/PL
W(1,2) = PY/PL
W(1,3) = PZ/PL
W(2,1) = GX/OL
W(2,2) = GY/OL
W(2,5) = CZ/OL
W(3,1) = RX/RL
W(3,2) = PY/RL
W(3,3) = RZ/RL
DO 10 J=1,12
10 DO 10 I=1,12
10 \( i, j \) = 0
CALL EULEP \( \mathbf{EJ}(1,1), \mathbf{T}, 3 \)
CALL MULTB \( \mathbf{W}, \mathbf{T}, 3, 3, 3, 3 \)
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 \( \mathbf{EJ}(1,2), \mathbf{T}, 3 \)
CALL MULTB \( \mathbf{W}, \mathbf{T}, 3, 3, 3, 3 \)
DO 24 J=1,3
JP6 = J+6
Z(2, JP6) = T(1, J)
Z(6, JP6) = T(2, J)
Z(10, JP6) = T(2, 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 \( \mathbf{6HDOSIB}, \mathbf{NERRC} \)
END
SUBROUTINE DCS2 (C, 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, T2) JOINT 1, THEN JOINT 2, 3, NEXT

(T2, 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

(UV, W, P, C, F) JOINT 1, THEN JOINT 2, 3.

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

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

CALLS FORM SUBROUTINES EULER, MULT, ZZBOMB.

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.

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

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

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=18.

NERROR EXPLANATION

1 = DIMENSION SIZE LESS THAN 18.

IF (KZ .LT. 18) GO TO 999
PX = CJ(1,2)-CJ(1,1)
PY = CJ(2,2)-CJ(1,1)
PZ = CJ(2,3)-CJ(1,1)
PL = SQRT(PX**2 + PY**2 + PZ**2)
FX = PY*(CJ(1,2)-CJ(3,1)) - PZ*(CJ(2,3)-CJ(1,1))
RY = PZ*(CJ(1,2)-CJ(1,1)) - PX*(CJ(1,3)-CJ(1,1))
RZ = PX*(CJ(2,3)-CJ(1,1)) - PY*(CJ(1,3)-CJ(1,1))
RL = SQRT(FX**2 + RY**2 + RZ**2)
QX = QY*PZ - RZ*PY
LY = RZ*FX - PX*PZ
QZ = PX*PY - FY*PX
CL = SQRT(0.0**2 + QY**2 + QZ**2)
W(1,1) = PX/PL
W(1,2) = PY/PL
W(1,3) = PZ/PL
W(2,1) = CX/QL
W(2,2) = QY/QL
W(2,3) = CZ/QL
W(3,1) = FX/RL
W(3,2) = FY/RL
W(3,3) = PZ/RL
DO 10 J=1,18
DO 10 I=1,18
10 Z(I,J) = 0.0
DO 50 NW=1,3
CALL EULFR (FJ(I,NW), T3)
CALL MULTF (W, T, 3, 3, 3, 3)
IZZ = 3*(NW-1)
JZZ = 6*(NW-1)
DO 50 JW=1,3
JZ = JZZ + JW
Z(IZZ+1, JZ) = T1(JW)
Z(IZZ+2, JZ) = T2(JW)
Z(IZZ+1C, JZ) = T3(JW)
JZ = JZ+2
Z(IZZ+3, JZ) = T3(JW)
Z(IZZ+1I, JZ) = T1(JW)
50 Z(IZZ+12, JZ) = T2(JW)
RETURN
C
999 CALL ZZ5OME (6, DCOS2, NERROR)
END
SUBROUTINE DCOS3C (CJ,EJ,Z,KCJ,KEJ,KZ)
DIMENSION CJ(KCJ,1),EJ(KEJ,1),Z(KZ,1)
DIMENSION W(2,3),T(3,3)

SUBROUTINE TO CALCULATE FINITE ELEMENT...
DIRECTION COSINE MATRIX
FOR A RECTANGULAR SHEET PANEL ELEMENT.
THE DIRECTION COSINE MATRIX RELATES LOCAL COORDINATE DISPLACEMENTS
TO GLOBAL COORDINATE DISPLACEMENTS.
THE LOCAL COORDINATE SYSTEM ASSUMES THE PANEL TO LIE IN AN X-Y PLANE
WITH JOINT 1 AT THE X-Y ORIGIN, JOINT 2 LIES ALONG THE POSITIVE
X AXIS, JOINT 5 IS IN THE POSITIVE X,Y DIRECTION, AND JOINT 4 LIES
ALONG THE POSITIVE Y AXIS.
ROW ORDER (LOCAL COORDINATE ORDER) OF DIRECTION COSINE MATRIX IS
DX1,DX2,DX3,DX4, DY1,DY2,DY3,DY4
WHERE DX,DY ARE TRANSLATIONS.
COLUMN ORDER (GLOBAL COORDINATE ORDER) OF DIRECTION COSINE MATRIX IS
(U,V,W) JOINT 1, THEN JOINT 2, 3, 4.
WHERE U,V,W ARE TRANSLATIONS.
EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
CALLS FORMA SUBROUTINES EULER,MULTIPLYZEBOMB.
DEVELOPED BY RL WOHLEN. APRIL 1974.
LAST REVISION BY WA BERNFIELD. MARCH 1976.

SUBROUTINE: ARGUMENTS
CJ = INPUT MATRIX OF GLOBAL X,Y,Z COORDINATES AT PANEL 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 PANEL 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).
Z = OUTPUT DIRECTION COSINE MATRIX. SIZE(P,12).
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=8.

NEPRES: EXPLANATION
1 = DIMENSION SIZE TOO SMALL.

IF (KZ.LT.8) CC TC 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)
CX = CJ(1,4)-CJ(1,1)
CY = CJ(2,4)-CJ(2,1)
CZ = CJ(3,4)-CJ(3,1)
CL = SQRT(CX**2+CY**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

NERROR=1
DO 10 J=1,12
50 DO 10 I=1,8
10 Z(I,J) = 0.0
DO 50 IJNT=1,4
CALL EULEF (EJ(1,IJNT),T,3)
CALL MULTF (W,T,2,3,3,2,3)
J2Z = 2*(IJNT-1)
DO 50 JW=1,3
JZ = J2Z+JW
Z(IJNT,JZ) = T(1,JW)
50 Z(IJNT+4,JZ) = T(2,JW)
RETURN

999 CALL Z26OMB (6,RDCOS3C,MERROR)
END
SUBROUTINE EULER (E, R, KR)
DIMENSION E(1), R(KR, 1)

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

C SUBROUTINE ARGUMENTS
C T = 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 D 
C
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
F(1, 3) = S2
F(2, 1) = C1*S3 + S1*S2*C3
F(2, 2) = C1*C3 - S1*S2*S3
F(2, 3) = -S1*C2
F(3, 1) = S1*S3 - C1*S2*C3
F(3, 2) = S1*C3 + C1*S2*S3
F(3, 3) = C1*C2

C RETURN
END
SUBROUTINE FINEL (XYZ, JDQF, EUL, NUTEL, NJ,
               NUTM, NUTK, NULT, NUST, NUTE, V, LV, KV,
               KRX, KRE, NUTX, NUTY, NUT1, NUT2, NUT3)

DIMENSION XYZ(KRX,1), JDQF(KRE,1), EUL(KRE,1), V(1), LV(1)
DIMENSION W1(24,24), W2(24,24), W3(24,24)
DATA KW/24/, IFLANK/6: /, 11/7
DATA NIT, NOT/5, 6/

C SUBROUTINE TO CALCULATE (ON OPTION) FINITE ELEMENT...
C ASSMELED MASS MATRIX (ON NUTM),
C ASSMELED STIFFNESS MATRIX (ON NUTK),
C ELEMENT LOCAL LOAD TRANSFORMATION MATRICES, IVECS (ON NULT),
C ELEMENT GLOBAL LOAD TRANSFORMATION MATRICES, IVECS (ON NUTX),
C ELEMENT STRESS TRANSFORMATION MATRICES, IVECS (ON NUST),
C ELEMENT UNIT LOAD BUCKLING MATRICES, IVECS (ON NUTE),
C IVEC GIVES ELEMENT DOF INTO GLOBAL DOF. EXAMPLES...
C IVEC(6)=834 PLACES ELEMENT DOF 6 INTO GLOBAL DOF 834.
C IVEC(3)=6 OMITS ELEMENT DOF 3 FROM GLOBAL DOF. THIS CONSTRANS
C ELEMENT DOF 3 TO ZERO MOTION.

C DATA ARRANGEMENT ON NUTM, NUTK FOR THE ASSEMBLED MATRICES IS IN
C SPARSE (Y) FORMA SUBROUTINE FORMAT.
C DATA ARRANGEMENT ON NULT, NUTK, NUST, NUTE FOR EACH FINITE
C ELEMENT (WRITTEN IN SUBROUTINE AXIAL, BAR, ETC) IS
C WRITE (NUTM) NAMEW, NEL, INF, NC, NAMEL (IFLAG, I=1, 5),
C (W1, J, I=1, NC), (IVEC(I), I=1, NC)
C NAMEW = NAMELT, NAMEXX, NAMEST, OR NAMEB.
C NAMEL = AXIAL, PAP, ETC.
C LAST RECORD TO DENOTE TERMINATION IS,
C WRITE (NUTM) IFLANK, (II, I=1, 30)
C THE FOLLOWING UTILITY TAPES USE BASIC FORTRAN READ, WRITE. DO NOT
C USE THESE TAPES IN SPARSE (Y) FORMA SUBROUTINES WHICH USE FORMA
C SUBROUTINES YIN, YOUT (IF THEY USE BUFFER IN, BUFFER OUT).
C NUTL, NUST, NUTC, NUTX, NUTE.
C THE FOLLOWING UTILITY TAPES USE FORMA YIN, YOUT.
C NUTM, NUTK, NUTC, NUT3.
C CALLS FORMA SUBROUTINES AXIAL, BAR, FLUID, GRAVITY, PAGEHD, QUAD,
C RECTSP, TRNGL, YRVADZ, ZIBMB.
C LAST REVISION BY RL WOHLER, MAY 1976.
C
C**********************************************************************
C INPUT DATA READ IN THIS SUBROUTINE FROM NUTEL. IF NUTEL = 5, DATA IS
C READ FROM CARDS.
C 50 NAMEL FORMAT (A6)
C IF (NAMEL .EQ. 6HRETURN) RETURN
C IF (NAMEL .EQ. 6HAXIAL ) 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).
C MAY BE EQUIVALENCED TO VI(1) IN CALLING PROGRAM.
JDOF = MATRIX OF JOINT GLOBAL DEGREES OF FREEDOM. ROWS CORRESPOND TO JOINT NUMBERS. COLUMNS 1, 2, 3 CORRESPOND TO THE JOINT TRANSLATION DOFS AND COLUMNS 4, 5, 6 CORRESPOND TO THE JOINT ROTATION DOFS. SIZE(NJ,6).
C MAY BE EQUIVALENCED TO LV(1) IN CALLING PROGRAM.
EUL = MATRIX OF JOINT EULER ANGLES (DEGREES). ROWS CORRESPOND TO JOINT NUMBERS. COLUMNS 1, 2, 3 CORRESPOND TO THE LOCAL X, Y, Z PERMUTATION. SIZE(NJ,3). MAY BE EQUIVALENCED TO VKRX*(XYZ COL DIM)+1) IN CALLING PROGRAM.
NUTEL = LOGICAL NUMBER OF TAPE CONTAINING ELEMENT INPUT DATA FOR THIS SUBROUTINE AND SUBROUTINES AXIAL, ETC GIVEN BY NAMEL. IF NUTEL = 5, DATA WILL BE READ FROM CARDS.
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.
C NUTM MAY BE ZERO IF MASS MATRIX IS NOT FORMED.
C USES FORTRAN READ, WRITE.
NUTK = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ASSEMBLED STIFFNESS MATRIX IS OUTPUT IN SPARSE NOTATION.
C NUTK MAY BE ZERO IF STIFFNESS MATRIX IS NOT FORMED.
C USES FORTRAN READ, WRITE.
NUTLT = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT LOAD TRANSFORMATION MATRICES AND IVECS ARE OUTPUT.
C NUTLT MAY BE ZERO IF LOAD TRANSFORMATIONS ARE NOT FORMED.
C USES FORTRAN READ, WRITE.
NUTST = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT STRESS TRANSFORMATION MATRICES AND IVECS ARE OUTPUT.
C NUTST MAY BE ZERO IF STRESS TRANSFORMATIONS ARE NOT FORMED.
C USES FORTRAN READ, WRITE.
NUTB = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT UNIT LOAD BUCKLING MATRICES AND IVECS ARE OUTPUT.
C NUTB MAY BE ZERO IF BUCKLING MATRICES ARE NOT FORMED.
C USES FORTRAN READ, WRITE.
V = VECTOR WORK SPACE.
LV = VECTOR WORK SPACE.
KV = DIMENSION SIZE OF V, LV IN CALLING PROGRAM.
KRX = ROW DIMENSION OF XYZ IN CALLING PROGRAM.
KRJ = 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.
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 INECS ARE STORED.
C NUTKX MAY BE ZERO IF STIFFNESS MATRIX IS NOT FORMED.
C USES FORTRAN READ, WRITE.
C NUT1 = LOGICAL NUMBER OF UTILITY TAPE USES FORMA YIN, YOUT.
C NUT2 = LOGICAL NUMBER OF UTILITY TAPE USES FORMA YIN, YOUT.
C NUT3 = LOGICAL NUMBER OF UTILITY TAPE USES FORMA YIN, YOUT.
C
C ERROR EXPLANATION
C 1 = NAMEL IMPROPERLY DEFINED.
C
1001 FORMAT (A6)
2001 FORMAT (/ /41X 35HJOINT DATA USED IN SUBROUTINE FINEL)
2002 FORMAT (/ /35X 47HJOINT DATA USED IN SUBROUTINE FINEL (CONTINUED))
2003 FORMAT (/ /16X .8HDEGREES OF FREEDOM
* 1PX 27HGLOBAL CARTESIAN COORDINATES
* 12X 22HEULER ANGLES (DEGREES)
* /14X 11HTRANSATION 8X 8ROTATION
* /2X5HJOINT 6X1IH 5X1IW 5X1HI 5X1HR
 11X1IX 11X1HY 11X1HZ 14X1IX 10X1IH 10X1IXZ /)
2004 FORMAT (1X 15, 3X 616, 3X 3F12.4, 4X 3F11.4
C
IF (NUTMX .GT. 0) REWIND NUTMX
IF (NUTKX .GT. 0) REWIND NUTKX
IF (NUTL .GT. 0) REWIND NULT
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. NDOF) NDOF=JDOF(I,J)
 35 CONTINUE
C
C PRINT JOINT DOF, XYZ COORDINATES, EULER ANGLES.
C 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
C 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
C READ FINITE ELEMENT TYPE.
50 READ (NUTEL,1001) NAMEL
IF (NAMEL .EQ. 6HRETURN) GO TO 50C
IF (TITLE .EQ. '6AXIAL') GO TO 110
IF (TITLE .EQ. '6HEAR') GO TO 140
IF (TITLE .EQ. '6TRNGL') GO TO 150
IF (TITLE .EQ. '6FLUID') GO TO 151
IF (TITLE .EQ. '6QUAD') GO TO 160
IF (TITLE .EQ. '6RECTSP') GO TO 162
IF (TITLE .EQ. '6GRAVITY') GO TO 171

NERROR=1
GO TO 999

C BAR FINITE ELEMENT (AXIAL ONLY).
110 CALL AXIAL (XYZ, JD, EUL, NUTH, NJ,
* NUTM, NUTK, NULT, NUST,
* W, W2, W3, KRX, KRJ, KRE, KW)
GO TO 50

C BAR FINITE ELEMENT (COMBINED AXIAL, TORSION, BENDING).
140 CALL BAR (XYZ, JD, EUL, NUTH, NJ,
* NUTM, NUTK, NUTB, NULT, NUST,
* W1, W2, W3, KRX, KRJ, KRE, KW)
GO TO 50

C TRIANGULAR PLATE ELEMENT.
150 CALL TRNGL (XYZ, JD, EUL, NUTH, NJ,
* NUTM, NUTK, NULT, NUST,
* W1, W2, W3, KRX, KRJ, KRE, KW)
GO TO 50

C FLUID ELEMENT.
151 CALL FLUID (XYZ, JD, EUL, NUTH, NJ,
* NUTM, NUTK, NULT, NUST,
* W1, W2, W3, KRX, KRJ, KRE, KW)
GO TO 50

C QUADRILATERAL PLATE ELEMENT.
160 CALL QUAD (XYZ, JD, EUL, NUTH, NJ,
* NUTM, NUTK, NUTP, NULT, NUST,
* W1, W2, W3, KRX, KRJ, KRE, KW)
GO TO 50

C RECTANGULAR SHEAR PANEL.
162 CALL RECTSP (XYZ, JD, EUL, NUTH, NJ,
* NUTM, NUTK, NULT, NUST,
* W1, W2, W3, KRX, KRJ, KRE, KW)
GO TO 50

C GRAVITY ELEMENT.
171 CALL GRAVITY (XYZ, JD, EUL, NUTH, NJ,
* NUTK,
* W1, W2, W3, KRX, KRJ, KRE, KW)
GO TO 50

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

C SUM FINITE ELEMENT MATRICES.
IF (NUTM .GT. 0) CALL YZERO (NUTM, NDCF, NDCF)
IF (NUTK .GT. 0) CALL YZERO (NUTK, NDCF, NDCF)
IF (NUTMX .GT. 0) CALL YRVAD2 (NUTMX, NUTH, NDOF, WI, KW, V, LV, KV,
* NUT1, NUT2, NUT3)
IF (NUTKX .GT. 0) CALL YRVAD2 (NUTKX, NUTK, NDOF, WI, KW, V, LV, KV,
* NUT1, NUT2, NUT3)
RETURN
C
999 CALL ZEBOM6 (HFINEL, NERROR)
END
SUBROUTINE FLUID (XYZ, JDGF, EUL, NUTEL, NJ,
* NUTMX, NUTKX, NUTLT, NUST,
* W, T, S, XX, KJ, KE, KW)
DIMENSION XYZ(KJ, 1), JDGF(KJ, 1), EUL(KE, 1), W(KW, 1),
T(KW, 1), S(KW, 1)
DIMENSION CJ(3, 8), EJ(3, 8), IV(24), IVET(12), JM(4, 16), VL(10),
* DV(12), DIST(12, 12), TV(24)
DATA NRW, NRS T/24, !, IBLNK/6H /, I1ST/0/
DATA NIT, NOS / 5,6/;
DATA NAME / 6HFLUID /
DATA KCI / 2, _KJM / 4 /;
DATA KDST / 12, _, IFBAD / 1 /
DATA JM/1,2,3,4, 6,6,4,5, 2,4,4,5, 3,5,1,2,
* 1,3,6,5, 1,6,4,5, 2,1,4,5, 1,2,4,5,
* 4,7,8,5, 5,2,7,6, 4,2,3,7, 1,2,5,6,
* 1,6,8,5, 1,3,4,8, 1,2,3,6, 8,3,7,6 /
C
C SUBROUTINE TO CALCULATE (ON OPTION) FINITE ELEMENT ...
C MASS MATRICES AND IVECS (ON NUTMX),
C STIFFNESS MATRICES (SAME AS GLOBAL LOAD TRANSFORMATION MATRICES)
C AND IVECS (ON NUTKX),
C PRESSURE TRANSFORMATION MATRICES AND IVECS (ON NUST),
C FOR FLUID ELEMENTS.
C ELEMENT SHAPE MAY BE TETRAHEDRON, PENTAHEDRON, OR HEXAHEDRON.
C MASS, STIFFNESS MATRICES ARE IN GLOBAL COORDINATE DIRECTIONS.
C GLOBAL COORDINATE ORDER IS
C (U, V, W) JOINT 1, THEN JOINT 2,3,4,(5,6,7,8).
C WHERE U,V,W ARE TRANSLATIONS.
C IVEC GIVES ELEMENT DOF INTO GLOBAL DOF. EXAMPLES...
C IVEC(6)=834 PLACES ELEMENT DOF 6 INTO GLOBAL DOF 834.
C IVEC(3)=0 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, NUTKX, NUST FOR EACH FINITE ELEMENT IS
C (W=M,K,ST)
C WRITE (NUTWX) NAMEW, NEL, NP, NC, NAME, IBLNK, I=1,5,
C ((W(I,J), I=1, NR), J=1, NC), (IVEC(I), I=1, NC)
C CALLS FORMA SUBROUTINES TEGEM, VCRS, VDOT , Z2ZBOM
C DEVELOPED BY C S EODLEY. FEBRUARY 1974.
C LAST REVISION BY WA BENFIELD. MARCH 1976.
C
C INPUT DATA READ IN THIS SUBROUTINE FROM NUTEL. IF NUTEL = NIT, DATA IS
C READ FROM CARDS.
C NAME, NAMEK, NAMET, NAMET
C RC, EKM
C ZC(NEL, J1, J2, J3, J4, J5, J6, J7, J8
C IF (J1 .EQ. 0) RETURN
C GC TO 20
C
C DEFINITION OF INPUT VARIABLES.
C NAME = TYPE OF MASS MATRIX WANTED.
C = M1, LUMPED MASS MATRIX.
C = M2, QUASI-IRRATIONAL CONSISTENT MASS MATRIX.
C = M3, IRRATIONAL MASS MATRIX.
C = 6P OR 6HMONASS, NO MASS MATRIX CALCULATED.
C NAMEK = TYPE OF STIFFNESS MATRIX WANTED.
C = K1, LINEAR DISPLACEMENT ASSUMED.
C = 6H OR 6HINSTIF, NO STIFFNESS MATRIX CALCULATED.
C NAMEL = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES, (NOT YET).
C NAMEST = IDENTIFICATION NAME FOR PRESSURE TRANSFORMATION MATRICES.
C = 6H OR 6HINSTIF, NO PRESSURE TRANSFORMATIONS CALCULATED.
C RO = MASS DENSITY.
C BMK = 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 HEXAHEDRON).
C J6 = JOINT NUMBER AT ELEMENT VERTEX 6. (USED FOR PENTAHEDRON AND HEXAHEDRON).
C FOR A PENTAHEDRON, FACE 1,2,3 MUST BE NUMBERED 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.
C EXPLANATION OF INPUT FORMATS. NUMBER INDICATES CARD COLUMNS USED.
C I = INTEGER DATA, RIGHT ADJUSTED.
C E = DECIMAL POINT DATA, ANYWHERE IN FIELD. EXPONENT RIGHT ADJUSTED.
C X = CARD COLUMNS SKIPPED.
C SUBROUTINE ARGUMENTS (ALL INPUT)
C XYZ = MATRIX OF JOINT GLOBAL X,Y,Z LOCATIONS. ROWS CORRESPOND TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE JOINT X,Y,Z LOCATIONS RESPECTIVELY. SIZE(NJ,3).
C JDOF = MATRIX OF JOINT GLOBAL DEGREES OF FREEDOM. ROWS CORRESPOND TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE JOINT TRANSLATION DOFS AND COLUMNS 4,5,6 CORRESPOND TO THE JOINT ROTATION DOFS. SIZE(NJ,6).
C EUL = MATRIX OF JOINT EULER ANGLES (DEGREES). ROWS CORRESPOND TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE GLOBAL X,Y,Z PERMUTATION. SIZE(NJ,3).
C NUTEL = LOGICAL NUMBER OF TAPE CONTAINING ELEMENT INPUT DATA FOR THIS SUBROUTINE. IF NUTEL = NIT, DATA IS READ FROM CARDS.
C NJ = NUMBER OF JOINTS OR ROWS IN MATRICES (XYZ), (JDOF), (EUL).
C NUTMX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT MASS MATRICES AND IVECS ARE OUTPUT.
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 NUTLT = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT LOAD
C TRANSFORMATION MATRICES AND IVECS ARE OUTPUT. (NOT YET).
C NUTST = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
C PRESSURE TRANSFORMATION MATRICES AND IVECS ARE OUTPUT.
C NUTST MAY BE ZERO IF PRESSURE TRANSFORMATIONS ARE
C 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 JOOF IN CALLING PROGRAM.
C KE = ROW DIMENSION OF EUL IN CALLING PROGRAM.
C
C NERROR EXPLANATION
C 1 = INCORRECT TETRAHEDRON GEOMETRY.
C 2 = INPUT JOINT NUMBER EXCEEDS MAXIMUM ALLOWABLE NUMBER OF JOINTS.
C 3 = NUTMX NOT POSITIVE.
C 4 = NUTKX NOT POSITIVE.
C 5 = NUTST NOT POSITIVE.
C
1001 FORMAT (5(A6,4X))
1002 FORMAT (3(5X,E10.0))
1003 FORMAT (9(15))
2001 FORMAT (//25X 38HINPUT DATA FOR FLUID (TETRA, PENTA, OR
* 21H HEXAHEDRON) ELEMENTS)
2002 FORMAT (//20X 38HINPUT DATA FOR FLUID (TETRA, PENTA, OR
* 33H HEXAHEDRON) ELEMENTS (CONTINUED))
2003 FORMAT (//12X7HMASS = A6,13X7HSTIF = A6,6X13HLOAD TRANS = A5,
* 3X15HSTRESS TRANS = A6, 3X
* / 15X,4HRC = E10.3, 13X7HDLK = E10.3,
* / 9X7HELEMENT 6 : JOINT 1 6X7HJOINT 2 6X7HJOINT 3 6X7HJOINT 4
* 6X7HJOINT 5 6X7HJOINT 6 6X7HJOINT 7 6X7HJOINT 8
* / 9X6HNUMBER)
2004 FORMAT (3X,9(18X,15))
3601 FORMAT (51H * * * * * UNCONVENTIONAL JOINT NUMBERING * * * * *,
* 915)
C
C IF (11ST .EQ. 1) GO TO 3
11ST = 1
DO 4 I=1,4
I1 = 3*I - 2
DO 4 J=1,4
J1 = 3*J - 2
4 CALL UNITY (DIST(I1,J1),3,KDIST)
C
3 NLINE = 0
CALL PAGEHD
WRITE (NOT, 2001)
READ (NUTEL, 1001) NAMEF, NAMEK, NAMELT, NAMEST
READ (NUTEL, 1002) RO, BKM
WRITE (NOT, 2003) NAMEF, NAMEK, NAMELT, NAMEST,
* RO, BKM
IF (NAMEF .NE. 6HM3) GO TO 20
DO 21 I = 1, 12
21 DIST(I, I) = 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
NLIN = NLINE + 1
IF (NLINE .LE. 42) GO TO 30
CALL PAGEHD
WRITE (NOT, 2002)
WRITE (NOT, 2003) NAMEF, NAMEK, 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, NCOL
DO 5 J = 1, NCOL
WI(I, J) = 0.
SJ(I, J) = 0.
5 T(I, J) = 0.
DO 40 I = 1, 3
CJ(I, 1) = XYZ(J1, I)
CJ(I, 2) = XYZ(J2, I)
CJ(I, 3) = XYZ(J3, I)
CJ(I, 4) = XYZ(J4, 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)
IVI(I) = JDOF(J1, I)
IVI(I+3) = JDOF(J2, I)
IVL(I+12) = JDCF(J5,I)

IF (LR .NE. 1) GO TO 50

C

DO 42 I=1,3
CJ(I,5) = XYZ(J5,I)
CJ(I,6) = XYZ(J6,I)
EJ(I,5) = EUL(J5,I)
EJ(I,6) = EUL(J6,I)
IVL(I+12) = JDCF(J5,I)

IVL(I+15) = JDCF(J6,I)

IF (LP .EQ. 6) GO TO 50

C

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

IVL(I+21) = J3*F(J6,I)

C

50 DO 52 L=1,LR
LA = L
IF (LR .EQ. 10) LA=L+6
DO 52 I=1,4
JNO = JM(I,LA)
LJ = 3*I - 2
IVTET(L1) = 3*JNC - 2
IVTET(L1+1) = 3*JNC - 1

53 IVTET(L1+2) = 3*JNC

C

CALL TEGEOM (CJ,JM(1,LA ),VL(L),DV, KCJ,IFEAD)
IF (IFBAD .NE. 0) GO TO 51
WRITE (N01,3001) NEL,J1,J2,J3,J4,J5,J6,J7,J8
IFBAD = -1

51 SM = RO*VL(L)/16.0
IF (NAMEM .EQ. 6HM3 ) SM=RO*VL(L)/20.0
IF (LR .GT. 1) SM = SM/2.

CALL REVADD (15,DV,L,IVTET,T',12,LR,NCOL,1,KW)

C

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

C

IF (NAMEM .NE. 6HM1 ) GO TO 220

DO 210 I=1,NCOL
SAVE = 0.0
DO 215 J=1,NCOL
SAVE = SAVE + W(I,J)

215 WI(I,J) = 0.0

210 WI(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

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

C

60 DO 61 J=1,NCOL
61 TV(J) = T(I,J)
   DO 65 J=1,JNJ
   J1 = 3*J - 2
65 CALL EULEP (EJ(I,J),S(J1,J1),KW)
IF (NAMEST .EQ. 6H .OR. NAMEST .EQ. 6HNOSTIF) GO TO 90
CALL PRESS (CJ,T,KJN,NCOL,NCOL,KW)
CALL MULTA (T,S,J,JN,NCOL,NCOL,KW)
90 CALL RTAPA (W,S,NCOL,NCOL,KW,KW)
CALL MULTA (TV,S,1,NCOL,NCOL,1,KW)
BOV = EKM/VE(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. 6HNOCMASS) GO TO 110
   NERROR=3
   IF (NUTMX .LE. 0) GO TO 999
   WRITE (NUTMX) NAMEM,NEL,NCOL,NCOL,NAMEL,(IBLNK,I=1,5),
   * (IVI(I),I=1,NCOL), (IVI(J),J=1,NCOL)
C
110 IF (NAMEK .EQ. 6H .OR. NAMEK .EQ. 6HNOSTIF) GO TO 120
   NERROR=4
   IF (NUTKK .LE. 0) GO TO 999
   WRITE (NUTKK) NAMEK,NEL,NCOL,NCOL,NAMEL,(IBLNK,I=1,5),
   * (SI(I),I=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 MULT (T,S,T(NJNP1),JN,NCOL,NCOL,KW,KW)
   CALL MULTA (T,W,JNJ,NCOL,NCOL,KW,KW)
   NRST = 2*NJN
   WRITE (NUTST) NAMEST,NEL,NRST,NCOL,NAMEL,VL(I),(I=1,4),
   * (IVI(I),I=1,NRST),J=1,NCOL), (IVI(I),I=1,NCOL)
   GO TO 20
C
999 CALL ZZBOMF (6H,FLUID,NERROR)
   END
SUBROUTINE GRAVITY (XYZ,JD0F,EUL,NUTEL,NJ,
*      NUTKX,
*      W, T, S, RX, KJ, KE, KW)
DIMENSION XYZ(KX,1),JD0F(KJ,1), EUL(KE,1), W(KW,1),
*     (KW,1), S(KW,1)
DIMENSION CJJ(3,4),EJJ(3,4),IVL(12),IVTRI(9),JM(3,4),GV(3),EV(3)
DATA IBLNK/6H /
DATA NIT,NOT/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 NUTKX),
C FOR GRAVITY ELEMENTS.
C STIFFNESS MATRICES ARE 9- GLOBAL 300-49-IT 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.
DATA ARRANGEMENT ON NUTKX FOR EACH FINITE ELEMENT IS
(W=K)
WRITE (NUTKX) NAMEW,NEL,NR,NC,NAMEL,((IBLNK,I=1,5),
   ((W(I,J),I=1,4),J=1,NC)),(IVEC(I),I=1,NC)
CALLS FORMA SUBROUTINES KGRAV, MULTA, MULTE, VCROSS, ZZBOMB.
DEVELOPED BY C.S. COKLELY. FEBRUARY 1974.
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 NAMEM,NAMEMK FORMAT (2(A6,4X)
C RO FORMAT (5X,E10)
C (GV(I),I=1,3) FORMAT (3(5X,E10))
C 20 NEL,J1,J2,J3,J4 FORMAT (S15)
C IF (J1 ,E0. 0) RETURN
C GO TO 20
C
DEFINITION OF INPUT VARIABLES.
C NAMEM = TYPE OF MASS MATRIX WANTED.
C = 6H OR 6HNMMASS, NO MASS MATRIX CALCULATED.
C NAMEK = TYPE OF STIFFNESS MATRIX WANTED.
C = K1, LINEAR DISPLACEMENT ASSUMED.
C = 6H OR 6HNOSTIF, NO STIFFNESS MATRIX CALCULATED.
C RO = MASS DENSITY.
C GV = GRAVITY VECTOR.
C NEL = FINITE ELEMENT NUMBER, FOR REFERENCE ONLY, NOT USED IN
C CALCULATIONS, WRITTEN ON NUTKX.
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
GRAVITY--

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******************************************************************************
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 IVECS 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 NERDCO 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 (/25X 45INPUT DATA FOR GRAVITY STIFFNESS (TRIANGLE OR
*     24H QUADRILATERAL) ELEMENTS)
2002 FORMAT (/20X 45INPUT DATA FOR GRAVITY STIFFNESS (TRIANGLE OR
*     36H QUADRILATERAL) ELEMENTS (CONTINUED))
2003 FORMAT (/12X7HMASS = A6,13X7HSTIF = A6,6X
*     /15X,4HRG = E10.3, 13X5HGXX = E10.3, 13X5HGYY = E10.3,
*     13X5HGZV = E10.3,
*     //15X7HFLEMENT 13X7HJOINT 1 13X7HJOINT 2 13X7HJOINT 3
*     13X7HJOINT 4
*     /15X6HNUMBER)
2004 FORMAT (15X,9(15,15X))
C
C NLINE = 0
CALL PAGEHD
WRITE (NOT,2001)
READ (NUTEL,1001) NAMEK,NAMEK
READ (NUTEL,10C2) P0
READ (NUTEL,1002) (GVI(I),I=1,3)
WRITE (NOT,2003) NAMEK,NAMEK,
  * RC, (GVI(I),I=1,3)
C
20 READ (NUTEL,1003) NEL,J1,J2,J3,J4
   IF (J1 .LE. 0) RETURN
   NLINE = NLINE + 1
   IF (NLINE .LE. 42) GO TO 30
   CALL PAGEHD
   WRITE (NOT,2002)
   WRITE (NOT,2003) NAMEK,NAMEK,
     * RC, (GVI(I),I=1,3)
   NLINE = 0
30 WRITE (NOT,2004) NEL,J1,J2,J3,J4
    NERROR=1
    IF (J1.GT.NJ .OR. J2.GT.NJ .OR. J3.GT.NJ .OR. J4.GT.NJ) GO TO 999
C
C FORM FINITE ELEMENT 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.
C
   DO 40 I=1,3
      C(I,1) = XYZ(J1,I)
      C(I,2) = XYZ(J2,I)
      C(I,3) = XYZ(J3,I)
      F(J,1) = FUL(J1,I)
      F(J,2) = FUL(J2,I)
      F(J,3) = FUL(J3,I)
      IVI(I) = JDCF(J1,I)
      IVI(I+3) = JDCF(J2,I)
   40 IVI(I+6) = JDCF(J3,I)
   IF (LP .NE. 1) GO TO 50
C
   DO 42 I=1,3
      C(I,4) = XYZ(J4,I)
      F(J,4) = FUL(J4,I)
   42 IVI(I+9) = JDCF(J4,I)
C
50  G = SORT(EV(1)**2 + GV(2)**2 + GV(3)**2)
    DO 5 I=1,3
51  EV(I) = -GV(I)/G
    DO 52 I=-1,1
      CALL KGRAV (CJ,JM(I,L),EV,A,W,KW,KCJM)
    CALL
    DO 53 I=1,3
      JNO = JM(I,L)
      L1 = 3*I - 2
      IVTRI(L1) = 3*JNO - 2
      IVTRI(L1+1) = 3*JNO - 1
      IVTRI(L1+2) = 3*JNO
      SS = RO*G*A/24.
      IF (LR .GT. 1) SS = SS/2.
    CALL REVADD (SS,W,IVTRI,IVTRI,S,9,9,NCOL,NCOL,KW,KW)
    DO 65 J=1,NJN
      J1 = 3*J - 2
      CALL FULEF (FJ(I,J),T(J1,J1),KW)
      CALL ETABA (S,T,NCOL,NCOL,KW,KW)
    CALL
    IF (NAMEK .EQ. 6H) 
      IF (NAMEK .EQ. 6HNDSTIF) GO TO 20
      NERROR=2
    WRITE (NUTXY,LE) GC TO 999
    WRITE (NUTXY) NAMEK,NFL,NCOL,NCOL,NAMEL,(IBLK,I=1,5),
      *(S(I,J),I=1,NCOL),J=1,NCOL), (IVII(I),I=1,NCOL)
    GO TO 20
  CALL 2ZBOMP (6HGRAVITY,NERROR)
END
SUBROUTINE KIA1 (A1, A2, RL, E, Z, TS, KZ, KTS)  
DIMENSION Z(KZ,1), TS(KTS,1)

C C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C C STIFFNESS MATRIX,
C C STRESS TRANSFORMATION MATRIX,
C C FOR AN AXIAL ROD ELEMENT WITH UNRESTRICTED BOUNDARIES.
C C ROD MAY BE LINEARLY TAPERED OR UNIFORM.
C C CONSTANT FORCE ASSUMED.
C C STIFFNESS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C C STRESS TRANSFORMATION MATRIX RELATES STRESS AT ROD ENDS IN LOCAL
C C COORDINATE SYSTEM TO DEFLECTIONS IN LOCAL COORDINATE SYSTEM.
C C ROW ORDER IN STRESS TRANSFORMATION MATRIX IS
C C SIGMA-X1, SIGMA-X2
C C WHERE SIGMA X IS NORMAL STRESS.
C C SX1(-), SX2(*) IS TENSION. SX1(+), SX2(-) IS COMPRESSION.
C 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 C LOCAL COORDINATE ORDER IS
C C DX1, DX2
C C WHERE DX IS TRANSLATION.
C C DEVELOPED BY RL WOHLEN. SEPTEMBER 1972.
C
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
C S = A1/E/RL
R = A2/A1
IF (ABS(R-1.) .GT. .01) S = (A2-A1)*E / (RL*ALOG(R))

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

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

C RETURN
END
SUBROUTINE KIP1 (B11,B12,C1,C2,A1,A2,SR,RL,E,G,Z,TS,KZ,KTS)
DIMENSION ZIKZ,1), TS(KTS,1)
DATA EPS/1.E-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,EIGMA-X1,EIGMA-X2
C WHERE SIGMA IS NORMAL STRESS (MC/I) AND TAU IS SHEAR STRESS (P/A).
C THE LOCAL COORDINATE SYSTEM ASSUMES THE BEAM TO LIE IN THE X-Z PLANE
C WITH JOINT 1 AT THE ORIGIN, JOINT 2 ALONG THE POSITIVE X AXIS.
C LOCAL COORDINATE ORDER IS
C D21,D22,TY1,TY2
C WHERE DZ IS TRANSLATION AND TY IS ROTATION.
C LAST REVISION BY RL WOHLEN. APRIL 1976.
C

SUBROUTINE ARGUMENTS
C B11 = INPUT CROSS-SECTION AREA MOMENT OF INERTIA AT BEAM END 1.
C B12 = INPUT SAME AS B11 AT BEAM END 2.
C C1 = INPUT DISTANCE FROM BENDING NEUTRAL AXIS TO OUTER FIBER
C AT BEAM END 1.
C C2 = INPUT SAME AS C1 AT BEAM END 2.
C A1 = INPUT CROSS-SECTION AREA AT BEAM END 1. CAN BE ZERO FOR NO
C SHEAR DEFORMATION IN BENDING. SHEAR STRESS IN STRESS
C TRANSFORMATION WILL BE SET TO ZERO.
C A2 = INPUT SAME AS A1 AT BEAM END 2.
C SF = INPUT SHAPE FACTOR (K) FOR SHEAR IN KAG.
C USE SF=0.0 FOR NO SHEAR DEFORMATION IN BENDING.
C SF=1.0 FOR A SOLID CIRCULAR CYLINDER.
C SF=.5 FOR A THIN WALLED CIRCULAR CYLINDER.
C RL = INPUT ROD LENGTH.
C E = INPUT YOUNG'S MODULUS OF ELASTICITY.
C G = INPUT SHEAR MODULUS OF ELASTICITY. CAN BE ZERO FOR NO SHEAR
C DEFORMATION IN BENDING.
C Z = OUTPUT STIFFNESS MATRIX. SIZE(4,4).
C TS = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(4,4).
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=4.
C KTS = INPUT ROW DIMENSION OF TS IN CALLING PROGRAM. MIN=4.
C

C BENDING FLEXIBILITY.
RPI = F12/F11
REIM = RPI-1.
IF (ABS(REIM) .LT. .01) GO TO 15
ERR = F*PI*P*IMI
REILN = ALOG(RPI)
C SHEAR FLEXIBILITY.
20 IF (SF*LT.EPS OR A1*LT.EPS OR A2*LT.EPS OR G*LT.EPS) GO TO 30
RA = A2/A1
IF (ABS(RA-1.*) LT. 0.01) GO TO 25
F11 = F11 + RL * ALOG(RA) / (SF*G*(A2-A1))
GO TO 30
C
C BENDING + SHEAR STIFFNESS MATRIX.
30 D = F11-F22 - F12**2
Z(1,1) = F22/D
Z(1,2) = -Z(1,1)
Z(1,3) = -F12/D
Z(1,4) = (-RL*F22 + F12)/D
Z(2,1) = Z(1,1)
Z(2,2) = -Z(1,3)
Z(2,4) = -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) = 0.*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/B12
C
RETURN
END
SUBROUTINE KIC1 (TJ1, TJ2, R1, R2, RL, G, Z, TS, KZ, KTS)
DIMENSION Z(KZ,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 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 WOHLN. FEBRUARY 1973.
C LAST REVIEW BY RL WOHLN. SEPTEMBER 1973.
C
C SUBROUTINE ARGUMENTS
C TJ1 = INPUT CROSS-SECTION SAINT VENANTS TORSION CONSTANT (J) IN JG
C AT ROD END 1. E.G., TJ1=5*PI*PI**4 FOR A SOLID CIRCULAR
C CYLINDER. TJ1=2*PI*T*R**3 FOR A THIN WALL 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 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 = TJ1*G/RL
R = TJ2/TJ1
IF (ABS(R-1.) .GT. .01) S = (TJ2-TJ1)*G / (RL*ALOG(R))

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

C STRESS TRANSFORMATION MATRIX.
TS(1,1) = Z(1,1)*R1/TJ1
TS(1,2) = Z(1,2)*R1/TJ1
TS(2,1) = Z(2,1)*R2/TJ2
TS(2,2) = Z(2,2)*R2/TJ2
RETURN
END
DIMENSION Z(K2,1),T(KT,1),R(KR,1)
DIMENSION XE(3),ET(3)
C
!
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.
!
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 POISSONS 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).
K2 = 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=1,9
DO 5 J=1,9
5 T(I,J) = 0,0
DO 10 I=1,9
DO 10 J=1,9
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/(1.* + 2.*ANU)
DD = F*TH/(1. - ANU**2)
DNU = DD*ANU
DG = G*TH

D0 15 I=1,8
DC 15 J=1,9
15 R(I,J) = 0.

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.

Z(1,1) = DD*F00/X22
Z(1,3) = DD*F01/X22
Z(1,6) = DNU*F00/X2Y3
Z(1,8) = DNU*F10/X2Y3
Z(2,2) = DG*F00/Y32
Z(2,3) = DG*F10/Y32
Z(2,4) = 2.*DG*F01/Y32
Z(2,5) = DG*F00/X2Y3
Z(2,7) = 2.*DG*F10/X2Y3
Z(2,8) = DG*F01/X2Y3
Z(3,3) = DD*F02/X22 + DG*F20/Y32
Z(3,4) = 2.*DG*F11/Y32
Z(3,5) = DG*F10/X2Y3
Z(3,6) = DNU*F01/X2Y3
Z(3,7) = 2.*DG*F20/X2Y3
Z(3,8) = DNU*F11/X2Y3 + DG*F11/X2Y3
Z(4,4) = 4.*DG*F02/Y32
Z(4,5) = 2.*DG*F01/X2Y3
Z(4,7) = 4.*DG*F11/X2Y3
Z(4,8) = 2.*DG*F02/X2Y3
Z(5,5) = DG*F00/X22
Z(5,7) = 2.*DG*F10/X22
Z(5,8) = DG*F01/X22
Z(6,6) = DD*F00/Y32
Z(6,8) = DD*F10/Y32
Z(7,7) = 4.*DG*F20/X22
Z(7,8) = 2.*DG*F11/X22
Z(8,8) = DD*F20/Y32 + DG*F02/X22
DC 20 I=1,8
DD 20 J=1,8
20 Z(I+J) = Z(I,J)

R(1,1) = -1.
R(1,2) = 1.
R(2,1) = SE1 - 1.
R(2,3) = -Y3
R(2,4) = -SE1
R(2,7) = 1.
R(2,9) = Y3
R(3,2) = Y2
R(3,6) = -Y3
R(4,3) = Y3*(1. - SE1)
R(4,6) = Y3*SE1
R(4,8) = -Y3
R(5,2) = -1.*
R(5,3) = X2
R(5,5) = 1.*
R(5,6) = -X2
R(6,2) = +SE1 - 1.*
R(6,5) = -SE1
R(6,6) = X3
R(6,8) = 1.*
R(6,9) = -X3
R(7,3) = -X2
R(7,6) = X2
P(8,3) = X2*(SE1 - 1.*
R(5,y0) = +X3
R(8,9) = X2

C
CALL BTABA (Z,R,8,9,KZ,KR)

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

C
RETURN
END
SUBROUTINE K2E1 (X2, X3, Y3, TH, E, ANU, Z, TS, T, K2, KTS, KT)
DIMENSION Z(K2,1), TS(KTS,1), T(KT,1)
DIMENSION R(10,10), IVEG(10), CCEF(9), XE(3), ET(3)

SUBROUTINE TO CALCULATE FINITE ELEMENT...
STIFFNESS MATRIX,
STRESS TRANSFORMATION MATRIX,
FOR A FLEXING TRIANGLE PLATE ELEMENT WITH UNRESTRAINED BOUNDARIES.
CUBIC DISPLACEMENT (LINEAR CURVATURE) FIELD IS USED.
STIFFNESS MATRIX IS IN LOCAL COORDINATE SYSTEM.
STRESS TRANSFORMATION MATRIX RELATES STRESS AT JOINTS TO LOCAL
COORDINATE SYSTEM TO DEFLECTIONS IN THE LOCAL SYSTEM.
ROW ORDER IN STRESS TRANSFORMATION MATRIX IS
\( \sigma_x, \sigma_y, \tau_{xy} \) FOR \( z - \text{TH}/2 \) AT JOINT 1, THEN JOINT 2, 3,
\( \sigma_x, \sigma_y, \tau_{xy} \) FOR \( z - \text{TH}/2 \) AT JOINT 1, THEN JOINT 2, 3.
WHERE \( \sigma \) IS NORMAL STRESS AND \( \tau \) IS SHEAR STRESS.
THE LOCAL COORDINATE SYSTEM ASSUMES THE PLATE TO LIE IN AN X-Y PLANE
WITH JOINT 1 AT THE X-Y ORIGIN, JOINT 2 LIES ALONG THE POSITIVE
X AXIS, AND JOINT 3 IS IN THE POSITIVE Y DIRECTION.
LOCAL COORDINATE ORDER IS
\( (XZ, TX, TY) \) JOINT 1, THEN JOINT 2, 3.
WHERE \( DZ \) IS TRANSLATION AND \( TX, TY \) ARE ROTATIONS.
CALLS FORMA SUBROUTINES ETAA AND MULTA.
DEVELOPED BY CS EDDLEY. MARCH 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 RATIO. (E/2G)-1.
Z = OUTPUT StIFFNESS MATRIX. SIZE(9,9).
TS = OUTPUT LOCAL STRESS TRANSFORMATION MATRIX. SIZE(18,9).
T = OUTPUT MATRIX WRT SF. CEF. SIZE(10,10).
K2 = INPUT ROW DIMENSION OF 2 IN CALLING PROGRAM. MIN=9.
KTS = INPUT ROW DIMENSION OF TS IN CALLING PROGRAM. MIN=18.
KT = INPUT ROW DIMENSION OF T IN CALLING PROGRAM. MIN=10.

DC 16 I=1,9
DC 16 J=1,9
10 Z(I,J) = 0.0
DC 11 I=1,10
DC 11 J=1,9
11 TS(I,J) = 0.0
IF (TH > .01) LT TURN
DC 12 I=1,10
DC 12 J=1,10
12 TS(I,J) = 0.0
X22 = X2*X2
Y24 = X2*X3
Y32 = Y2*Y3
Y34 = Y2*Y32
\[ SE_1 = \frac{X_2}{X_2} \]
\[ SE_2 = SE_1 \times SE_1 \]
\[ SE_3 = SE_2 \times SE_1 \]
\[ SE_4 = SE_3 \times SE_1 \]
\[ SE_5 = \left(1 + SE_1\right) / 3 \]
\[ SEC_2 = SEC_1 \times 2 \]
\[ SEC_3 = SEC_1 \times 3 \]
\[ G = \frac{1}{(2 + 2 \times ANU)} \]
\[ DD = \left(5 \times T - 3.3 \right) / (12.5 \times (1 - ANU \times 2)) \]
\[ DNU = DD \times ANU \]
\[ DG = (G \times T + 3) / 12 \]
\[ AL = DD / X \]
\[ FE = DNU / (Y_22 + Y_32) \]
\[ GA = D/DY_34 \]
\[ DE = 4 \times DG / (X_22 + Y_32) \]

\[
\begin{align*}
T(1,1) &= 1.0 \\
T(2,1) &= 1.0 \\
T(3,1) &= 1.0 \\
T(4,1) &= 1.0 \\
T(4,2) &= 1.0 \\
T(4,3) &= 1.0 \\
T(4,4) &= 1.0 \\
T(4,7) &= 1.0 \\
T(5,3) &= 1.0 \\
T(5,5) &= 1.0 \\
T(5,8) &= 1.0 \\
T(6,2) &= 1.0 \\
T(6,4) &= 2.0 \\
T(6,7) &= 3.0 \\
T(7,1) &= 1.0 \\
T(7,2) &= SE_1 \\
T(7,3) &= 1.0 \\
T(7,4) &= SF_2 \\
T(7,5) &= SF_1 \\
T(7,6) &= 1.0 \\
T(7,7) &= SF_3 \\
T(7,8) &= SF_2 \\
T(7,9) &= SF_1 \\
T(7,10) &= 1.0 \\
T(8,2) &= 1.0 \\
T(8,5) &= SF_1 \\
T(8,6) &= 2.0 \\
T(9,8) &= SF_2 \\
T(8,9) &= 2.0 \times SF_1 \\
T(9,10) &= 2.0 \\
T(9,2) &= 1.0 \\
T(9,4) &= 2.0 \times SF_1 \\
T(9,5) &= 1.0 \\
T(9,7) &= SF_2 \\
T(9,9) &= 1.0 \\
T(10,1) &= 1.0 \\
T(10,2) &= SF_1 \\
T(10,3) &= 1.0 \times SF_1 \\
T(10,4) &= SF_2 
\end{align*}
\]


```
T(10,5) = SEC1/3.
T(10,6) = 1./9.
T(10,7) = SEC2.
T(10,8) = SEC9/3.
T(10,9) = SEC9/9.
T(10,10) = 1./27.
C
DO 5 I=1,10
DO 7 J=1,10
7 R(I,J) = 0.
5 R(I,I) = 1.
C
DC 100 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
ALJIEG = T(L,JEIG)
DO 17 J=1,10
T(L,J) = T(L,J)/ALJIEG
17 R(L,J) = F(L,J)/ALJIEG
DC 25 I=1,10
ALJIEG = T(I,JEIG)
IF (".*EC. L") GO TO 25
DC 35 J=1,10
T(I,J) = T(I,J) - ALJIEG*T(L,J)
30 R(I,J) = F(I,J) - ALJIEG*R(L,J)
25 CONTINUE
100 CONTINUE
C
DC 40 I=1,10
IP = IVEC(I)
DC 40 J=1,10
40 T(IF,J) = R(I,J)
DC 50 I=1,10
DC 50 J=1,10
50 R(I,J) = T(I,J)
C
DC 26 I=1,10
R(1,2) = Y2*F(1,2)
R(1,3) = -Y2*F(1,2)
R(1,5) = Y2*F(1,5)
R(1,6) = -Y2*F(1,6)
F(1,8) = Y2*F(1,8)
20 R(1,9) = -Y2*F(1,9)
C
CCEFF(1) = 1./3.
CCEFF(2) = Y2/1.
CCEFF(3) = -(X2+X2)/4.
CCEFF(4) = 1./3.
```
COEF(5) = Y3/18.
COEF(6) = (2.*X2 - X3)/18.
COEF(7) = 1./2.
COEF(8) = -Y3/6.
COEF(9) = (2.*X3 - X2)/18.
DO 80 I=1,10
DO 80 J=1,9
80 R(I,J) = F(I,J) + R(I,10)*COEF(J).

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

C
FOO = X2*Y3/2.
F10 = X2*Y3*(1. + SE1)/6.
F01 = X2*Y3/6.
F20 = X2*Y3*(1. + SE1 + SE2)/12.
F11 = X2*Y3*(1. + 2.*SE1)/24.
F02 = X2*Y3/12.

C
T(4,4) = 4.*AL*FOO
T(4,6) = 4.*EE*FOO
T(4,7) = 12.*AL*F10
T(4,8) = 4.*AL*FO1
T(4,9) = 4.*EE*F10
T(4,10) = 12.*EE*F01
T(5,5) = DE*FOO
T(5,6) = 2.*DE*F10
T(5,7) = 2.*DE*FO1
T(6,6) = 4.*GA*FO0
T(6,7) = 12.*EE*F10
T(6,8) = 4.*EE*F01
T(6,9) = 4.*GA*F10
T(6,10) = 12.*GA*FO1
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*FO2 + 4.*DE*F20
T(8,9) = 4.*EE*F11 + 4.*DE*F11
T(8,10) = 12.*EE*FO2
T(9,9) = 4.*GA*F20 + 4.*DE*FO2
T(9,10) = 12.*GA*F11
T(10,10) = 26.*GA*FO2

C
DO 60 I=1,10
DO 60 J=1,10
60 T(J,I) = T(I,J)
CALL ETAFA(T,F,16,9,KT,10)
DO 85 I=1,6
DO 85 J=1,6
85 Z(I,J) = T(I,J)

C
DC 73 I=1,6
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.*DG/((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*XE(I)
   T(K1,8) = 2.*D11*ET(I)
   T(K1,9) = 2.*D12*XE(I)
   T(K1,10) = 6.*D12*ET(I)
   T(K2,4) = 2.*D21
   T(K2,6) = 2.*D22
   T(K2,7) = 6.*D21*XE(I)
   T(K2,8) = 2.*D21*ET(I)
   T(K2,9) = 2.*D22*XE(I)
   T(K2,10) = 6.*D22*ET(I)
   T(K3,5) = D33
   T(K3,8) = 2.*D33*XE(I)
   CALL MULTA(T,K5,K10,9,KT,16)
   DO 77 I=1,9
      IP9 = 1 + 9
   DO 77 J=1,9
      T5(I,J) = T(I,J)
    77 T5(IP9,J) = -T5(I,J)
   C
      RETURN
    ENDC
SUBROUTINE K3C1 (X3,Y3,TH,G,Z,T,KZ,KT)
DIMENSION Z(KZ,1), T(KT,1)

C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C STIFFNESS MATRIX,
C STRESS TRANSFORMATION MATRIX,
C FOR A RECTANGULAR SHEAR PANEL ELEMENT WITH UNRESTRAINED BOUNDARIES.
C LINEAR DISPLACEMENT (CONSTANT STRAIN) FIELD IS USED.
C STIFFNESS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C STRESS TRANSFORMATION MATRIX RELATES PANEL SHEAR STRESS (CONSTANT)
C IN LOCAL COORDINATE SYSTEM TO DEFLECTIONS IN THE LOCAL SYSTEM.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE PANEL TO LIE IN AN X-Y PLANE
C WITH JOINT 1 AT THE X-Y ORIGIN, JOINT 2 LIES ALONG THE POSITIVE
C X AXIS, JOINT 3 IS IN THE POSITIVE X,Y DIRECTION, AND JOINT 4 LIES
C ALONG THE POSITIVE Y AXIS.
C LOCAL COORDINATE ORDER IS
C DX1,DX2,DX3,DX4, DY1,DY2,DY3,DY4
C WHERE DX, DY ARE TRANSLATIONS.
C DEVELOPED BY RL WOHLEN. 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 G = INPUT SHEAR MODULUS OF ELASTICITY.
C Z = OUTPUT STIFFNESS MATRIX. SIZE(6,6).
C T = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(1,8).
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=8.
C KT = INPUT ROW DIMENSION OF T IN CALLING PROGRAM. MIN=1.

C STIFFNESS MATRIX.
C = TH*G/4,
A = C*X3/Y3,
B = C*Y3/X3,
Z(1,1) = A,
Z(1,2) = A,
Z(1,3) = -A,
Z(1,4) = -A,
Z(1,5) = C,
Z(1,6) = -C,
Z(1,7) = -C,
Z(1,8) = C,
Z(2,2) = B,
Z(2,3) = -B,
Z(2,4) = -B,
Z(2,5) = C,
Z(2,6) = -C,
Z(2,7) = C,
Z(2,8) = C,
Z(3,2) = B,
Z(3,4) = B,
Z(3,5) = -C,
Z(3,6) = (,
Z(3,7) = 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) = -E
Z(5,8) = E
Z(6,6) = F
Z(6,7) = B
Z(6,8) = -E
Z(7,7) = B
Z(7,8) = -F
Z(8,8) = F

C. SYMMETRIZE LOWER HALF.
   DO 10 J=1,8
   DC 10 I=J,F
   10 Z(I,J) = Z(J,I)
C
C. STRESS TRANSFORMATION MATRIX.
   DO 20 J=1,6
   20 T(1,J) = 2.*Z(3,J)/(TH*X3)
C
RETURN
END
SUBROUTINE KGRAV (CJ, JM, EV, A, W, KW, KCJ)
DIMENSION CJ(KCJ, 1), JM (1), EV(1),
DIMENSION E(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 FORMA SUBROUTINES MULTA, MULTB, VCRoss.
DEVELOPED BY C S EDDLEY, FEBRUARY 1974.
LAST REVISION BY C S EDDELEY, NOVEMBER 1974.

SUBROUTINE ARGUMENTS
C CJ = INPUT MATRIX OF JOINT COORDINATES. SIZE (3,4).
C JM = INPUT Row D I M E N S I O N SIZE OF W IN CALLING PROGRAM. MIN=3.
C EV = INPUT VECTOR OF JOINTS DEFINING A TRIANGLE. SIZE (3).
C A = OUTPUT AREA.
C W = OUTPUT STIFFNESS MATRIX.
C KW = INPUT ROW DIMENSION SIZE OF CJ IN CALLING PROGRAM. MIN=9.
C KCJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM. MIN=3.

C
J1 = JM(1)
J2 = JM(2)
J3 = JM(3)
DO 5 I=1,9
5 E(I, I) = 0.
DO 7 I=1,3
R12(I) = CJ(I, J2) - CJ(I, J1)
R13(I) = CJ(I, J3) - CJ(I, J1)
7 E(I, J) = 1.
7 F(I, I) = 2.
C
CALL VCRoss (R12, R13, VN, VAMAG, VEMAG, A, SINAB)
DO 10 I=1,3
10 VN(I) = VN(I)/A
ACUM = 0.0
DO 15 I=1,3
11 = 3*I - 3
ACUM = ACUM + VN(I)*EV(I)
15 J=1,2
E(I, 11+J) = VN(I)

C
15 W(I1+J, I) = VN(I)
CALL MULTB (F, E, 3, 2, 9, KEF, KEF)
CALL MULTA (W, F, 3, 9, KEF, KEF)
A = A*ACUM*ACUM*ACUM
C
RETURN
END
SUBROUTINE M1A1 (A1,A2,RL,RO,Z,KZ)
DIMENSION Z(KZ,1)

C
C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C LUMPED MASS MATRIX
C FOR AN AXIAL ROD ELEMENT WITH UNRESTRAINED BOUNDARIES.
C ROD MAY BE LINEARLY 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 LOW DIMENSION OF Z IN CALLING PROGRAM. MIN=2.
C
W1 = A1*RL*RO/6.
W2 = A2*RL*RO/6.
Z(1,1) = Z(2,2) = W1 + W2
Z(1,2) = 0.
Z(2,1) = 0.
Z(2,2) = W1 + 2.*W2

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

SUBROUTINE TO CALCULATE FINITE ELEMENT...

CONSISTENT MASS MATRIX

FOR AN AXIAL ROD ELEMENT WITH UNRESTRAINED BOUNDARIES.

ROD MAY BE LINEARLY TAPEPED 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 WOHLLEN. SEPTEMBER 1972.


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
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 2 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(1,2) = W1 + 2.*W2
Z(4,4) = (A2*RO*RL**3)/24.

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

C C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C C CONSISTENT MASS MATRIX
C FOR A BENDING BEAM ELEMENT WITH UNRESTRAINED BOUNDARIES.
C BEAM MAY BE LINEARLY TAPERED OR UNIFORM.
C CUBIC DISPLACEMENT FUNCTION ASSUMED.
C MASS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE BEAM TO LIE IN THE X-Z PLANE
C WITH JOINT 1 AT THE ORIGIN, JOINT 2 ALONG THE POSITIVE X AXES.
C LOCAL COORDINATE ORDER IS
C OZ, OZ, OY1, OY2
C WHERE OZ IS TRANSLATION AND OY IS ROTATION.
C DEVELOPED BY RL WOHLLEN. FEBRUARY 1973.
C
C C SUBROUTINE ARGUMENTS
C A1 = INPUT CROSS-SECTION AREA AT BEAM END 1.
C A2 = INPUT CROSS-SECTION AREA AT BEAM END 2.
C RL = INPUT BEAM LENGTH.
C KO = INPUT MASS DENSITY.
C Z = OUTPUT MASS MATRIX. SIZE(4,4).
C KZ = INPUT CEB DIMENSION OF Z IN CALLING PROGRAM. MIN=4.
C
C W1 = A1*RL*K0/4.0
C W2 = A2*RL*K0/4.0
C RL2 = RL**2
Z(1,1) = 240.*W1 + 72.*W2
Z(1,2) = 54.*W1 + 54.*W2
Z(2,2) = 72.*W1 + 240.*W2
Z(1,3) = -(30.*W1 + 14.*W2)*RL
Z(1,4) = -(14.*W1 + 12.*W2)*RL
Z(2,3) = -(12.*W1 + 14.*W2)*RL
Z(2,4) = -(14.*W1 + 30.*W2)*RL
Z(3,3) = -(5.*W1 + 3.*W2)*RL2
Z(3,4) = -(3.*W1 + 3.*W2)*RL2
Z(4,4) = -(3.*W1 + 5.*W2)*RL2
DO 10 J=1,4
    DO 10 I=J,4
10  Z(I,J) = Z(J,I)
C
RETURN
END
SUBROUTINE M1C1 (PI1, PI2, RL, RO, Z, KZ)
  DIMENSION Z(KZ,1)

SUBROUTINE TO CALCULATE FINITE ELEMENT...
LUMPED MASS MATRIX
FOR A TORSION ROD ELEMENT WITH UNRESTRAINED BOUNDARIES.
ROD MAY BE LINEARLY TAPERED OR UNIFORM.
MASS MATRIX IS IN LOCAL COORDINATE SYSTEM.
The local coordinate system assumes the rod to lie along the X axis
with joint 1 at the origin, joint 2 along the positive X axis.
Local coordinate order is
TX1, TX2
Where TX is notation.
Last revision by RL Wohlen, September 1973.

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

W1 = PI1*RL*RO/6.
W2 = PI2*RL*RO/6.
Z1(1,1) = Z*W1 + W2
Z1(1,2) = 0.
Z1(2,1) = 0.
Z1(2,2) = W1 + 2.*W2

RETURN
END
SUBROUTINE MIC, (PI1, PI2, RL, RO, I, KZ)
DIMENSION Z(KZ,1)
C
C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C CONSISTENT MASS MATRIX
C FOR A TORSION FEM 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 DEVELOPED BY RL WOHLLEN. FEBRUARY 1973.
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 I = OUTPUT MASS MATRIX. SIZE(2,2).
C KZ = INPUT ROW DIMENSION OF I IN CALLING PROGRAM. MIN=2.
C
W1 = PI1*RL**2/12.
W2 = PI2*RL**2/12.
Z(1,1) = 3.*W1 + W2
Z(1,2) = W1 + W2
Z(2,1) = Z(1,2)
Z(2,2) = W1 + 3.*W2
C
RETURN
END
SUBROUTINE M2A1 (X2,Y3,TH,RC,Z,KZ)
DIMENSION Z(KZ,1)
C
C SUBROUTINE M 2 A 1: CALCULATE FINITE ELEMENT...
C LUMPED MASS MASS IX,
C FOR A MEMBRANE TRIANGLE PLATE ELEMENT WITH UNRESTRAINED BOUNDARIES.
C MASS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE PLATE TO LIE IN AN X-Y PLANE
C WITH JOINT 1 AT THE X-Y ORIGIN, JOINT 2 LIES ALONG THE POSITIVE
C X AXIS, AND JOINT 3 IS IN THE POSITIVE Y DIRECTION.
C LOCAL COORDINATE ORFF IS
C (EX,EY,EZ) JOINT 1, THEN JOINT 2, 3.
C WHERE EX,EY ARE TRANSLATIONS AND EZ IS ROTATION.
C DEVELOPED BY WZ BENFIELD. FEBRUARY 1972.
C
C SUBROUTINE ARGUMENTS
C X2 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 2.
C Y3 = INPUT LOCAL Y COORDINATE LOCATION OF JOINT 3.
C TH = INPUT PLATE THICKNESS.
C RC = INPUT MASS DENSITY.
C Z = OUTPUT MASS MATRIX. SIZE(9,9).
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=9.
C
AREA = 0.5*X2*Y2
CM = (K0*TH/AREA)/2.0
DO 10 I=1,6
  DO 10 J=1,6
10  Z(I,J) = CM
DO 20 I=1,6
20  Z(I,1) = CM
RETURN
END
SUBROUTINE M2A2 (X2, Y3, T, PHC, Z, I, R, KZ, KT, KR)
DIMENSION Z(KZ, 1), T(KT, 1), F(KR, 1)

SUBROUTINE TO CALCULATE FINITE ELEMENT...  
CONSISTENT MASS MATRIX, 
FOR A MEMBRANE TRIANGLE PLATE ELEMENT WITH UNRESTRAINED BOUNDARIES. 
QUADRATIC DISPLACEMENT (LINEAR STRAIN) FIELD IS USED. 
MASS MATRIX IS IN LOCAL COORDINATE SYSTEM. 
THE LOCAL COORDINATE SYSTEM ASSUMES THE PLATE TO LIE IN AN X-Y PLANE 
WITH JOINT 1 AT THE X-Y ORIGIN, JOINT 2 LIES ALONG THE POSITIVE 
X AXIS, AND JOINT 3 IS IN THE POSITIVE Y DIRECTION. 
LOCAL COORDINATE ORDER IS 
OXY, OYZ, OZX, THEN JOINT 1, 2, 3. 
WHERE OXY, OYZ ARE TRANSLATIONS AND OZX IS ROTATION. 
CALL FORMA SUBROUTINES ETAA. 
DEVELOPED BY CS BOPLEY. MARCH 1973. 
LAST REVISION BY WA BENDER. SEPTEMBER 1973.

SUBROUTINE ARGUMENTS
X2 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 2.
X3 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 3.
Y3 = INPUT LOCAL Y COORDINATE LOCATION OF JOINT 3.
TH = INPUT PLATE THICKNESS.
PHC = INPUT MASS DENSITY.
Z = OUTPUT MASS MATRIX. SIZE(9, 9).
T = INPUT MATRIX WORK SPACE. SIZE(10, 10).
R = INPUT MATRIX WORK SPACE. SIZE(10, 10).
KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=9.
KT = INPUT ROW DIMENSION OF T IN CALLING PROGRAM. MIN=10.
KR = INPUT ROW DIMENSION OF R IN CALLING PROGRAM. MIN=10.

SE1 = X2/X2
SE2 = SE1 * SE1
SE3 = SE2 * SE1
SE4 = SE3 * SE1
X2 Y3 = X2 * Y2 * PHC * TH

DO 10 I = 1, 10
D0 10 J = 1, 10
10 T(I, J) = 0.
10 R(I, J) = 0.

FC0 = X2 Y3 / 2.
FC1 = X2 Y2 * (1.0 + SE1) / 6.
FC2 = X2 Y2 / 6.
FC3 = X2 Y3 * (1.0 + SE1 + SE2) / 12.
FC4 = X2 Y3 * (1.0 + 2.0 * SE1 + SE2) / 24.
FC5 = X2 Y3 / 12.
FC6 = X2 Y3 * (1.0 + SE1 + SE2 + SE3) / 20.
FC7 = X2 Y3 * (1.0 + 2.0 * SE1 + 3.0 * SE2 + 4.0 * SE3) / 60.
FC8 = X2 Y3 / 20.
FC9 = X2 Y3 * (1.0 + SE1 + SE2 + SE3 + SE4) / 30.
FC10 = X2 Y3 * (1.0 + 2.0 * SE1 + 3.0 * SE2 + 4.0 * SE3) / 120.
FC11 = X2 Y3 * (1.0 + 3.0 * SE1 + 6.0 * SE2) / 180.
M2A2 -- 2/3

F13 = \( x \cdot 2 \cdot 3 \cdot (1. + 4. \cdot \sqrt{E1}) / 120. \)
F04 = \( x \cdot 2 \cdot 3 / 30. \)
T(1,1) = F00
T(1,2) = F10
T(1,3) = F03
T(1,4) = F11
T(1,5) = F02
T(2,2) = F20
T(2,3) = F11
T(2,4) = F21
T(2,5) = F12
T(3,2) = F02
T(3,4) = F12
T(3,5) = F03
T(4,4) = F22
T(4,5) = F04
T(5,5) = F44
T(6,6) = F10
T(6,7) = F10
T(6,8) = F01
T(6,9) = F20
T(6,10) = F11
T(7,7) = F20
T(7,8) = F11
T(7,9) = F21
T(7,10) = F21
T(8,8) = F22
T(8,9) = F21
T(8,10) = F12
T(9,9) = F44
T(9,10) = F21
T(10,10) = F22
DC 20 J=1,10
DO 30 J=1,10

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

C

F(1,1) = 1.
R(1,1) = -1.
R(2,2) = 1.
P(3,1) = \( \frac{1}{2} \cdot 1 - 1. \)
R(3,3) = -\( \sqrt{3} \).
F(4,4) = -\( \sqrt{1} \).
P(5,7) = 1.
R(5,6) = \( \sqrt{5} \).
P(4,6) = -\( \sqrt{3} \).
R(5,2) = \( \sqrt{2} \).
P(5,6) = \( \sqrt{2} \).
R(5,6) = \( \sqrt{3} \).
R(6,2) = 1.
P(7,2) = -1.
F(7,3) = \( \sqrt{2} \).
P(7,3) = 1.
R(7,6) = -\( \sqrt{2} \).
P(6,2) = \( \sqrt{2} \).
R(F,5) = -$\text{SEL}$
R(F,6) = $X_3$
R(F,8) = 1
F(F,0) = $-Y_3$
F(F,3) = $-X_2$
F(0,6) = $X_2$
F(10,2) = $X_2*(\text{SEL} - 1.0)$
F(1u,6) = $-X_3$
F(10,0) = $X_2$

CALL PTAEA(T,F,10,9,K1,KP)
CC 40 I=1,6
CC 40 J=1,6
40 Z(I,J) = T(I,J)

C
C RETURN
END
SUBROUTINE M261 (X2,Y3,TH,R0,Z,KZ)
DIMENSION Z(KZ,1)

SUBROUTINE TO CALCULATE FINITE ELEMENT...
LUMPED MASS MATRIX.
FOR A PENDING 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.

SUBROUTINE ARGUMENTS
X2 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 2.
Y3 = INPUT LOCAL Y COORDINATE LOCATION OF JOINT 3.
TH = INPUT PLATE THICKNESS.
R0 = 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 = (R0+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
DIMENSION 2(KZ,1),1(K1,1),1(KR,1)
DIMENSION IVEC(16),CCEF(19)

C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C CONSISTENT MASS MATRIX,
C FOR A BENDING TRIANGLE PLATE ELEMENT WITH UNPRESTAINED BOUNDARIES.
C CUBIC DISPLACEMENT (LINEAR CURVATURE) FIELD IS USED.
C THIS IS NOT THE SI CALLED STRICKLAND ELEMENT.
C MASS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE PLATE TO LIE IN AN X-Y PLANE
C WITH JOINT 1 AT THE X-Y ORIGIN, JOINT 2 LIES ALONG THE POSITIVE
C X AXIS, AND JOINT 3 IS IN THE POSITIVE Y DIRECTION.
C LOCAL COORDINATE CHECK IS
C (DZ,TX,TY) JOINT 1, THEN JOINT 2, 3.
C WHERE DZ IS TRANSLATION AND TX,TY ARE ROTATIONS.
C CALLS FROM SUBROUTINES STAEK.
C DEVELOPED BY CAFL FOOLEY MARCH 1973.

C SUBROUTINE ARGUMENTS
C X2 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 2.
C X3 = INPUT LOCAL Y COORDINATE LOCATION OF JOINT 3.
C Y3 = INPUT LOCAL Y COORDINATE LOCATION OF JOINT 3.
C TH = INPUT PLATE THICKNESS.
C RHO = INPUT MASS DENSITY.
C Z = OUTPUT MASS MATRIX SIZE(9,9).
C T = OUTPUT MATRIX WORK SPACE SIZE(10,10).
C R = INPUT MATRIX WORK SPACE SIZE(10,10).
C K2 = INPUT ROW DIMENSION OF 2 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.

SE1 = X2/Y3
SE2 = SE1**SE1
SE3 = SE2**SE1
SE4 = SE3**SE1
SE5 = SE4**SE1
SE6 = SE5**SE1
SEC1 = (1. + ST(1)/3.
SEC2 = SEC1**2
SEC3 = SEC2**2

CC 10 I=1,10
DO 10 J=1,10
10 T(I,J) = 0.

T(1,1) = 1.
T(2,2) = 1.
T(3,3) = 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,I) = 1.

C
DC 160 L=1,10
JREF = 1
A1 = AES(T(L,1))
DO 15 J=2,10
A2 = AES(T(L,J))
IF (A2 .LT. A1) GO TO 15
A1 = A2
JREF = J
15 CONTINUE
IVEC(L) = JREF
ALJREF = T(L,JREF)
DC 17 J=1,10
T(L,J) = T(L,J)/ALJF1G
17 R(L,J) = R(L,J)/ALJ61G
DO 25 I=1,10
  ALJF1G = T(I,J)/1G
  IF (I.EQ.L) GO TO 25
  DO 30 J=1,J10
    T(I,J) = T(I,J) - ALJ61G*T(L,J)
  30 R(I,J) = R(I,J) - ALJ61G*R(L,J)
25 CONTINUE
C
DO 40 I=1,10
  IF = IVEC(I)
DO 40 J=1,10
40 T(R,I,J) = R(I,J)
DO 50 I=1,10
  CO 50 J=1,10
50 R(I,J) = T(I,J)
C
DO 20 I=1,10
  R(1,2) = Y3*R(I,2)
  R(1,3) = -X2*R(I,3)
  R(1,5) = Y3*R(I,5)
  R(1,6) = -Y2*R(I,6)
  R(1,8) = Y3*R(I,8)
20 R(I,9) = -X2*R(I,9)
C
COEF(1) = 1./3.
COEF(2) = Y3/18.
COEF(3) = -(X2+X3)/16.
COEF(4) = 1./3.
COEF(5) = Y3/18.
COEF(6) = (2.*X2 - X3)/16.
COEF(7) = 1./3.
COEF(8) = -Y3/6.
COEF(9) = (2.*X3 - X2)/16.
DO 80 I=1,10
DO 80 J=1,9
80 R(I,J) = R(I,J) + R(I,10)*COEF(J)
C
DO 55 I=1,10
DC 55 J=1,10
55 T(I,J) = 0.
C
X2Y3 = Y2*Y3*TH*RHO
FC0 = X2Y3/2.
F10 = X2Y3+(1.*SE1)/6.
FC1 = X2Y3/6.
F20 = Y2*Y3+(1.*SE1 + SE2)/12.
F11 = X2Y3*(1. + 2.*SE1)/24.
FC2 = Y2*Y3/12.
F30 = X2Y3+(1.*SE1 + SE2 + SE3)/20.
F21 = X2Y3*SE1 + 3.*SE2)/60.
F12 = X2Y3*(1. + SE1 + SE2)/60.
FC3 = X2Y3/20.
\[ F_{40} = X Y^3 (1. + 3 E1 + 4 E2 + 5 E3 + E4)/30. \]
\[ F_{31} = X Y^3 (1. + 2 E1 + 3 E2 + 4 E3)/120. \]
\[ F_{22} = X Y^3 (1. + 3 E1 + 6 E2 + E3)/180. \]
\[ F_{13} = X Y^3 (1. + 4 E1)/120. \]
\[ F_{04} = X Y^3/30. \]
\[ F_{50} = X Y^3 (1. + E1 + E2 + E3 + E4 + E5)/42. \]
\[ F_{41} = X Y^3 (1. + 2 E1 + 3 E2 + 4 E3 + 5 E4)/210. \]
\[ F_{32} = X Y^3 (1. + 3 E1 + 6 E2 + 10 E3 + E4)/420. \]
\[ F_{23} = X Y^3 (1. + 4 E1 + 10 E2 + E3)/420. \]
\[ F_{14} = X Y^3 (1. + 5 E1)/210. \]
\[ F_{05} = X Y^3/42. \]
\[ F_{60} = X Y^3 (1. + E1 + E2 + E3 + E4 + E5 + E6)/56. \]
\[ F_{51} = X Y^3 (1. + 2 E1 + 3 E2 + 4 E3 + 5 E4 + 6 E5)/336. \]
\[ F_{42} = X Y^3 (1. + 3 E1 + 6 E2 + 10 E3 + 15 E4 + E5)/840. \]
\[ F_{33} = X Y^3 (1. + 4 E1 + 10 E2 + 20 E3 + E4)/1120. \]
\[ F_{24} = X Y^3 (1. + 5 E1 + 15 E2)/840. \]
\[ F_{15} = X Y^3 (1. + 6 E1)/336. \]
\[ F_{06} = X Y^3/56. \]

\[
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_{51} \\
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(5,8) = F_{33} \\
T(5,9) = F_{13}
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) = F6C
T(7,8) = F51
T(7,9) = F42
T(7,10) = F33
T(8,7) = F47
T(8,8) = F33
T(8,9) = F24
T(8,10) = F15
T(10,10) = F06

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(2,1)

SUBROUTINE TO CALCULATE FINITE ELEMENT...

LUMPED MASS MATRIX
FOR A RECTANGULAR SHEET PANEL ELEMENT WITH UNRESTRAINED BOUNDARIES.
M MASS MATRIX IS IN LOCAL COORDINATE SYSTEM.
THE LOCAL COORDINATE SYSTEM ASSUMES THE PANEL TO LIE IN AN X-Y PLANE
WITH JOINT 1 AT THE X-Y ORIGIN, JOINT 2 LIES ALONG THE POSITIVE
X AXIS, JOINT 3 IS IN THE POSITIVE X,Y DIRECTION, AND JOINT 4 LIES
ALONG THE POSITIVE Y AXIS.
LOCAL COORDINATE ORDER IS
DX1,DX2,DX3,DX4, DY1,DY2,DY3,DY4
WHERE DX,DY ARE TRANSLATIONS.
DEVELOPED BY RL WOHLEN. APRIL 1974.

SUBROUTINE ARGUMENTS
X3 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 3.
Y3 = INPUT LOCAL Y COORDINATE LOCATION OF JOINT 3.
TH = INPUT PANEL THICKNESS.
RO = INPUT MASS DENSITY.
Z = OUTPUT MASS MATRIX SIZE(8,8).
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
RETURN
END
SUBROUTINE MASIA (CJ,EJ,A1,A2,RU,NAMEM,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 FORM SUBROUTINES EULER,M1A1,M1A2,Z2BOM.
- 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.
- NAMEM = 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.

ERROR EXPLANATION
1 = DIMENSION SIZE EXCEEDED (KZ).
2 = NAMEM IMPROPERLY DEFINED.

IF (KZ .LT. 6) GO TO 999
DC 5 J=1,6
DO 5 I=1,6
5 2(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 (NAMEM .EQ. 'M1') GO TO 110
IF (NAMEM .EQ. 'M2') GO TO 126
GO TO 999

LUMPED.
110 CALL M1A1 (A1,A2,RL,RO,W,2)
   DC 112 I=1,2
112 2(I,1) = W(I,1)
DO 114 I=4,6
114   Z(I,J) = W(2,2) -
      RETURN

C CONSISTENT.
120   CALL M1A2   (A1,A2,RL,RO,W,2)
      DO 122 I=1,3
      CALL EULER   (EJ(I,1),E1,3)
      CALL EULER   (EJ(I,2),E2,3)
      CALL ATXRB   (E1,E2,3,3,3,3,3)
      DO 124 I=1,3
      DO 124 J=4,6
      Z(I,J) = W(1,2)*E2(I,J-3)
124     Z(J,I) = Z(I,J)
      DO 126 I=4,6
126   Z(I,J) = W(2,2)
      RETURN

C
999   CALL ?ZBUMB (6HMASIA ,NERROR)
      END
SUBROUTINE MAS1B (CJ, EJ, A1, A2, PI1, PI2, RO, NAMEM, Z, W, KCJ, KEJ, KZ, KW)
DIMENSION CJ(KCJ, JC), EJ(KEJ, IC), Z(KZ, IC), W(KW, IC)

SUBROUTINE TO CALCULATE FINITE ELEMENT...  
MASS MATRIX
FOR A COMBINED AXIAL-TORSION-BENDING BAR ELEMENT WITH UNRESTRAINED
BOUNDARIES.
BAR MAY BE LINEARLY TAPERED OR UNIFORM.
MASS MATRIX IS IN GLOBAL COORDINATE DIRECTIONS.
GLOBAL COORDINATE ORDER 1:
(U, V, W, P, C, R) J0INT 1, THEN JOINT 2
WHERE U, V, W ARE TRANSLATIONS AND P, C, R ARE ROTATIONS.
EULER ANGLE CONVENTION IS GLOBAL X, Y, Z PERMUTATION.
CALLS FORM SUBROUTINES ETABA, DCOS1B, M1A1, M1A2, M1B1, M1B2, M1C1, M1C2,
2ZPME.
LAST REVISION BY WA BENFIELD. MARCH 1976.

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 CORRESPONS
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 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=12.
C KW = INPUT ROW DIMENSION OF W IN CALLING PROGRAM. MIN=12.

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

IF (KZ .LT. 12 .OR. KW .LT. 12) GO TO 999
DC 5 J=1,12
DC 5 I=1,12
5 7(I,J) = 0
RL = SQRT((CJ(1,1)-CJ(1,1))**2 + (CJ(1,2)-CJ(2,1))**2
* + (CJ(3,1)-CJ(3,1))**2)
IF (NAMEM .EQ. 1 .OR. 2) GO TO 110
IF (NAMEM .EQ. 6 .OR. 7) GO TO 120
NERROR=1

NERROR=2
C AXIAL=M1A1 (LUMPED), TORSION=M1C1 (LUMPED), BENDING=M1B1 (LUMPED).
110 CALL M1A1 (A1, A2, PL, RC, Z1, KZ)
  CALL M1C1 (P11, P12, PL, RC, Z(3,3), KZ)
  CALL M1S1 (A1, A2, PL, RC, Z(5,5), KZ)
  CALL M1R1 (A1, A2, PL, RC, Z(9,9), KZ)
  GO TO 300
C
C AXIAL=M1A2 (LINEAR DISP), TORSION=M1C2 (LINEAR DISP),
C BENDING=M1F2 (CURIC DISP).
120 CALL M1A2 (A1, A2, PL, RC, Z1, KZ)
  CALL M1C2 (P11, P12, PL, RC, Z(3,3), KZ)
  CALL M1F2 (A1, A2, PL, RC, Z(5,5), KZ)
 DO 125 J=7,8
 DO 125 I=5,6
   Z(J,J) =-Z(I,J)
125 Z(J,I) =-Z(J,I)
  CALL M1F2 (A1, A2, PL, RC, Z(9,9), KZ)
C
300 CALL DCOS1F (CJ, EJ, W, KCJ, KEJ, KW)
  CALL E2F4A (Z, W, 12, 12, KZ, KW)
  RETURN
C
999 CALL Z2FCMF (6+MASIE, NEFOP)
   END
SUBROUTINE MAS2 (CJ, EJ, TMAS, RO, NAMEM, Z, W1, W2, KCJ, KEJ, KZ, KW1, KW2)
DIMENSION CJ(KCJ, 1), EJ(KEJ, 1), Z(KZ, 1), W1(KW1, 1), W2(KW2, 1)
DIMENSION MVC(11)
DATA MVC/1, 2, 6, 7, 8, 12, 13, 14, 18, 3, 4, 5, 9, 10, 11, 15, 16, 17/

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 (U, V, W, P, C, R) J0INT 1, THEN J0INT 2, 3.
C WHERE U, V, W ARE TRANSLATIONS AND P, O, R ARE ROTATIONS.
C FULL ANGLE CONVENTION IS GLOBAL X, Y, Z PERMUTATION.
C CALLS FORM SUBROUTINES DABA, DCCS2, M2A1, M2A2, M2B1, M2B2, ZZ00B1B.
C DEVELOPED BY WA FENWICK, FL WOHLER. FEBRUARY 1973.
C LAST REVISION BY KR 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 COLUMNS 1, 2, 3 CORRESPOND TO JOINTS 1, 2, 3. SIZE(3, 3).
C EJ = INPUT MATRIX OF EULER ANGLES (DEGREES) AT TRAINGLE JOINTS.
C ROWS 1, 2, 3 CORRESPOND TO GLOBAL X, Y, Z PERMUTATION.
C COLUMNS 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 = 0, LUMPED.
C = 1, 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 NEPROP EXPLANATION
C 1 = DIMENSION SIZE EXCEEDED (KZ, KW1, KW2).
C 2 = NAMEM IMPROPERLY DEFINED.
C
NEPROP = 1

IF (KZ .LT. 16 .OR. KW1 .LT. 16 .OR. KW2 .LT. 16) GO TO 999
DC 5, J = 1, 16
DC 5, J = 1, 16
5 Z(I, J) = 0.
SL12 = SQRT((CJ(I, 1) - CJ(I, 2))**2 + (CJ(I, 2) - CJ(I, 3))**2
         + (CJ(I, 3) - CJ(I, 1))**2)
SL23 = SQRT((CJ(I, 1) - CJ(I, 2))**2 + (CJ(I, 2) - CJ(I, 2))**2
         + (CJ(I, 3) - CJ(I, 2))**2)
SL13 = SQRT((CJ(I, 2) - CJ(I, 1))**2 + (CJ(I, 3) - CJ(I, 2))**2
         + (CJ(I, 3) - CJ(I, 1))**2)
X3 = (SL12**2 + SL12**2 - SL23**2)/(2.0*SL12)
Y3 = SQRT(SL13**2-X3**2)

IF (NAMEM .EQ. 6HM1) GO TO 110
IF (NAMEM .EQ. 6HM2) GO TO 120

GO TO 999

C  MEMERANE = M2A1 (LUMPED), BENDING = M2F1 (LUMPED).
110 CALL M2A1 (SL12,Y3,TMAS,KC,W1,KW1)
    CALL M2F1 (SL12,Y3,TMAS,KC,W1(10,10),KW1)
    DC 115 IW=1,15
    IZ = IVFC(IW)
115 Z(IIZ,IZ) = W1(IW,IW)
    RETURN

C  MEMERANE = M2A2 (CONSISTENT), BENDING = M2E2 (CONSISTENT).
120 CALL M2A2 (SL12,X3,Y3,TMAS,RC,Z,W1,W2,KZ,KW1,KW2)
    CALL M2E2 (SL12,X3,Y3,TMAS,PO,Z(10,10),W1,W2,KZ,KW1,KW2)
    CALL DCOS2 (CJ,EJ,W1,KCJ,KECJ,KW1)
    CALL RTABA (Z,W1,18,18,KZ,KW1)
    RETURN

C  CALL ZZLONB (TSMAS2,NERROR)
END
SUBROUTINE MAS3 (CJ, EJ, TMAS, RC, NAMEM, Z, W1, 2, KCJ, KEJ, KZ, KW1, KW2)
DIMENSION (JKCJ, 1), EJKEJ, 11, ZIKZ, 11, W1, (KW1, 11), W2, (KW2, 1)
DIMENSION CW1(3, 2), CW(3, 3), IV1(18), IV2(18), IV3(18), IV4(18),
  W3(10, 10)
DATA IV1/ 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18/,
  IV2/ 1, 2, 3, 4, 5, 6, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24/,
  IV3/ 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 19, 20, 21, 22, 23, 24/,
  IV4/ 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24/

SUBROUTINE TO CALCULATE FINITE ELEMENT...

MASS MATRIX

FOR A COMBINED MEMBRANE-BENDING QUADRILATERAL PLATE ELEMENT WITH
UNPRESTRAINED 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, ZPOMP.

LAST REVISION BY W. BENFIELD. MARCH 1976.

SUBROUTINE ARGUMENTS

CJ = INPUT MATRIX OF GLOBAL X, Y, Z COORDINATES AT QUAD JOINTS.
  ROWS 1, 2, 3 CORRESPOND TO X, Y, Z COORDINATES.
  Cols 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18.
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, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18.
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 RCW DIMENSION OF CJ IN CALLING PROGRAM. MIN=3.
KEJ = INPUT RCW DIMENSION OF EJ IN CALLING PROGRAM. MIN=3.
KZ = INPUT RCW DIMENSION OF Z IN CALLING PROGRAM. MIN=24.
KW1 = INPUT RCW DIMENSION OF W1 IN CALLING PROGRAM. MIN=18.
KW2 = INPUT RCW DIMENSION OF W2 IN CALLING PROGRAM. MIN=18.

NEFORC
  BY EQUATION
  1 = DIMENSION SIZE EXCEEDED (KZ, KW1, KW2).
  2 = NAMEM IMPROPERLY DEFINED.

IF (KZ .LT. 24 .OR. KW1 .LT. 18) GO TO 999
 IF (KZ .LT. 18) GO TO 999

NEFORC=1

IF (NAMEM .LT. 6) GO TO 110
IF (NAMEM .LT. 6) GO TO 110

NERFORC=2
GO TO 999

C

110 DO 112 I=1,3
    CW(I,1) = CJ(I,1)
    EW(I,1) = EJ(I,1)
    CW(I,2) = CJ(I,2)
    EW(I,2) = EJ(I,2)
    CW(I,3) = CJ(I,3)
    112 EW(I,3) = EJ(I,3)
    CALL MAS2 (CW,EW,TMAS,RO,NAMEM,W1,W2,W3,3,3,KW1,KW2,10)
    CALL REVADD (.5,W1,IV1,IV1,2, 18,18,24,24, KM1,KZ)
    DC 113 I=1,3
    CW(I,1) = CJ(I,1)
    EW(I,1) = EJ(I,1)
    CW(I,2) = CJ(I,2)
    EW(I,2) = EJ(I,2)
    CW(I,3) = CJ(I,3)
    113 EW(I,3) = EJ(I,4)
    CALL MAS2 (CW,EW,TMAS,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)
    114 EW(I,3) = EJ(I,4)
    CALL MAS2 (CW,EW,TMAS,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)
    115 EW(I,3) = EJ(I,4)
    CALL MAS2 (CW,EW,TMAS,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 ZZECMB (SHMAS3,NEF,ERR)
END
SUBROUTINE MAS3A (CJ,EJ,TMAS,RO,NAMEM,Z,W1,W2,KCJ,KEJ,KZ,KWI,KW2)
DIMENSION CJ(KCJ,1), EJ(KEJ,1), Z(KZ,1), W1(KWI,1), W2(KW2,1)
C
C SUBROUTINE TO CALCULATE FINITE ELEMENT...
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) JIINT 1, THEN JIINT 2, 3, 4.
C WHERE U,V,W ARE TRANSLATIONS.
C EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
C CALLS FORMA SUBROUTINES M3CI,2ZIOME.
C DEVELOPED BY RL WOHLLEN APRIL 1974.
C LAST REVISION BY RL WOHLLEN MAY 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 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(*,*).
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=2.
C KWI = INPUT ROW DIMENSION OF W1 IN CALLING PROGRAM. MIN=12.
C KW2 = INPUT ROW DIMENSION OF W2 IN CALLING PROGRAM. MIN=.*.
C
C NERROR EXPLANATION
C 1 = DIMENSION SIZE EXCEEDED (KZ,KWI,KW2).
C 2 = NAMEM IMPROPERLY DEFINED.
C
C IF (KZ NE 12 .OR. KWI NE 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 .NE. 6) 100
C GO TO 999
C NERROR=1
C LUMPED.
C 110 DO 111 J=1,12
C 111 W1(J) = CJ(J,1)
C 112 DO 113 K=1,12
C 113 Z(K,J) = W1(K) * 2
C CALL M3CI (SL12,SL14,TMAS,RO,W1,KWI)
C DC 115 TM=1,4
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)

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

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 ZERO (T, NJN, NCOL, KW)
LC = 18
NTF = 24
IF (NJN = 8) GO TO 5
LC = 4
NTF = 14
IF (NJN = 6) GO TO 5
LO = 0
NTF = 4
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))
Tc = 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, 3
IV(I) = JNM(I, LOC)
DC 30 J=1, 3
J1 = 3*I - 3 + J
JL = (IV(I) - 1)*3 + J
30 JV(J1) = JL

DC 25 I=1, 3
DC 35 I=1, 3
IL = I + 3*(L - 1)
DO 35 J=1,3
F = 1.
IF (L LE J) F = 2.
35 C(J,IL) = F*V(NJ)
CALL REVADD (AC, C, IV, JV, T, 3, 9, NJN, NCOL, 3, KW)
20 CONTINUE
C
DO 40 I=1,NJN
DC 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, 8)
CALL MULT (A, T, NJN, NJN, NCOL, 8, KW)
C
RETURN
END
SUBROUTINE TO CALCULATE (IN OPTION) FINITE ELEMENT ...

- MASS MATRICES AND IVECS (IN NUTMX),
- STIFFNESS MATRICES (SAME AS GLOBAL LOAD TRANSFORMATION MATRICES)
- AND IVECS (ON NUTX),
- LOCAL LOAD BUCKLING MATRICES AND IVECS (ON NUTBX), (NOT YET)
- LOCAL LOAD TRANSFORMATION MATRICES AND IVECS (ON NULTT), (NOT YET)
- STRESS TRANSFORMATION MATRICES AND IVECS (ON NUST), (NOT YET)

FOR COMBINED MEMBRENE-ENDING QUADRILATERAL PLATE ELEMENTS.

MASS, STIFFNESS, BUCKLING MATRICES ARE IN GLOBAL COORDINATE
DIRECTIONS.

GLOBAL COORDINATE ORDER IS

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

IVEC GIVES ELEMENT DOF INTO GLOBAL DOF. EXAMPLES...

IVEC(6)=834 PLACES ELEMENT DOF 6 INTO GLOBAL DOF 834.
IVEC(3)=0 OMMITS ELEMENT DOF 3 FROM GLOBAL DOF. THIS CONSTRAINTS

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

ROW ORDER IN GLOBAL LOAD TRANSFORMATION MATRIX IS

WHERE P IS FORCE AND M IS MOMENT.

LOCAL LOAD TRANSFORMATION MATRICES RELATES LOAD AT QUAD VERTICES IN
LOCAL COORDINATE SYSTEM TO DEFORMATIONS IN THE GLOBAL COORDINATE
DIRECTIONS.

STRESS TRANSFORMATION MATRICES RELATES STRESS AT QUAD VERTICES IN
LOCAL COORDINATE SYSTEM TO DEFORMATIONS IN THE GLOBAL COORDINATE
DIRECTIONS.

DATA ARRANGEMENT ON NUTMX, NUTX, NUTEX, NULT, NUST FOR EACH FINITE
ELEMENT IS \((\text{W=})\text{M},\text{K},\text{P},\text{LT},\text{ST})\)

WRITE (NUTMX) NAMEW,NFL,SNK,NC,NAMEL,(IBLENK,I=1,N),
(C(I,J),I=1,NJ,J=1,NC),((IVEC(I),I=1,NC)

CALLS FORMA SUBROUTINES MASS, PAGEDF, STF3, Z2POMR.

DEVELOPED BY WA PENFIELD, CS RODFORD, RL WHALEN. MAY 1976.

LAST REVISION BY RL WHALEN. MARCH 1976.

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

INPUT DATA READ IN THIS SUBROUTINE FROM NUTEL. IF NUTEL = 5, DATA IS
READ FROM CAFES:

NAMEW,NAMK,NAMLT,NAMST,NAMEF
PC,E,NU
TMAC,TMEF,TNF
20 NEL,J1,J2,J3,J4,TMAS,TMEV,TEENV
IF (J1 = 0.0) 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 6HCMASS, NO MASS MATRIX CALCULATED.
C NAMEK = TYPE OF STIFFNESS MATRIX WANTED.
C = K1, OVERLAP AVERAGE OF FOUR TRIANGLES.
C = 6H OR 6HNOSTIF, NO STIFFNESS MATRIX CALCULATED.
C NAMELT = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES.
C = 6H OR 6HNLOAD, NO LOAD TRANSFORMATIONS CALCULATED.
C NAMEST = IDENTIFICATION NAME FOR STRESS TRANSFORMATION MATRICES.
C = 6H OR 6HNOSTAS, NO STRESS TRANSFORMATIONS CALCULATED.
C NAMEB = TYPE OF BUCKLING MATRIX WANTED.
C = 6H OR 6HNOBUCK, NO BUCKLING MATRIX CALCULATED.
C RC = MASS DENSITY.
C E = YOUNG'S MODULUS OF ELASTICITY.
C ANU = POISSON'S RATIO. ((E/2G)-1).
C TMASSC = EFFECTIVE MASS THICKNESS, (CONSTANT).
C TMASSV = EFFECTIVE MASS THICKNESS, (VARIABLE).
C IF .LE. 0., TMASS IS USED.
C TMEMC = EFFECTIVE MEMBRANE THICKNESS, (CONSTANT).
C TMEMV = EFFECTIVE MEMBRANE THICKNESS, (VARIABLE).
C IF .LE. 0., TMEM IS USED.
C TEENC = EFFECTIVE ENDING THICKNESS, (CONSTANT).
C TEENV = EFFECTIVE ENDING THICKNESS, (VARIABLE).
C IF .LE. 0., TEEN IS USED.
C NEL = FINE 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. NUMBER INDICATES CARD COLUMNS USED.
C I = INTEGER DATA, RIGHT ADJUSTED.
C E = DECIMAL POINT DATA, ANYWHERE IN FIELD. EXPONENT RIGHT ADJUSTED
C X = CARD COLUMNS SKIPPED.
C
C SUBROUTINE ARGUMENTS (ALL INPUT)
C XYZ = MATRIX OF JOINT GLOBAL X,Y,Z LOCATIONS. ROWS CORRESPOND
C TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE JOINT
C X,Y,Z LOCATIONS RESPECTIVELY. SIZE(NJ,3).
C JDOP = MATRIX OF JOINT GLOBAL DEGREES OF FREEDOM. ROWS CORRESPOND
C TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE JOINT
C TRANSLATION DOFS AND COLUMNS 4,5,6 CORRESPOND TO THE JOINT
C ROTATION DOFS. SIZE(NJ,6).
C EUl = MATRIX OF JOINT EULER ANGLES (DEGREES). ROWS CORRESPOND
C TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE
C 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 OR ROWS IN MATRICES (XYZ), (JDOP), (EUL).
C NUTMX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
C MASS MATRICES AND IVECS ARE OUTPUT.
C NUTMX MAY BE ZERO IF MASS MATRIX IS NOT FORMED.
C USES FORTRAN READ, WRITE.
C NUTKX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
C STIFFNESS MATRICES (SAME AS GLOBAL LOADS TRANSFORMATION
C MATRICES) AND IVECS ARE OUTPUT.
C NUTKX MAY BE ZERO IF STIFFNESS MATRIX IS NOT FORMED.
C USES FORTRAN READ, WRITE.
C NUTRX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT UNIT LOAD
C BUCKLING MATRICES AND IVECS ARE OUTPUT.
C NUTRX MAY BE ZERO IF BUCKLING MATRIX IS NOT FORMED.
C USES FORTRAN READ, WRITE.
C 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 JOINT IN CALLING PROGRAM.
C KE = ROW DIMENSION OF EUL IN CALLING PROGRAM.
C
C NERRCR EXPLANATION
C 1 = JOINT NUMBER GREATER THAN NUMBER OF JINTS.
C 2 = MASS MATRIX FORMED, NUTMX .LE. ZERO.
C 3 = STIFFNESS MATRIX FORMED, NUTKX .LE. ZERO.
C 4 = LT MATRIX FORMED, NUTLT .LE. ZERO.
C 5 = ST MATRIX FORMED, NUTST .LE. ZERO.
C
1001 FORMAT (5((A6,4X))
1002 FORMAT (5((X,F10.0))
1003 FORMAT (5((E13.6))
2001 FORMAT (125X 40H INPUT DATA FOR COMBINED MEMBRANE-BENDING
* 20H QUADRILATERAL PLATE ELEMENTS)
2002 FORMAT (165X 40H INPUT DATA FOR COMBINED MEMBRANE-BENDING
* 41H QUADRILATERAL PLATE ELEMENTS (CONTINUED))
2003 FORMAT (13X7HMASS = A6, 13X7HTSTIF = A6, 6X13HLOAD TRANS = A6,
* 3X15HSTRESS TRANS = A6, 3X15HBUCKLING = A6,
* 15X4HEC = E10.3, 13X3HBE = E10.3,
* 15X4HT(MASS) = E10.3, 12X4HNU = E10.3,
* 32X13HT(MEMBRANE) = E10.3,
* 32X13HT(BENDING) = E10.3,
* 12X7HELEMENT 5X 7HJOINT 1 5X 7HJOINT 2 5X 7HJOINT 3
* 5X 7HJOINT 4 5X 7H(MASS) 6X 11HT(MEMBRANE)
* 5X 10H(T(BENDING))
* 12X5HNUME6 4X 2(5X 10H(VARIABLE))
2004 FORM (12X 5(I5,7X),(11L+2,5X))
2005 FORMAT (12(7X))

C READ AND WRITE FINITE ELEMENT DATA.
NLINE = 0
CALL PAGHD
WRITE (NOT,2001)
READ (NUTEL,1001) NAMEM,NAMEM,NAMEM,NAMEM,NAMEM
READ (NUTEL,1002) ROC,E,ANU
READ (NUTEL,1002) TMASC,TMEMC,TEENC
WRITE (NOT,2003) ROC,E,TMASC,ANU,TMEMC,TEENC
* 20 READ (NUTEL,1003) NEL,J1,J2,J3,J4,TMASV,TMEMV,TEENV
NO THK = 1
IF (TMASV.LE.0.0 .AND. TMEMV.LE.0.0 .AND. TEENV.LE.0.0) NO THK=0
IF (J1.LE.0) RETURN
NLINE = NLINE + 1
IF (NLINE.LE.42) GO TO 30
CALL PAGHD
WRITE (NOT,2002)
WRITE (NOT,2003) ROC,E,TMASC,ANU,TMEMC,TEENC
* 30 NLINE = 0
IF (NO THK.EQ.1)
*WRITE (NOT,2004) NEL,J1,J2,J3,J4,TMASV,TMEMV,TEENV
IF (NO THK.EQ.0) WRITE (NOT,2005) NEL,J1,J2,J3,J4
IF (J1.GT.NJ .OR. J2.GT.NJ .OR. J3.GT.NJ .OR. J4.GT.NJ) GO TO 999
C
C SET THICKNESS:
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 1VEL.
DO 42 I=1,3
CJ(I,1) = XYZ(J1,I)
CJ(I,2) = XYZ(J2,I)
CJ(I,3) = XYZ(J3,I)
EJ(I,1) = -EUL(I,1)
EJ(I,2) = -EUL(I,2)
EJ(I,3) = 0
42 EJ(I,4) = 0(J4,I)
DO 44 I=1,4
IV(I) = JCDF(J1,I)
IV(I+1) = JCDF(J2,I)
IV(I+2) = JCDF(J3,I)
44 IV(I+4) = JCDF(J4,I)
C
C FORM MASS MATRIX (W).
IF APMX = 6.6H .OR. NAMEM .EQ. 6HCMMASS) GO TO 110
CMASS = (CJ,EJ,TMAS+PL,NAMEM,W,1..KCJ,KCJ,KCW,KCW)
NEKCR=2
IF (NMIMA .LE. 0) GO TO 609
WRITE (NUTMX) NAMEM,NEL,NPW,NEX,NAMEL,(IPLNK,I=1,2),
((W(I,J),I=1,NROW),J=1,NROW),(IVL(I),I=1,NROW))

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,EF,TMEM,TEN,E,ANU,NAMEN,NAMET,W,T,S,NRS1, *
   KCLJ,KCLJ,KW,KW,KW)
      NERROR=3
   IF (NUTKX.LE.0) GO TO 999
   WRITE (NUTKX) NAMEK,NEM,NRE,NSR,NSR,NAMEL,(IELNK,I=1,5), *
      ((W(I,J),I=1,NROW),J=1,NROW),(IVL(I),I=1,NROW)
   IF (NAMELT.EQ.6H*OR. NAMELT.EQ.6HNOLOAD) GO TO 115
      NERRCH=4
   IF (NUTFI.LE.0) GO TO 996
   WRITE (NUTFI) NAMEF,MEI,NREL,NSR,NAMEL,(IELNK,I=1,5), *
      ((T(I,J),I=1,NREL),J=1,NROW),(IVL(I),I=1,NROW)
   115 IF (NAMEST.EQ.6H*OR. NAMEST.EQ.6HNOSTRS) GO TO 20
      NERROR=5
   IF (NUTST.LE.0) GO TO 997
   WRITE (NUTST) NAMEST,NEM,NRSR,NPS,NAMEL,(IBLNK,I=1,5), *
      ((S(I,J),I=1,NRSR),J=1,NROW),(IVL(I),I=1,NROW)
   GO TO 20
C
999 CALL ZZPOMP (6HCUAD,NERROR)
END
![Image of the page with text](image-url)
**NAMEK = TYPE OF STIFFNESS MATRIX WANTED.**

- **= K1, LINEAR DISPLACEMENT (CONSTANT STRAIN).**
- **= 6H OR 6HNCSTIF, NO STIFFNESS MATRIX CALCULATED.**

**NAMELT = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES.**

- **= 6H OR 6HNLDOAD, NO LOAD TRANSFORMATIONS CALCULATED.**

**NAMEST = IDENTIFICATION NAME FOR STRESS TRANSFORMATION MATRICES.**

- **= 6H OR 6HNSTPS, NO STRESS TRANSFORMATIONS CALCULATED.**

**RD = MASS DENSITY.**

**G = SIF, MODULUS OF ELASTICITY.**

**MTAS = EFFECTIVE MASS THICKNESS.**

**STSF = EFFECTIVE STIFFNESS THICKNESS.**

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

**J1 = JOINT NUMBER AT PANEL VERTEX 1.**

**J2 = JOINT NUMBER AT PANEL VERTEX 2.**

**J3 = JOINT NUMBER AT PANEL VERTEX 3.**

**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)**

**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).**

**JDCF = MATRIX OF JOINT GLOBAL DEGREE 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).**

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

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

**NJ = NUMBER OF JOINTS OR ROWS IN MATRICES (XYZ), (JDCF), (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.**

**NULTT = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT LOCAL LOAD TRANSFORMATION MATRICES AND IVECS ARE OUTPUT.**

**NULTT 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 FCPTREN READ, WRITE.
W = MATRIX WORK SPACE. MIN SIZE(12,12).
T = MATRIX WORK SPACE. MIN SIZE(12,12).
S = MATRIX WORK SPACE. MIN SIZE(12,12).
XX = ROW DIMENSION OF XYZ IN CALLING PROGRAM.
KJ = ROW DIMENSION OF JOEF IN CALLING PROGRAM.
KE = ROW DIMENSION OF EUL IN CALLING PROGRAM.
KW = ROW DIMENSION OF W, T, AND S IN CALLING PROGRAM. MIN=12.
NEROR EXPLANATION
1 = INPUT JOINT NUMBER EXCEEDS MAXIMUM ALLOWABLE NUMBER OF JOINTS.
2 = NUTMX NON POSITIVE.
3 = NUTKX NON POSITIVE.
4 = NULTF NON POSITIVE.
5 = NUTST NON POSITIVE.
1001 FORMAT (4(A6,4X))
1002 FORMAT (2(5X,E10.0))
1003 FORMAT (5(15))
2001 FORMAT (//3EX 47HINPUT DATA FCP RECTANGULAR SHEAR PANEL ELEMENTS)
2002 FORMAT (//32X 47HINPUT DATA FOR RECTANGULAR SHEAR PANEL ELEMENTS
* 12H CONTINUED))
2003 FORMAT (//14X4HMASS = A6, 14X7HSTIF = A6, 11X3HLOAD TRANS = A6,
* 8X15HSTRESS TRANS = A6,
* / 16X4HRD = E10.3, 14X3HHG = E10.3,
* / 11X9H(QUAL) = E10.3, 8X9HTH(STIF) = E10.3,
* / 18X7HELEMENT 15X7HJOINT 1 13X7HJOINT 2 13X7HJOINT 3
* 13X7HJOINT 4 / 18X6HNUMBER)
2004 FORMAT (1FX,5(15,15X))
C
READ AND WRITE FINITE ELEMENT DATA.
NLINE = 0
CALL PAGEBD
WRITE (NCT,2041)
READ (NUTFL,1001) NAMEM,NAMEK,NAMET,NAMEST
READ (NUTFL,1002) RO,G
READ (NUTFL,1002) TMAS,TSTF
WRITE (NCT,2033) NAMEM,NAMEK,NAMET,NAMEST,RO,G,TMAS,TSTF
20 READ (NUTFL,1003) NEL,J1,J2,J3,J4
IF (J1 LE. 6) RETURN
NLINE = NLINE + 1
IF (NLINE LE. 42) GO TO 30
CALL PAGEBD
WRITE (NCT,2002)
WRITE (NCT,2003) NAMEM,NAMEK,NAMET,NAMEST,RO,G,TMAS,TSTF
NLINE = 0
30 WRITE (NCT,2004) NEL,J1,J2,J3,J4
NEROR=1
IF (J1.GT.NJ .OR. J2.GT.NJ .OR. J3.GT.NJ .OR. J4.GT.NJ) GO TO 999
C
FORM FINITE ELEMENT COORDINATE LOCATIONS, EULER ANGLES, REVADD IVEC.
DO 42 1=1,3
CJ(I,1) = YZ(J1,1)
C
C FORM MASS MATRIX (W).
IF (NAMEM .EQ. 6H) THEN
  CALL MAS3A (CJ,EJ,TEMAS,RO,NAMEM,W,T,S,KCJ,KCJX,KW,KW
  NERROR=2
ENDIF

C
C FORM STIFFNESS MATRIX (W), LOCAL LOAD TRANSFORMATION MATRIX (T),
C STRESS TRANSFORMATION MATRIX (S).
110 IF (NAMEK .EQ. 6H) THEN
  CALL STF3A (CJ,EJ,TSTF,G1,NAMEK,NAMEST,W,T,S,LRST,
  *     KCJ,KCJX,KW,KW
  NERROR=3
ENDIF

C
C IF (NAMET .EQ. 6H) THEN
  CALL NAMET .EQ. 6H NERROR=4
ENDIF

C
C IF (NAMET .EQ. 6H) THEN
  CALL NAMET .EQ. 6H NERROR=5
ENDIF

C CALL ZEROM (6HRECTSP,NERROR)
END
SUBROUTINE STFA (CJ,EJ,A1,A2,E,NAMEK,NAMES1,S,TL,TS,NRST)
*  DIMENSION CJ(KCJ), EJ(KEJ), S(KS), TL(KTL), TS(KTS)
C
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 UNRESTRAINED 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 ROD 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 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 EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
C CALLS FORMA SUBROUTINES ATXBA1, DCOS1A, K1A1, MULTA, ZS0MB.
C DEVELOPED BY FL WOHLEN. SEPTEMBER 1972.
C LAST REVISION BY WA BENFIELD. MARCH 1976.
C
C SUBROUTINE ARGUMENTS
C CJ = INPUT MATRIX OF GLOBAL X,Y,Z COORDINATES AT ROD JOINTS.
C ROWS 1,2,3 CORRESPOND TO X,Y,Z COORDINATES.
C COLS 1,2 CORRESPOND TO JOINTS 1,2. SIZE(3,2).
C EJ = INPUT MATRIX OF EULEP 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 STIF MATRIX WANTED.
C = K1, CONSTANT AXIAL FORCE ASSUMED.
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(2,6).
C TS = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(NRST,6).
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=6.
C KTL = INPUT ROW DIMENSION OF TL IN CALLING PROGRAM. MIN=2.
C KTS = INPUT ROW DIMENSION OF TS IN CALLING PROGRAM. MIN=NREST.
C
C NERROR EXPLANATION
C 1 = SIZE LIMITATION EXCEEDED.
C 2 = NAMEK IMPROPERLY DEFINED.
C
NRST = 2

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

NERRO=1
NERRO=2

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

CALL DCOS1A (CJ,EJ,S,KCJ,KEJ,KS) S=DC
CALL MULTA (TL,S,2,2,6,KTL,KS)
IF (NAMES1 .EQ. 6F) OR (NAMES1 .EQ. 6HNS) GO TO 210
CALL MULTA (TS,S,NREST,2,6,KTS,KS)
210 CALL ATXBA1 (S,TL,2,6,KS,KTL) RETURN

999 CALL ZZPROP (6HSTF1A,NERROR)
END
SUBROUTINE STF18 (CJ,CJ,KODE,A1,A2,TJ1,TJ2,R121,B122,B1Y1,B1Y2,
  *  K1,R2,CY1,CY2,CZ1,CZ2,SE,G,NAMEK,NAMEST,
  *  S,TL,T5,MPST,KCJ,KD1,KS,KTL,KTS)
  .DIMENSION CJ(KCJ,1),EJ(KEJ,1),KODE(1),S(KS,1),I(T(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 AXIAL-TORSION-BENDING BAR ELEMENT WITH UNRESTRAINED
C BOUNDARIES.
C BAR MAY BE LINEARLY TAPERED OR UNIFORM.
C STIFFNESS MATRIX IS IN GLOBAL COORDINATE DIRECTIONS.
C LOCAL 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 GLOBAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT BAR ENDS IN GLOBAL
C COORDINATE DIRECTIONS TO DEFORMATIONS IN THE GLOBAL COORDINATE
C DIRECTIONS.
C ROW ORDER IN GLOBAL LOAD TRANSFORMATION MATRIX IS
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 DIRECTIONS.
C ROW ORDER IN LOCAL LOAD TRANSFORMATION MATRIX IS
C PX1,PX2,MX1,MX2,MY1,MY2,MZ1,MZ2,P12,P22,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 DIRECTIONS.
C ROW ORDER IN STRESS TRANSFORMATION MATRIX IS
C PX1/A1,PX2/A2, MX1/R1/TJ1,MX2/R2/TJ2,
C MY1/A1,MY2/A2,MZ1/CY1/EZ1,MZ2/CY2/B122,
C PZ1/A1,PZ2/A2,MY1/CZ1/B1Y1,MZ2/CZ2/B1Y2
C WHERE P IS FORCE AND M IS MOMENT.
C EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
C CALLS FORMA SUBROUTINES ATXPAI,DCOSIB,KI1,T1B1,KI1C1,MULTA,ZZBOMB.
C LAST REVISION BY RL WOHLEN. APRIL 1976.
C
C SUBROUTINE ARGUMENTS
C CJ = INPUT
C 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 EN = INPUT
C 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 KODE = INPUT
C OPTION CODE FOR AXIAL, TORSION, BENDING Z, BENDING Y
C LOCAL STIFFNESS. IF BLANK, ALL FOUR ARE CALCULATED.
C SIZE(4).
C KODE(1)=A, LOCAL STIFFNESS MATRIX IS CALCULATED
C FOR AXIAL (ALONG LOCAL X-AXIS).
C KODE(2)=T, LOCAL STIFFNESS MATRIX IS CALCULATED
C FOR TORSION (ABOUT LOCAL X-AXIS).
C KODE(3)=B, LOCAL STIFFNESS MATRIX IS CALCULATED
C FOR LOCAL Y-AXIS.
C KODE(4)=Z, LOCAL STIFFNESS MATRIX IS CALCULATED
C FOR LOCAL Z-AXIS.
C FOR BENDING (ABOUT LOCAL Z-AXIS).*
C "KODE(4)=6Y, LOCAL STIFFNESS MATRIX IS CALCULATED
C FOR BENDING (ABOUT LOCAL Y-AXIS).*
C A1 = INPUT CROSS-SECTION AREA AT BAR END 1.
C A2 = INPUT SAME AS A1 AT BAR END 2.
C T1 = INPUT CROSS-SECTION SAINT VENANTS TORSION CONSTANT (J) IN
C JG AT BAR END 1.
C T2 = INPUT SAME AS TJ1 AT BAR END 2.
C B1Z1 = INPUT CROSS-SECTION AREA MOMENT OF INERTIA ABOUT LOCAL
C 2-AXIS (FOR BENDING) AT BAR END 1.
C B1Z2 = INPUT SAME AS B1Z1 AT BAR END 2.
C B1Y1 = INPUT CROSS-SECTION AREA MOMENT OF INERTIA ABOUT LOCAL
C Y-AXIS (FOR BENDING) AT BAR END 1.
C B1Y2 = INPUT SAME AS B1Y1 AT BAR END 2.
C K1 = INPUT DISTANCE FROM LOCAL X-AXIS TO OUTER FIBER FOR
C TORSION STRESS CALCULATION AT BAR END 1.
C K2 = INPUT SAME AS K1 AT BAR END 2.
C CY1 = INPUT DISTANCE FROM XZ PLANE TO OUTER FIBER FOR BENDING
C STRESS CALCULATION AT BAR END 1. LOCAL Y DIRECTION.
C CY2 = INPUT SAME AS CY1 AT BAR END 2.
C CZ1 = INPUT DISTANCE FROM XY PLANE TO OUTER FIBER FOR BENDING
C STRESS CALCULATION AT BAR END 1. LOCAL Z DIRECTION.
C CZ2 = INPUT SAME AS CZ1 AT BAR END 2.
C SF = INPUT SHAPE FACTOR (K) FOR SHEAR IN KAG.
C USE SF=0.0 FOR NO SHEAR DEFORMATION IN BENDING.
C SF=1.0 FOR A SOLID CIRCULAR CYLINDER.
C SF=.5 FOR A THIN WALLED CIRCULAR CYLINDER.
C E = INPUT YOUNG'S MODULUS OF ELASTICITY.
C G = INPUT SHEAR MODULUS OF ELASTICITY.
C NAMEK = INPUT TYPE OF STIF MATPIX WANTED.
C = K1, USES K1A1 FOR AXIAL, K1C1 FOR TORSION,
C K1B1 FOR BENDING.
C NAMEST = INPUT OPTION FOR STRESS TRANSFORMATION.
C = 6H OR 6HNCSTRS ,NO STRESS TRANS CALCULATED.
C S = OUTPUT STIFFNESS MATRIX (SAME AS GLOBAL LOAD TRANSFORMATION
C MATRIX). SIZE(12,12).
C TL = OUTPUT LOCAL LOAD TRANSFORMATION MATRIX. SIZE(12,12).
C TS = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(NPST,12).
C NRST = OUTPUT NUMBER OF ROWS IN STRESS TRANSFORMATION MATRIX.
C KCE = 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=12.
C KTL = INPUT ROW DIMENSION OF TL IN CALLING PROGRAM. MIN=12.
C KTS = INPUT ROW DIMENSION OF TS IN CALLING PROGRAM. MIN=NRST.
C
C "PROF EXPLANATION
C 1 = SIZE LIMITATION EXCEEDED.
C 2 = NAMEK IMPROPERLY DEFINED.
C NRST = 12
C NERROR=1

IF (KS .LT. 12 .OR. KTL .LT. 12 .OR. KTS .LT. NRST) GO TO 999
DO 5 J=1,12
DO 5 1=1,12
TL(I,J) = 0.0
5 TS(I,J) = 0.0
RL = SQRT((CJ(1,2)-CJ(1,1))**2 + (CJ(2,2)-CJ(2,1))**2 + (CJ(3,2)-CJ(3,1))**2)
*
KODEA = 1
KODET = 1
KODEBZ = 1
KODEBY = 1
IF (KODE(1), .EQ., 1H) .AND. KODE(2), .EQ., 1H .AND.
* KODE(3).NE. 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., 2HBY .AND. KODE(4), .NE., 2HBZ) KODEBY = 0
10 IF (NAMEME, .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,TS,KTL,KTS)
IF (KODET, .EQ., 1) CALL K1C1(TJ1,TJ2,R1,R2,RL,G,TL(3,3),TS(3,3),
* KTL,KTS)
IF (KODEBZ, .EQ., 1) CALL K1B1(BIZ1,BIZ2,CY1,CY2,A1,A2,FR,RL,E,G,
* TL(5,5),TS(5,5),KTL,KTS)
DC 115 J=7,8
DC 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(PIY1,PIY2,CZ1,CZ2,A1,A2,FR,RL,E,G,
* TL(9,9),TS(9,9),KTL,KTS) TL=K
C
CALL DCOS1B(CJ,EJ,S,KJ,KFJ,KS)
CALL MULTA(TL,S,12,12,12,KTL,KS)
IF (NAMEME, .EQ., 6HNO) .OR. NAMEME, .EQ., 6HNO) GO TO 210
CALL MULTA(TS,S,12ST,12,12,KS,KS)
210 CALL ATXEA1(F,T,12,12,KS,KTL)
RETURN
C
999 CALL ZZECME(6HSTF1B ,MERROR) END
SUBROUTINE STF2 (CJ,EJ,THEM,TBEN,E,ANU,NAMET,S,TL,ST,NSST,
*  KJ,KEJ,KS,KTL,KTS)
DIMENSION CJ(KJ,1), EJ(KEJ,1), ST(KS,1), TL(KTL,1), ST(KTS,1)
C
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 MATRlX 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,PM,PM,MR) JOINT 1, THEN JOINT 2,3.
C WHERE P IS FORCE AND M IS MOMENT.
C LOCAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT TRNGL VERTICES IN
C LOCAL COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE
C DIRECTIONS.
C ROW ORDER IN LOCAL LOAD TRANSFORMATION MATRIX IS
C (PX,PY,PZ) JOINT 1 THEN 2,3, NEXT
C (PZ,PM,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 IS NORMAL STRESS AND TAU IS SHEAR STRESS.
C EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
C CALLS FORMA SUBROUTINES ATXBA,DCOS2,K2A1,K2B1,MULTA,2ZBOMB.
C LAST REVISION BY WA BENFIELD. MARCH 1976.
C
C SUBROUTINE ARGUMENTS
C CJ = INPUT MATRIX OF GLOBAL X,Y,Z COORDINATES AT TRIANGLE JOINTS.
C ROWS 1,2,3 CORRESPOND TO X,Y,Z COORDINATES.
C COLS 1,2,3 CORRESPOND TO JOINTS 1,2,3. SIZE(3,3).
C EJ = INPUT MATRIX OF EULER ANGLES (DEGREES) AT TRIANGLE JOINTS.
C ROWS 1,2,3 CORRESPOND TO GLOBAL X,Y,Z PERMUTATION.
C COLS 1,2,3 CORRESPOND TO JOINTS 1,2,3. SIZE(3,3).
C THEM = INPUT EFFECTIVE membrane thickness.
C TBEN = INPUT EFFECTIVE bending thickness.
C ANU = INPUT YOUNGS MODULUS OF ELASTICITY.
C E = INPUT POISSONS RATIO. (E/2G)-1.
C NAMEK = INPUT TYPE OF STIFF MATRIX WANTED.
C = K1, USFS K2A1 FOR MEMBRANE, K2B1 FOR BENDING.
C NAMET = INPUT OPTION FOR STRESS TRANSFORMATION.
C = 6H OR 6HNOSTRS ,NO STRESS TRANS CALCULATED.
C S = OUTPUT STIFFNESS MATRIX (SAME AS GLOBAL LOAD TRANSFORMATION
C MATRIX), SIZE(18,18).
C TL = OUTPUT LOCAL LOAD TRANSFORMATION MATRIX, SIZE(18,18).
C TS = OUTPUT STRESS TRANSFORMATION MATRIX, SIZE(NRST,18).
C NRST = OUTPUT NUMBER OF ROWS IN STRESS TRANSFORMATION MATRIX.
C KCJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM.
C KEJ = INPUT ROW DIMENSION OF EJ IN CALLING PROGRAM.
C KS = INPUT ROW DIMENSION OF S IN CALLING PROGRAM. MIN=18.
C KTL = INPUT ROW DIMENSION OF TL IN CALLING PROGRAM. MIN=18.
C KTS = INPUT ROW DIMENSION OF TS IN CALLING PROGRAM. MIN=NRST.
C
C NERROR EXPLANATION
C 1 = SIZE LIMITATION EXCEEDED.
C 2 = NAMEK IMPROPERLY DEFINED.
C
C NRST = 18
C
C IF (KS LT 18 OR KTL LT 18 OR KTS LT NRST) GO TO 999
C DO 5 J=1,18
C DO 5 I=1,18
C TL(I,J) = 0.0
C 5 TS(I,J) = 0.0
C S12 = SQRT((CJ(1,2)-CJ(1,1))**2 + (CJ(2,2)-CJ(2,1))**2
C * + (CJ(3,2)-CJ(3,1))**2)
C S123 = SQRT((CJ(1,3)-CJ(1,2))**2 + (CJ(2,3)-CJ(2,2))**2
C * + (CJ(3,3)-CJ(3,2))**2)
C S13 = SQRT((CJ(1,3)-CJ(1,1))**2 + (CJ(2,3)-CJ(2,1))**2
C * + (CJ(3,3)-CJ(3,1))**2)
C X3 = (S13**2*S12**2-S13**2)/(2.0*S12)
C Y3 = SQRT(S13**2-X3**2)
C IF (NAMEK EQ '6H') GO TO 110
C GO TO 999
C
C 110 CALL K2A1 (SL12,X3,Y3,TM,E,F,ANUM,TL,TS,KL,KTS,KS)
C CALL K2B1 (SL12,X3,Y3,TBEN,E,ANUM,TL(10,10),TS(1,10),S,
C * KTL,KTS,KS)
C DO 111 I=1,9
C 111 II = I+9
C DO 111 J=1,9
C 111 TS(II,J) = TS(1,J)
C
C CALL DCOS2 (CJ,EJ,S,KCJ,KEJ,KS)
C CALL MUL TA (TL,S,18,18,18,KL,KTS)
C IF (NAMEST EQ '6H' OR NAMEST EQ '6'HNOSTRS) GO TO 210
C CALL MUL TA (TS,S,NRST,18,18,KTS,KS)
C 210 CALL ATXFA1 (S,TL,18,18,KS,KTL)
C RETURN
C
C 999 CALL ZZBOMP (SHSTF2,NERROR)
C END
SUBROUTINE STF3 (CJ,EJ,TMEM,TBEN,E,ANU,NAMES,T,SL,TS,MRST,
                  KCJ,KFJ,K5,K1,TL,TS,KTS)
DIMENSION CJ(KCJ,1),EJ(KEJ,1),S(KS,1),TL(KTL,1),TS(KTS,1)
DIMENSION CW(3,3),EW(3,3),WI(16,18),
                  IVI(18), IV2(18), IV3(18), IV4(18)
DATA KCW/KW1/3,18/
DATA IV1/1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18/
  *  IV2/1,2,3,4,5,6,13,14,15,16,17,18,19,20,21,22,23,24/
  *  IV3/1,2,3,4,5,6,7,8,9,10,11,12,19,20,21,22,23,24/
  *  IV4/7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24/

C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C STIFFNESS MATRIX (SAME AS GLOBAL LOAD TRANSFORMATION MATRIX),
C LOCAL LOAD TRANSFORMATION MATRIX (NOT YET),
C STRESS TRANSFORMATION MATRIX (NOT YET),
C FOR A COMINDED MEMBRANE-BENDING QUADRILATERAL PLATE ELEMENT WITH
C UNRESTRAINED BOUNDARIES,
C STIFFNESS MATRIX IS IN GLOBAL COORDINATE DIRECTIONS.
C GLOBAL COORDINATE ORDER IS
C (U,V,W,P,Q,R) JOINT 1, THEN JOINT 2, 3, 4.
C WHERE U,V,W ARE TRANSLATIONS AND P,Q,R ARE ROTATIONS.
C GLOBAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT QUAD VERTICES IN
C GLOBAL COORDINATE DIRECTIONS TO DEFLECTIONS IN THE GLOBAL COORDINATE
C DIRECTIONS.
C ROW ORDER IN GLOBAL LOAD TRANSFORMATION MATRIX IS
C (PU, PV, PW, MP, MQ, MR) JOINT 1, THEN JOINT 2,3,4.
C WHERE P IS FORCE AND M IS MOMENT.
C LOCAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT QUAD VERTICES
C TO LOCAL COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE
C DIRECTION.
C STRESS TRANSFORMATION MATRIX RELATES STRESS AT QUAD VERTICES IN LOCAL
C COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE DIRECTION.
C EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
C CALLS SUBROUTINES STF2, PEVADO, ZZBORM.
C DEVELOPED BY WA BENFIELD, RL WOHLER, FEBRUARY 1973.
C LAST REVISION BY WA BENFIELD, MARCH 1976.

C SUBROUTINE ARGUMENTS
C CJ = INPUT MATPIX OF GLOBAL X,Y,Z COORDINATES AT QUAD JOINTS.
C ROWS 1,2,3,4 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 MATPIX OF EULER ANGLES (DEGREES) AT QUAD JOINTS.
C ROWS 1,2,3 CORRESPOND TO GLOBAL X,Y,Z PERMUTATION.
C COLS 1,2,3,4 CORRESPOND TO JOINTS 1,2,3,4. SIZE(3,4).
C TMEM = INPUT EFFECTIVE MEMBRANE THICKNESS.
C TBEN = INPUT EFFECTIVE BENDING THICKNESS.
C E = INPUT YOUNG'S MODULUS OF ELASTICITY.
C ANU = INPUT POISSONS RATIO. (E/2G)-1.
C NAMEK = INPUT TYPE OF STIF MATRIX WANTED.
C NAMEST = INPUT OPTION FOR STRESS TRANSFORMATION.
C = 6M OR 6HNOSTRS, NO STRESS TRANS CALCULATED.
C S = OUTPUT STIFFNESS MATPIX (SAME AS GLOBAL LOAD TRANSFORMATION
C MATRIX). SIZE(24,24).
C TL = OUTPUT LOCAL LOAD TRANSFORMATION MATRX. SIZE(24,24).
C NSRST = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(NRST,24).
C KIC = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM. MIN=3.
C KE = INPUT ROW DIMENSION OF FJ IN CALLING PROGRAM. MIN=3.
C KTS = INPUT ROW DIMENSION OF TS IN CALLING PROGRAM. MIN=NRST.
C
C NERROR EXPLANATION
C 1 = SIZE LIMITATION EXCEEDED.
C 2 = NAMEK IMPROPERLY DEFINED.
C
NRST = 24
NERROR = 1

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-HK) GO TO 110
GO TO 999
NERROR = 2

110 DO 200 I=1,3
CW(I,1) = CJ(I,1)
EW(I,1) = FJ(I,1)
CW(I,2) = CJ(I,2)
EW(I,2) = FJ(I,2)
EW(I,3) = FJ(I,3)

200 CALL STF2 (CW, EW, TFME, THEN, E, ANU, NAMEK, NAMEST, WI, TL, TS, NRST, X,
*       KNW, KKW, KWL, KR)
CALL REVAMP (5, WI, IV1, IV2, S, 18, 18, 24, 24, 18, KS)
DO 201 I=1,3
CW(I,1) = CJ(I,1)
EW(I,1) = FJ(I,1)
CW(I,2) = CJ(I,2)
EW(I,2) = FJ(I,2)
EW(I,3) = FJ(I,3)

201 CALL STF2 (CW, EW, TFME, THEN, E, ANU, NAMEK, NAMEST, WI, TL, TS, NRST, X,
*       KNW, KKW, KWL, KR)
CALL REVAMP (5, WI, IV1, IV2, S, 18, 18, 24, 24, 18, KS)
DO 203 I=1,3
CW(I,1) = CJ(I,1)
EW(I,1) = FJ(I,1)
CW(I,2) = CJ(I,2)
EW(I,2) = FJ(I,2)
CW(I,3) = CJ(I,4)

203 CALL STF2 (CW, EW, TFME, THEN, E, ANU, NAMEK, NAMEST, WI, TL, TS, NRST, X,
*       KNW, KKW, KWL, KR)
CALL REVAMP (5, WI, IV1, IV2, S, 18, 18, 24, 24, 18, KS)
DO 205 I=1,3
CW(I,1) = CJ(I,2)
EW(I,1) = FJ(I,2)
CW(1,2) = CJ(I,3)
EW(I,?) = EJ(I,3)
CW(I,3) = CJ(I,4)
205 EW(I,3) = EJ(I,4)
   CALL STF2 (CW,EW,TMEM,TBEN,E,ANU,NAMEK,NAMEST,W1,TL,TS,NRSTX, *
               KCW,KCW,KW1,KTL,KTS)
   CALL REVADD (*5,W1,IV4,IV4,S, 18,16,24,24, 18,KS)
C
   DC 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 ,NERRO)
END
SUBROUTINE STF3A (CJ,EJ,TH,G,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
(PU,PV,PW) 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
(FLX,FLX,FLX,FLX,FLX,FLX,FLX,FLX,FLX,FLX,FLX,FLX,FLX,FLX,FLX,FLX,FLX,FLX,FLX,FLX)
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.
EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
CALLS FOR SUBROUTINES ATXBAI,DCOS3C,KSC1,MULTA,22BCMB.
DEVELOPED BY RL WCHLEN. 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.
C        ROWS 1,2,3 CORRESPOND TO X,Y,Z COORDINATES.
C        CCLS 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        CCLS 1,2,3,4 CORRESPOND TO JOINTS 1,2,3,4. SIZE(3,4).
C  TH = INPUT PANEL THICKNESS.
C  G = INPUT SHEAR MODULUS OF ELASTICITY.
C  NAME = INPUT TYPE OF STIF MATRIX WANTED.
C        = 1, USE KSC1.
C  NAMEST = INPUT OPTION FOR STRESS TRANSFORMATION.
C        = 6H IF AINDSTS = NO STRESS TRANS CALCULATED.
C  S = OUTPUT STIFFNESS MATRIX (SAME AS GLOBAL LOAD TRANSFORMATION
C        MATRIX). SIZE(12,12).
C  TL = OUTPUT LOCAL LOAD TRANSFORMATION MATRIX. SIZE(6,12).
C  TS = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(12,12).
C  NPSST = OUTPUT NUMBER OF ROWS (1) 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=12.
C  KTL = INPUT ROW DIMENSION OF TL IN CALLING PROGRAM. MIN=8.
C  KTS = INPUT ROW DIMENSION OF TS IN CALLING PROGRAM. MIN=1.
NEFORK EXPLANATION
1 = SIZE LIMITATION EXCEEDED.
2 = NAMEK IMPROPERLY DEFINED.

NRST = 1

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

GO TO 999

110 CALL K3C1 (SL12, SL14, TH, G, TL, TS, KTL, KTS)
   TL=K

CALL DCOS3C (CJ, EJ, SJ, KJ, KEJ, KS)
CALL MULTI (TL, S, E, &12, KTL, KKS)
IF (NAMEST .EQ. 6HM .OR. NAMEST .EQ. 6HNOSTRS) GO TO 210
CALL MULTI (TS, S, NRST, R, 12, KTS, KS)
210 CALL ATXEA1 (S, TL, E, 12, KS, KTL)
RETURN

999 CALL ZPOMF (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 C C C

C SUBROUTINE TO DETERMINE THE VOLUME AND VOLUME CHANGE COEFFICIENTS OF
C A TETRAHEDRON.
C CALLS FORMA SUBROUTINES VCROSS, VDOT.
C DEVELOPED BY C S HOOLEY. FEBRUARY 1974.
C LAST REVISION BY R A PHILIPPUS. AUGUST 1974.
C SUBROUTINE ARGUMENTS
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 ROW DIMENSION SIZE OF CJ IN CALLING PROGRAM. MIN = 3.
C IFBAD = OUTPUT
C = 0 . THE TETRAHEDRON VERTICES ARE NOT NUMBERED ACCORDING
C TO THE ESTABLISHED CONVENTION, OR LIE IN A PLANE.

C
J1 = JM(1)
J2 = JM(2)
J3 = JM(3)
J4 = JM(4)
DC 5 J=1,4
R12(I) = CJ(J,J1) - CJ(I,J1)
R13(I) = CJ(I,J3) - CJ(I,J1)
R14(I) = CJ(J,J4) - CJ(I,J1)
C
CALL VCROSS (R12, R13, DV(10), VAMAG, VPMAG, VZMAG, SINAB)
CALL VDOT (DV(10), R14, VCL, VAMAG, VPMAG, COSAB)
IF (VOL.LE.EPS) IFBAD=0
VL = VOL/6.

C
CALL VCROSS (R13, R14, DV(4), VAMAG, VPMAG, VZMAG, SINAB)
CALL VCROSS (R14, R12, DV(7), VAMAG, VPMAG, VZMAG, SINAB)
DC 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, JD0F, EUL, NUTEL, NJ,
  * NUTMX, NUTKX, NUTBX, NULT, NUSTT,
  * W, T, S, KX, KJ, KE, KW)
DIMENSION XYZ(KX, 1), JD0F(KJ, 1), EUL(KE, 1), W(KW, 1), T(KW, 1), S(KW, 1)
DIMENSION CJ(3, 3), EJ(3, 3), IVI(I8)
DATA NAMEI/6HTRNL /, NRW, NRTL/18, 18/, IBLNK/6H */ KCJ/3/
DATA NIT, NCT/5, 6/
C
C SUBROUTINE TO CALCULATE (ON OPTION) FINITE ELEMENT ...
C MASS MATRICES AND IVECS (ON NUTMX),
C STIFFNESS MATRICES (SAME AS GLOBAL LOAD TRANSFORMATION MATRICES)
C AND IVECS (ON NUTRX),
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 NUSTT),
C FOR COMBINED MEMBRANE-PENDING TRIANGLE PLATE ELEMENTS.
C MASS, STIFFNESS, BUCKLING MATRICES ARE IN GLOBAL COORDINATE
C DIRECTIONS.
C GLOBAL COORDINATE ORDER IS
C (UX, UY, W, P) JOINT 1, THEN JOINT 2, 3,
C WHERE UX, UY, W ARE TRANSLATIONS AND P ARE ROTATIONS.
C IVEC GIVES ELEMENT DEF INTO GLOBAL DOF. EXAMPLES...
C IVEC(6)=834 PLACES ELEMENT DOF 6 INTO GLOBAL DOF 834.
C IVEC(3)=0OMITS 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, MC, MP) 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 IS NORMAL STRESS AND TAU IS SHEAR STRESS.
C DATA ARRANGEMENT ON NUTMX, NUTKX, NUTBX, NULT, NUST FOR EACH
C FINITE ELEMENT IS (W, KX, KE, LT, ST)
C WRITE (NUTWX) N, MIEWS, NFL, NP, NC, NAMFL, (IBLNK, I=1, 5),
C ((W1(J), J=1, NR), J=1, NC), (IVEC(I), I=1, NC)
C CALLS FORMA SUBROUTINES M52, PAGEHD, STF2, Z2BOM.
C LAST REVISION BY RL WOHLER. MAY 1976.
C
*******************************************************************************
C INPUT DATA READ IN THIS SUBROUTINE FROM NUTEL. IF NUTEL = 5, DATA IS
C READ FROM CARDS.
C NAMEM,NAMEK,NAMET,NAMEST,NAMEB FORMAT (5(A6,4X))
C RO,E,ANU FORMAT (3(5X,E10))
C TMAVC,TMEMC,TEFNC FORMAT (3(5X,E10))
C 20 NEL,J1,J2,J3,TMAVC,TMEMC,TEFNC FORMAT (415,3E10)
C IF (J1 .EQ. 0) RETURN
C GO TO 20

C DEFINITION OF INPUT VARIABLES.
C NAMEM = TYPE OF MASS MATRIX WANTED.
C = M1, DIAGONAL LUMPED.
C = M2, CONSISTENT.
C = 6H OR 6HOMASS, NO MASS MATRIX CALCULATED.
C NAMEK = TYPE OF STIFFNESS MATRIX WANTED.
C = K1, QUADRATIC DISPLACEMENT FOR MEMBRANE, CUBIC
C DISPLACEMENT FOR BENDING.
C = 6H OR 6HOMSTIF, NO STIFFNESS MATRIX CALCULATED.
C NAMET = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES.
C = 6H OR 6HOLoad, NC LOAD TRANSFORMATIONS CALCULATED.
C NAMEST = IDENTIFICATION NAME FOR STRESS TRANSFORMATION MATRICES.
C = 6H OR 6HOSTIF, NC STRESS TRANSFORMATIONS CALCULATED.
C NAMEF = TYPE OF BUCKLING MATRIX WANTED.
C = 6H OR 6HOBUCK, NO BUCKLING MATRIX CALCULATED.
C RO = MASS DENSITY.
C E = YOUNG'S MODULUS OF ELASTICITY.
C ANU = POISSONS RATIO. (E/2G)-1.
C TMAVC = EFFECTIVE MASS THICKNESS, (CONSTANT).
C TMAVC = EFFECTIVE MASS THICKNESS, (VARIABLE).
C IF .LE. 0., TMAVC IS USED.
C TMEMC = EFFECTIVE MEMBRANE THICKNESS, (CONSTANT).
C TMEMC = EFFECTIVE MEMBRANE THICKNESS, (VARIABLE).
C IF .LE. 0., TMEMC IS USED.
C TEFNC = EFFECTIVE BENDING THICKNESS, (CONSTANT).
C TEFNC = EFFECTIVE BENDING THICKNESS, (VARIABLE).
C IF .LE. 0., TEFNC IS USED.
C NEL = FINITE ELEMENT NUMBER. FOR REFERENCE ONLY, NOT USED IN
C CALCULATIONS. WRITTEN ON NUTMX, ETC.
C J1 = JOINT NUMBER AT TRIANGLE VERTEX 1.
C J2 = JOINT NUMBER AT TRIANGLE VERTEX 2.
C J3 = JOINT NUMBER AT TRIANGLE VERTEX 3.

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

C SUPROUTINE 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 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 = 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 NUTBX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT UNIT LOAD PUCKLING MATRICES AND IVECS ARE OUTPUT.
C NUTBX MAY BE ZERO IF PUCKLING MATRIX IS NOT FORMED.
C USES FORTRAN READ, WRITE.
C NUTEX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT UNIT LOAD PUCKLING MATRICES AND IVECS ARE OUTPUT.
C NUTEX MAY BE ZERO IF PUCKLING MATRIX IS NOT FORMED.
C USES FORTRAN READ, WRITE.
C NUTLT = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT LOCAL 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 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(18,18).
C T = MATRIX WORK SPACE. MIN SIZE(18,18).
C S = MATRX WORK 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.
C
C 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 = UNIT MATRICE FORMED, NUTLT .LE. ZERO.
C 5 = ST MATRIX FORMED, NUTST .LE. ZERO.
C
1001 FORMAT (5(F6.4))
1002 FORMAT (3(F5.1,E10.0))
1003 FORMAT (4(F15.3,E10.0))
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 (/ 13X7HMASS = A6, 13X7HSTIF = A6, 6X13HLOAD TRANS = A6,
     * 5X13HSTIFFNESS TRANS = A6, 3X13HPUCKLING = A6,
     * / 15X4HP = E10.3, 13X3HE = F10.3,
     * / 10X4HT(MASS) = E10.3, 12X4HT(MEMBRANE) = E10.3,
C READ AND WRITE FINITE ELEMENT DATA.
NLINE = 1;
CALL PAGE+D
WRITE (NO, '6001)
READ (NUTLI,1001) NAMEK,NAMELT,NAMEST,NAMEM
READ (NUTEL,1002) RD,E,ANU
READ (NUTEL,1002) TMASC,TMEMC,TEBNC
WRITE (NOT,2003) NAMEK,NAMELT,NAMEST,NAMEM,
*   RC,E,TMASC,ANU,TMEMC,TEBNC
20 READ (NUTEL,1003) NEL,J1,J2,J3,TMASV,TMEMV,TEBNC
NO THIK = 0
IF (TMASV.LE.0. AND. TMEMV.LE.0. AND. TEBNC.LE.0.) NO THIK=0
IF (J1 .LE. 0) RETURN
NLINE = NLINE + 1
IF (NLINE .LE. 42) GO TO 30
CALL PAGE+D
WRITE (NOT,2002)
WRITE (NOT,2003) NAMEK,NAMELT,NAMEST,NAMEM,
*   RC,E,TMASC,ANU,TMEMC,TEBNC
NLINE = 0
30 IF (NO THIK,EQ.1) *WRITE (NOT,2004)NFL,J1,J2,J3,TMASV,TMEMV,TEBNC
IF (NO THIK,EQ.0) WRITE (NOT,2005) NFL,J1,J2,J3
NERR=1
IF (J1 .GT. NJ .OR. J2 .GT. NJ .OR. J3 .GT. NJ) GO TO 999
C SET THICKNESSES.
TMAS = TMASC
TMEM = TMEMC
TEBEN = TEBNC
IF (TMASV.GT.0.) TMAS=TMASV
IF (TMEMV.GT.0.) TMEM=TMEMV
IF (TEBNC.GT.0.) TEBEN=TEBNC
C
C FORM FINITE ELEMENT COORDINATE LOCATIONS, EULER ANGLES, REVADD IVEC.
DO 42 I=1,3
C(JI,J) = YYZ(J1,I)
C(JI,J) = YYZ(J2,I)
C(JI,J) = YYZ(J3,I)
E(JI,J) = FUL(J1,I)
E(JI,J) = FUL(J2,I)
E(JI,J) = FUL(J3,I)
42 E(JI,J) = FUL(J3,I)
DO 44 I=1,6
IVL(I) = JDIF(J1,I)
IVL(I+6) = JDIF(J2,I)
44 IVL(I+12) = JDIF(J3,I)
C
C FORM MASS MATRIX (W).
IF (NAMFM.EQ.6H) GO TO 110
CALL MAS2 (CJ,EJ,TMA5,PO,NAMFM,W,T,S,KCJ,KCJ,KW,KW)

IF (NUTMX.LE.0) GO TO 999
WRITE (NUTMX) NAMFM,NEL,NRW,NRW,NAMFL,(IBLNK,I=1,5),
* (((W1J),I=1,NRW),J=1,NPWW),1IV1(1),I=1,NRW)

C FORM STIFFNESS MATRIX (W), LOCAL LOAD TRANSFORMATION MATRIX (T),
C STRESS TRANSFORMATION MATRIX (S).
110 IF (NAMEK.EQ.6H) GO TO 20
CALL STF2 (CJ,EJ,TMEM,EBEN,F,ANU,NAMEK,NAMEST,W,T,S,NRST,
* KCJ,KCJ,KW,KW,KW)

IF (NUTX .LE. 0) GO TO 999
WRITE (NUTX) NAMEK,NEL,NPW,NRW,NAMET,(IBLNK,I=1,5),
* (((W1J),I=1,NPW),J=1,NPW),1IV1(1),I=1,NPW)
115 IF (NAMELT .EQ. 6H) GO TO 115
WRITE (NAMELT) NAMELT,NEL,NPWL,NRW,NAMET,(IBLNK,I=1,5),
* (((T1J),I=1,NPWL),J=1,NPW),1IV1(I),I=1,NPW)
115 IF (NAMEST .EQ. 6H) GO TO 115
WRITE (NAMEST) NAMEST,NEL,NRST,NRW,NAMET,(IBLNK,I=1,5),
* (((S1J),I=1,NRST),J=1,NRW),1IV1(I),I=1,NRW)
GO TO 20

C 999 CALL ZZBOM2 (6HTRNGL,NEROR)
END