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OF THE FORMA SYSTEM FOR RESPONSE AND LOAD
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EXPANSION AND IMPROVEMENT OF THE FORMA
SYSTEM FOR RESPONSE AND LOAD ANALYSIS

Volume IIC - Listings, Finite Element FORMA Subroutines

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

This report is published in seven volumes:

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

This report presents techniques for the solution of structural dynamic systems on 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.
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, NUTXX, 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 CJ(3,2), I(3,2), IV(6)
DATA NAMEL/6HAXIAL /, NRW, NRTL/6, 2/, IBLNK/6H /, KCG/3/
DATA NIT, NCI/5, 6/
C
SUBROUTINE TO CALCULATE (ON OPTION) FINITE ELEMENT ...
C MASS MATRICES AND IVECS (ON NUTMX),
C STIFFNESS MATRICES (SAME AS GLOBAL LOAD TRANSFORMATION MATRICES)
C AND IVECS (ON NUTXX),
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 OMMITS ELEMENT DOF 3 FROM GLOBAL DOF. THIS CONSTRAINTS
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 PX, 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, NUTXX, NUTLT, NUTST FOR EACH FINITE
C ELEMENT IS (W=M, K, LT, ST)
C WRITE (NUTMX) NAMEN,NEL,NR,NC,NAMEN,(IBLNK,1=1,5),
C ((W(I,J),I=1,NR),J=1,NC),(IVEC(I),I=1,NC)
C CALLS FORMA SUBROUTINES MASIA, PAGEHD, STFIA, ZZBOMB.
C LAST REVISION BY WA EENFIELD. MARCH 1976.
C
C******************************************************************************
C INPUT DATA READ IN THIS SUBROUTINE FROM NUTEL. IF NUTEL = 5, DATA IS
C READ FROM CARDS.
C NAMEE,NAMEK,NAMELT,NAMEST
C READ,FORMAT(25X,E10))
C 20 NEL,J1,J2,A1,A2
C IF (J1 .EQ. 0) RETURN
C GO TO 20
C
C DEFINITION OF INPUT VARIABLES.
C NAMEM = TYPE OF MASS MATRIX WANTED.
C = M1, DIAGONAL LUMPED.
C = M2, CONSISTENT.
C = 6H OR 6HNUMASS, NO MASS MATRIX CALCULATED.
C NAMEK = TYPE OF STIFFNESS MATRIX WANTED.
C = K1, CONSTANT AXIAL FORCE ASSUMED.
C = 6H OR 6HNOSTIF, NO STIFFNESS MATRIX CALCULATED.
C NAMELT = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES.
C = 6H OR 6HNLOAD, NO LOAD TRANSFORMATIONS CALCULATED.
C NAMEST = IDENTIFICATION NAME FOR STRESS TRANSFORMATION MATRICES.
C = 6H OR 6HNSTRES, NO STRESS TRANSFORMATIONS CALCULATED.
C RD = MASS DENSITY.
C E = YOUNG'S MODULUS OF ELASTICITY.
C NEL = FINITE ELEMENT NUMBER, FOR REFERENCE ONLY, NOT USED IN
C CALCULATIONS, WRITTEN ON NUTMX, ETC.
C J1 = JOINT NUMBER AT ROD END 1.
C J2 = JOINT NUMBER AT ROD END 2.
C A1 = CROSS-SECTION AREA AT ROD END 1.
C A2 = CROSS-SECTION AREA AT ROD END 2.
C
C EXPLANATION OF INPUT FORMATS. NUMBER INDICATES CARD COLUMNS USED.
C I = INTEGER DATA, RIGHT ADJUSTED.
C F = DECIMAL POINT DATA, ANYWHERE IN FIELD, EXponent RIGHT ADJUSTED.
C X = CARD COLUMNS SKIPPED.
C******************************************************************************
C SUBROUTINE ARGUMENTS (ALL INPUT)
C XYZ = MATRIX OF JOINT GLOBAL X,Y,Z LOCATIONS. ROWS CORRESPOND
C TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE JOINT
C X,Y,Z LOCATIONS RESPECTIVELY. SIZE(NJ,3).
C JDOF = MATRIX OF JOINT GLOBAL DEGREES OF FREEDOM. ROWS CORRESPOND
C TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE JOINT
C TRANSLATION DOFS AND COLUMNS 4,5,6 CORRESPOND TO THE JOINT
C ROTATION DOFS. SIZE(NJ,6).
C EUL = MATRIX OF JOINT EULER ANGLES (DEGREES). ROWS CORRESPOND
C TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE
C GLOBAL X,Y,Z PERMUTATION. SIZE(NJ,3).
C NUTEL = LOGICAL NUMBER OF TAPE CONTAINING ELEMENT INPUT DATA FOR
C THIS SUBROUTINE. IF NUTEL = 5, DATA IS READ FROM CARDS.
C NJ = NUMBER OF JOINTS OR ROWS IN MATRICES (XYZ), (JDOF), (EUL).
C NUTMX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
C MASS MATRICES AND IVFCS ARE OUTPUT.
C NUTMX MAY BE ZERO IF MASS MATRIX IS NOT FORMED.
C USES FORTRAN READ, WRITE.
C NUTKX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
C STIFFNESS MATRICES (SAME AS GLOBAL LOADS TRANSFORMATION
C MATRICES) AND IVFCS ARE OUTPUT.
C NUTKX MAY BE ZERO IF STIFFNESS MATRIX IS NOT FORMED.
C USES FORTRAN READ, WRITE.
C NULTT = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT LOCAL
C LOAD TRANSFORMATION MATRICES AND IVECS ARE OUTPUT.
C NUTLT MAY BE ZERO IF LOAD TRANSFORMATIONS ARE NOT FORMED.
C USES FORTRAN READ, WRITE.
C NUTST = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
C STRESS TRANSFORMATION MATRICES AND IVECS ARE OUTPUT.
C NUTST MAY BE ZERO IF STRESS TRANSFORMATIONS ARE NOT FORMED.
C USES FORTRAN READ, WRITE.
C W = MATRIX WORK SPACE. MIN SIZE(6,6).
C T = MATRIX WORK SPACE. MIN SIZE(6,6).
C S = MATRIX WORK SPACE. MIN SIZE(6,6).
C 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 C ERROR EXPLANATION
C 1 = JOINT NUMBER GREATER THAN NUMBER OF JOINTS.
C 2 = MASS MATRIX FORMED, NUTMX .LE. ZERO.
C 3 = STIFFNESS MATRIX FORMED, NUTKX .LE. ZERO.
C 4 = LT MATRIX FORMED, NUTLT .LE. ZERO.
C 5 = ST MATRIX FORMED, NUST .LE. ZERO.
C
1001 FORMAT (4(A6,4X))  
1002 FORMAT (2(5X,E10.6))  
1003 FORMAT (3(F,4E10.0))  
2001 FORMAT (//46X 29H INPUT DATA FOR AXIAL ELEMENTS)  
2002 FORMAT (//40X 41H INPUT DATA FOR AXIAL ELEMENTS (CONTINUED))  
2003 FORMAT (// 16X7HMASS = A6, 9X7HSTIF = A6, 9X13HLOAD TRANS = A6, 
* 6X15HSTRESS TRANS = A6, 
* / 18X4HRO = E10.3, 9X3HE = E10.3, 
* //16X7THELEMENT 13X7HJOINT 1 13X7HJOINT 2 15X4HAREA 
* / 16X4HAREA / 16X6HNUMEER 55X7HJOINT 1 13X7HJOINT 2 //)  
2004 FORMAT (1X 3120, 14X E10.3, 10X E10.3)  

C READ AND WRITE FINITE ELEMENT DATA.
C  NLINE = 0
C  CALL PAGEHD
C  WRITE (NCT',2001)
C  READ (NUTEL,1001) NAMEM,NAMEK,NAMELT,NAMEST
C  READ (NUTEL,1002) RO,E
C  WRITE (NCT',2003) NAMEM,NAMEK,NAMELT,NAMEST,RO,E
C  
C 20 READ (NUTEL,1003) NEL,J1,J2,A1,A2
C  IF (J1 .LE. 0) RETURN
C  NLINE = NLINE + 1
C  IF (NLINE .LE. 42) GO TO 30
C  CALL PAGEHD
C  WRITE (NCT',2002)
C  WRITE (NCT',2003) NAMEM,NAMEK,NAMELT,NAMEST,RO,E
C  NLINE = 0
C 30 WRITE (NCT',2004) NEL,J1,J2,A1,A2
C
C IF (J1 .GT. NJ .OR. J2 .GT. NJ) GO TO 999
C
C C FORM FINITE ELEMENT COORDINATE LOCATIONS, EULER ANGLE! . REVADD IVEC.
C DO 42 I=1,3
AXIAL -- 4/4

C
C FORM MASS MATRIX (W).
IF (NAMEM .EQ. 6H .OR. NAMEM .EQ. 6HNOOMASS) GO TO 110
CALL MAS1A (CJ,EJ,A1,A2,R0,NAMEN,W,KCJ,KCJ,KW)

IF (NUTMX .LE. 0) GO TO 999
WRITE (NUTMX) NAMEM,NEL,NFW,NRW,NAMEL,(INBLN(I)=1,5),
*(WI(I,J),I=1,NRW),J=1,NRW),(IVI(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. 6HNOSTIF) GO TO 20
CALL STF1A (CJ,EJ,A1,A2,E,NAMEN,NAMEST,W,T,S,NRST,
*KCJ,KCJ,KW,KW,KW)

IF (NUTMX .LE. 0) GO TO 999
WRITE (NUTMK) NAMEK,NEL,NRW,NRW,NAMEL,(INBLN(I)=1,5),
*(WI(I,J),I=1,NRW),J=1,NRW),(IVI(I),I=1,NRW)

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

IF (NUTLT .LE. 0) GO TO 999
WRITE (NUTLT) NAMELT,NEL,NRTL,NRW,NAMEL,(INBLN(I)=1,5),
*(TI(I,J),I=1,NRTL),J=1,NRW),(IVI(I),I=1,NRW)

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

IF (NUST .LE. 0) GO TO 999
WRITE (NUST) NAMEST,NEL,NRST,NRW,NAMEL,(INBLN(I)=1,5),
*(SI(I,J),I=1,NRST),J=1,NRW),(IVI(I),I=1,NRW)
GO TO 20

C
999 CALL Z2BOME (6HAXIAL ,NERROR)
END
SUBROUTINE R1A1 (RL,Z,KZ)
DIMENSION Z(KZ,1)

C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C BUCKLING MATRIX
C FOR AN AXIAL ROD ELEMENT WITH UNRESTRAINED BOUNDARIES.
C BUCKLING MATRIX IS BASED ON UNIT AXIAL LOAD.
C BUCKLING MATRIX IS IN LOCAL COORDINATE SYSTEM.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE ROD TO LIE IN THE X-Z PLANE
C WITH JOINT 1 AT THE ORIGIN, JOINT 2 ALONG THE POSITIVE X AXIS.
C LOCAL COORDINATE ORDER IS
C DZ1,DZ2
C WHERE DZ IS TRANSLATION.
C
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 = 1./RL
Z(1,1) = C
Z(1,2) = -C
Z(2,1) = -C
Z(2,2) = C

RETURN
END
SUBROUTINE BIA2  (R1,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 = .1
C3 = (Z.*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, NUTRX, NULTT, NUSTT,
*       W T, S, Kx, KJ, KE, KW)
DIMENSION XYZ(KX,1), JDCF(K), EUL(KE,1), W(KW,1), T(KW,1), S(KW,1)
DIMENSION CJ(3,3), EJ(13,2), IV1(12), TR(12,12), TD(24,24)
DIMENSION KDEK(4), KDEB(2), IFPIN(4), IV2(4)
DATA NAMEL / 6HEAP /
DATA NUM, NRTL/12,12/, IBLNK/6H, /, KCI/3/, KTR/12/, KTD/24/
DATA NIT, NCT/5,6/

C SUBROUTINE TO CALCULATE (ON OPTION) FINITE ELEMENT...
C MASS MATRICES AND IVECS (ON NUTMX),
C STIFFNESS MATRICES (SAME AS GLOBAL LOAD TRANSFORMATION MATRICES)
C AND IVECS (ON NUTKX),
C UNIT LOAD BUCKLING MATRICES AND IVECS (ON NUTBX),
C LOCAL LOAD TRANSFORMATION MATRICES AND IVECS (ON NUTLT),
C STRESS TRANSFORMATION MATRICES AND IVECS (ON NUTST)
C FOR COMBINED AXIAL-TORSION-ENDING BAR ELEMENTS.
C MASS, STIFFNESS, BUCKLING MATRICES ARE IN GLOBAL COORDINATE
C DIRECTIONS.
C GLOBAL COORDINATE ORDER FOR EACH ELEMENT IS
C (U, V, W, P, Q, R) JOINT 1, THEN JOINT 2
C WHERE U, V, W ARE TRANSLATIONS AND P, Q, R ARE ROTATIONS.
C IVEC GIVES ELEMENT DOF INTO GLOBAL DOF. EXAMPLES...
C IVEC(6)=834 PLACES ELEMENT DOF 6 INTO GLOBAL DOF 834.
C IVEC(3)=0 OMITS ELEMENT DOF 3 FROM GLOBAL DOF. THIS CONSTRAINTS
C ELEMENT DOF 3 TO ZERO MOTION.
C GLOBAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT BAR ENDS IN GLOBAL
C COORDINATE 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.
C WHERE P IS FORCE AND M IS MOMENT.
C LOCAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT BAR ENDS IN LOCAL
C COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE DIRECTIONS.
C ROW ORDER IN LOCAL LOAD TRANSFORMATION MATRIX IS
C PX1, PX2, MX1, MX2, FY1, FY2, MZ1, MZ2, PZ1, PZ2, MY1, MY2
C WHERE P IS FORCE AND M IS MOMENT.
C STRESS TRANSFORMATION MATRIX RELATES STRESS AT BAR ENDS IN LOCAL
C COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE DIRECTIONS.
C ROW ORDER IN STRESS TRANSFORMATION MATRIX IS
C PX1/A1, PX2/A2, MX1*R1/TJ1, MX2*R2/TJ2,
C FY1/A1, FY2/A2, MZ1*CY1/BIZ1, MZ2*CY2/BIZ2,
C PZ1/A1, PZ2/A2, MY1*CZ1/EIY1, MY2*CZ2/EIY2
C WHERE P IS FORCE AND M IS MOMENT.
C DATA ARRANGEMENT ON NUTMX, NUTKX, NUTRX, NULTT, NUSTT FOR EACH
C FINITE ELEMENT IS (W=M, K, E, LTI, ST)
C WRITE (NUTNX) NAME*, NEL, NR, NC, NAMEL, (IBLNK, I=1,5),
C (W(I,J), I=1, NR), (J=1, NC), (IVEC(I), I=1, NC)
C CALLS FORM SUPROUTINES EUCIE, MASIE, PAGEHD, STFIB, ZPBOPM.
C LAST REVISION BY RL WOHLER. APRIL 1976.
C
INPUT DATA READ IN THIS SUBROUTINE FROM NUTEL. IF NUTEL = 5, DATA IS
READ FROM CARDS.

NAMEIN, NAMEK, NAMELT, NAMEST, NAMEE, FORMAT (5(A6, 4X),
KODEK(I) = 1, I = 1, 4), (KODEB(I), I = 1, 2)
R0, E, C
20 NEL, J1, J2, JREF, A1, P11, TJ1, 61Z1, BIY1, SF,
1FPY1, 1FPZ1, 1FPY2, 1FPZ2, 1IFTAPR
IF (J1 = FC, 0) RETURN
IF (IFTAPR .EQ. 1HT) A2, P12, TJ2, BI1Z2, BIY2
FORMAT (20X, 5E10)
30 IF (NAMEST .EQ. 6M) .OR. NAMENMM .EQ. 6HNOSTRS) GO TO 20
R1, CY1, CZ, R2, CY2, CZ
GO TO 20

INPUT DATA REQUIREMENTS

<table>
<thead>
<tr>
<th>AXIAL</th>
<th>TORSION</th>
<th>BENDING</th>
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<tr>
<td>ALNG</td>
<td>ABOUT</td>
<td>ABOUT</td>
<td>ABOUT</td>
</tr>
<tr>
<td>LOCAL X</td>
<td>LOCAL X</td>
<td>LOCAL Z</td>
<td>LOCAL Y</td>
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</table>

| MASS | A,RO | PI,RO | A,RO |
| SIIF, LOAD TRANS | A,F | TJ,G | E1Z,A, SF,E,E |
| BUCKLING | NONE | NONE | NONE |
| STRESS TRANS | SEE SIIF | SIIF+R | SIIF+CY |

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

DEFINITION OF INPUT VARIABLES

NAMEE = TYPE OF MASS MATRIX WANTED.
   = M1, DIAGONAL LUMPED.
   = M2, CONSISTENT.
   = 64, CR 6H-NOMASS, NO MASS MATRIX CALCULATED.
NAMEK = TYPE OF STIFFNESS MATRIX WANTED.
   = K1, CONSTANT FORCE FOR AXIAL, CONSTANT TORQUE FOR TORSION,
   CONSTANT SHEAR AND LINEAR MOMENT FOR BENDING.
   = 64, CR 6H-NOSTIF, NO STIFFNESS MATRIX CALCULATED.
NAMELT = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES.
   = 64, CR 6H-NOLOAD, NO LOAD TRANSFORMATIONS CALCULATED.
NAMEST = IDENTIFICATION NAME FOR STRESS TRANSFORMATION MATRICES.
   = 64, CR 6H-NOSTRS, NO STRESS TRANSFORMATIONS CALCULATED.
NAMEB = TYPE OF BUCKLING MATRIX WANTED.
   = F1, AXIAL RCD.
   = F2, BEAM.
   = 64, CR 6H-NOPUCK, NO BUCKLING MATRIX CALCULATED.
KODEK = OPTION CODE FOR AXIAL, TORSION, BENDING Z, BENDING Y LOCAL
STIFFNESS. IF BLANK, ALL FOUR ARE CALCULATED. SIZE(4).
KODEK(1) = A, LOCAL STIF MATRX IS CALCULATED FOR AXIAL
   (ALONG LOCAL X-AXIS).
KODEK(2) = T, LOCAL STIF MATRX IS CALCULATED FOR TORSION
   (ABOUT LOCAL X-AXIS).
KODEK(3) = E2, LOCAL STIF MATRX IS CALCULATED FOR BENDING
   (ABOUT LOCAL X-AXIS).
KODEK(4) = FY, LOCAL STIF MATRX IS CALCULATED FOR BENDING
   (ABOUT LOCAL Y-AXIS).
KODEK = OPTION CODE FOR BUCKLING IN LOCAL Y OR Z DIRECTION.
   IF BLANK, BOTH ARE CALCULATED. SIZE(2).
KODEK(1) = FY, LOCAL BUCKLING MATRIX IS CALCULATED FOR
BAR

DEFLECTION IN LOCAL Y DIRECTION.

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

RO = 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 SPIN VENANTS TORSION CONSTANT (J) IN JG FOR
TORSION STIFFNESS AT BAR END 1.
TJ2 = SAME AS TJ1 AT BAR END 2.
BIZ1 = CROSS-SECTION AREA MOMENT OF INERTIA ABOUT LOCAL Z-AXIS
(FCB BENDING) AT BAR END 1.
BIZ2 = SAME AS BIZ1 AT BAR END 2.
B1Y1 = CROSS-SECTION AREA MOMENT OF INERTIA ABOUT LOCAL Y-AXIS
(FCB 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.
= 1P+, 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.
= 1P+, PIN JOINT.
IFPZ2 = SAME AS IFPZ1 AT BAR END 2.
IFTAPR = OPTION FOR TAPERED EAR.
= 1H, CONSTANT SECTION PROPERTIES.
= 1T+, 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 DOFS AND COLUMNS 4, 5, 6 CORRESPOND TO THE JOINT ROTATION DOFS. SIZE(NJ, 6).

EUL = MATRIX OF JOINT GLOBAL 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.

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

USES FORTRAN READ, WRITE.

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

USES FORTRAN READ, WRITE.

W = MATRIX WORK SPACE. MIN SIZE(12, 12).

T = MATRIX WORK SPACE. MIN SIZE(12, 12).

S = MATRIX WORK SPACE. MIN SIZE(17, 12).

KX = ROW DIMENSION OF XYZ IN CALLING PROGRAM.

KJ = ROW DIMENSION OF JDOF IN CALLING PROGRAM.

KE = ROW DIMENSION OF EUL IN CALLING PROGRAM.

KW = ROW DIMENSION OF W, T, AND S IN CALLING PROGRAM. MIN=12.

NEPROF EXPLANATION

1 = JOINT NUMBER GREATER THAN NUMBER OF JOINTS.

2 = STIFFNESS MATRIX FORMED, NUTKX LE. ZERO.

3 = LOAD TRANSFORMATION MATRIX FORMED, NUTLT LE. ZERO.

4 = STRESS TRANSFORMATION MATRIX FORMED, NUTST LE. ZERO.

5 = MASS MATRIX FORMED, NUTMX LE. ZERO.

6 = BUCKLING MATRIX FORMED, NUTBX LE. ZERO.

1001 FORMAT (5(16, 4X), A1, A1, 4X, A2, 4X, A2, A2)
BAR -- 5/7

1002 FORMAT (3(5x,E10.0))
1003 FORMAT (4(5x,E10.0),E5.0,5A1)
1004 FORMAT (20x,6E10.0)
2001 FORMAT (//46x 27INPUT DATA FOR BAR ELEMENTS)
2002 FORMAT (//46x 39INPUT DATA FOR BAR ELEMENTS (CONTINUED))
2003 FORMAT (45x,6HKODEK = A1, A1, A2, A2, 4X 6HKODEB = A2, A2,
* / 10X7HMMASS = A6, 6X7HSTIF = A6, 6X13HLOAD TRANS = A6,
* / 3X15HSTRESS TRANS = A6, 3X11HBEUCKLING = A6,
* / 12X4HRC = E10.3, 6X3HE = E10.3, 80X7MI 1 1 I,
* / 32X3HG = E10.3, 80X7HF F F F,
* / 125X7HP P P P,
* / 1X7HELELEMENT 2X5HJOINT 2X5HJOINT 3X3HREF 5X4HAREA
* / 7X5HPOLAR 5X7HTORSION 3X9H2 BENDING 2X9H2 BENDING
* / 2X5HSHAP 3X6HSTRESS 5X6HSTRESS 5X6HSTRESS 3X7HY Z Y Z
* / 1X6HNUMBER 5X1H1 6X1H2 4X5HPOINT
* / 14X 7HINEFTIA 5X5HCONST 5X7HINEFTIA
* / 4X7HINEFTIA 3X6HFACTOR 5X1HR 9X2HCY 9X2HCZ 5X7MI 1 2 2 2)
2004 FORMAT (1X I5, I8, I2T, 1X 5E11.3, F7.3, 3E11.3, 4(I1A1))
2005 FORMAT (29x,5E11.3,7X,3E11.3)

C READ AND WRITE FINITE ELEMENT DATA.
R1 = 0.0
CY1 = 0.0
CZI = 0.0
NLINE = 0
CALL PAGEID
READ (NOT,2001) NAMEK,NAMET,NAMEM,NAMES,NAMES,
* (KODEK(I),I=1,4), (KODEB(I),I=1,2)
READ (NUTE,1001) RQ,E6
WRITE (NOT,2003) (KODEK(I),I=1,4), (KODEB(I),I=1,2),
* NAMEK,NAMET,NAMEM,NAMES,RQ,E6
20 READ (NUTE,1004) NEL,J1,J2,JREF,A1,P11,TJ1,BIZ1,BIY1,UF,
* IFP IN, IFTPAP
IF (J1 .LE. 0) RETURN
IF (IFTPAP .EQ. 1HT) READ (NUTE,1004) A2,P12,TJ2,BIZ2,BIY2
IF (NAMEST .EQ. 6H) OR. NAMET .EQ. 6HNOSTRS) GO TO 25
READ (NUTE,1004) R1, CY1, CZ1, R2, CY2, CZ2
25 NLINE = NLINE + 1
IF (IFTPAP .EQ. 1HT) NLINF = NLINE + I
IF (NLINE .LE. 42) GO TO 30
CALL PAGEID
WRITE (NOT,2002)
WRITE (NOT,2003) (KODEK(I),I=1,4), (KODEB(I),I=1,2),
* NAMEK,NAMET,NAMEM,NAMES,RQ,E6
NLINE = C
30 WRITE (NOT,2004) NEL, J1, J2, JREF, A1, P11, TJ1, BIZ1, BIY1, UF,
* R1, CY1, CZ1, IFP IN
    NERROR=1
IF (J1 .GT. NJ .CR. J2 .GT. NJ .CR. JREF .GT. NJ) GO TO 999
IF (IFTPAP .EQ. 1HT) WRITE (NOT,2005) A2, P12, TJ2, BIZ2, BIY2, R2,
* CY2, CZ2
C FORM FINITE ELEMENT COORDINATE LOCATIONS, EULER ANGLES, REVADD IVEC.
DC 42 I=1,3
C FORM DATA FOR UNIFORM ELEMENT.
IF (IFTAPR .EQ. IHT) GO TO 50
A2 = A1
PI2 = PI1
TJ2 = TJ1
RIZ2 = RIZ1
EIZ2 = EIZ1
R2 = R1
CY2 = CY1
CZ2 = CZ1

C FORM PINING IVEC.
50 NPIN = 0
DO 55 I=1,4
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) GO TO 110
   CALL STFB1B (CJ, EJ, KODEK, A1, A2, TJ1, TJ2, BIZ1, BIZ2, BIZI, BIZV, R1, R2, *
      CY1, CY2, C21, C22, SF, E, G, NAMEK, NAMEST, W, T, S, NRMST, *
      KCJ, KCJ, KW, KW, KW)
C
C PIN STIFFNESS MATRIX.
   IF (NPIN .EQ. 0) GO TO 105
   CALL DCOS1B (CJ, EJ, W, KCJ, KCJ, KW)
   CALL TRANS (W, TR, NRW, NRW, KW, KTR)
   CALL MULTA (TR, NRW, NRW, NRW, KW, KTR)
   CALL SPED3 (T, IV1, T, TD, NRW, NPIN, I, KW)
   CALL MULTA (TD, W, NRW, NRW, NRW, KTD, KW)
   CALL MULTA (TR, TD, NRW, NRW, NRW, KTR, KTD)
   CALL MULTA (T, W, NRW, NRW, NRW, KW, KW)
   CALL ATXPA1 (W, TR, NRW, NRW, KW, KTR)
IF (NAMEST .EQ. 6H) GO TO 105
   CALL MULTA (S, TR, NRW, NRW, NRW, KW, KTR)
105 NERROR=2
   IF (NUTKX .LE. 0) GO TO 999
   WRITE (NUTKX) NAMEK, NEL, NRW, NRW, NAMEL, (IRLNK, I=1,5), *
      ((WI, I, J), I=1, NRW, J=1, NRW), (IVI(I, I), I=1, NRW)
   IF (NAMELT .EQ. 6H) GO TO 115
IF (NUTLT .LE. 0) GO TO 999
WRITE (NUTLT) NAMELT,NFL,NRLT,NRW,NAMEL,(IBLNK,I=1,5),
*       ((T(I,J),I=1,NRLT),J=1,NRW),(IV1(I),I=1,NRW)
115 IF (NAMEST .EQ. '6H' .OR. NAMEST .EQ. '6HNOSTRS') GO TO 110
   NERROR=4
IF (NUTST .LE. 0) GO TO 999
WRITE (NUTST) NAMEST,NEL,NRST,NRW,NAMEL,(IBLNK,I=1,5),
*       ((S(I,J),I=1,NRST),J=1,NRW),(IV1(I),I=1,NRW)
C
C FORM MASS MATRIX (W).
110 IF (NAMEM .EQ. '6H' .OR. NAMEM .EQ. '6HNOmass') GO TO 140
   CALL MAS18 (CJ,EJ,A1,A2,PI1,PI2,RO,NAMEM,W,T,KCJ,KCJ,KW,KW)
C
C PIN MASS MATRIX.
   IF (NPIN .GT. 0) CALL Btaba (W,TR,NRW,NRW,KW,KTR)
   NERROR=5
IF (NUTMX .LE. 0) GO TO 999
WRITE (NUTMX) NAMEM,NEL,NRW,NRW,NAMEL,(IBLNK,I=1,5),
*       ((W(I,J),I=1,NRW),J=1,NRW),(IV1(I),I=1,NRW)
C
C FORM UNIT LOAD BUCKLING MATRIX (W).
140 IF (NAMEB .EQ. '6H' .OR. NAMEB .EQ. '6HNOBUCK') GO TO 20
   CALL Buc1b (CJ,EJ,Kodef,NAMER,W,S,KCJ,KCJ,KW,KW)
   NERROR=6
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),(IV1(I),I=1,NRW)
   GO TO 26
C
999 CALL ZZBOMB (6HBAR ,NERROR)
END
SUBROUTINE BUC1B (CJ, EJ, KODE, NAMER, Z, W, KCJ, KEJ, KZ, KW)

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

SUBROUTINE TO CALCULATE FINITE ELEMENT...

BUCKLING MATRIX

FOR A COMBINED AXIAL-TORSION-BENDING BAR ELEMENT WITH UNRESTRAINED
BOUNDARIES.

BUCKLING MATRIX IS BASED ON UNIT AXIAL LOAD.

BUCKLING MATRIX IS IN GLOBAL COORDINATE DIRECTIONS.

GLOBAL COORDINATE ORDER IS

(U, V, W, P, Q, R) JOINT 1, THEN JOINT 2

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

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

CALLS FORMA SUBROUTINES B1A1, B1A2, BTABA, DCOS1B, Z2BOMB.


LAST REVISION BY WA BENFIELD. MARCH 1976.

SUBROUTINE ARGUMENTS

C CJ = INPUT MATRIX OF GLOBAL X, Y, Z COORDINATES AT BAR JOINTS.
    ROWS 1, 2, 3 CORRESPOND TO X, Y, Z COORDINATES.
    COLS 1, 2 CORRESPOND TO JOINTS 1, 2. COL 3 CORRESPONDS
    TO REFERENCE POINT TO DEFINE LOCAL XY PLANE. SIZE(3,3).

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

C KODEB = INPUT OPTION CODE FOR LOCAL Y, LOCAL Z BUCKLING.
    IF BLANK, BOTH ARE CALCULATED. SIZE(2).
    KODEB(1)=BY, LOCAL BUCKLING MATRIX IS CALCULATED
    FOR LOCAL Y DIRECTION.
    KODEB(2)=EZ, LOCAL BUCKLING MATRIX IS CALCULATED
    FOR LOCAL Z DIRECTION.

C NAMEB = INPUT TYPE OF BUCKLING MATRIX WANTED.
    =P1, AXIAL RCD.
    =E2, BEAM.

C Z = OUTPUT BUCKLING MATRIX. SIZE(12,12).

C W = INPUT WORK SPACE MATRIX. SIZE(12,12).

C KCJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM.

C KEJ = INPUT ROW DIMENSION OF EJ IN CALLING PROGRAM.

C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=12.

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

NERROREXPLANATION

1 = DIMENSION SIZE EXCEEDED.

2 = IMPROPERLY DEFINED NAMEB.

IF (KZ .LT. 12) OR. KW .LT. 12) GG TO 999
DO 5 J=1,12
      DO 5 I=1,12
      Z(I,J) = 0.0
      5 PL = SQRT((CJ(1,2)-CJ(1,1))**2 + (CJ(2,2)-CJ(2,1))**2
           + (CJ(3,2)-CJ(3,1))**2)
      KODEBY = 1
      KODEBZ = 1
      IF (KODEB(1).EQ.2 .AND. KODEB(2).EQ.2 ) GG TO 10
IF (KODEP(1) .NE. 2HBY) KODEBY = 0
IF (KODEB(2) .NE. 2HBZ) KCODEB2 = 0
10 IF (NAMEB .EQ. 6HB1) GO TO 110
   IF (NAMEB .EQ. 6HB2) GO TO 120
GO TO 999
C
110 IF (KODERY .EQ. 1) CALL B1A1 (RL,Z(5,5),KZ)
   IF (KODEBZ .EQ. 1) CALL B1A1 (RL,Z(9,9),KZ)
   GO TO 300
C
120 IF (KODERY .EQ. 1) CALL B1A2 (RL,Z(5,5),KZ)
   DO 125 J=7,8
   DO 125 I=5,6
   Z(I,J) = -Z(J,I)
125
   IF (KODEBZ .EQ. 1) CALL B1A2 (RL,Z(9,9),KZ)
C
300 CALL DCOS1B (CJ,EJ,W,KCJ,KEJ,KW)
   CALL PTABA (Z,W,12,12,KZ,KW)
   RETURN
C
999 CALL ZZBOMB (6HBUCIB,NERROR)
END
SUBROUTINE DCOSIA (CJ, EJ, Z, KCJ, KEJ, KZ)
DIMENSION CJ(KCJ,1), EJ(KEJ,1), Z(KZ,1)
DIMENSION P(3), T(3,3)

SUBROUTINE TO CALCULATE FINITE ELEMENT...

DIRECT COSINE MATRIX
FOR AN AXIAL ROD ELEMENT.
The direction cosine matrix relates local coordinate displacements
to global coordinate displacements.
The local coordinate system assumes the rod to lie along the X axis
with joint 1 at the origin, joint 2 along the positive X axis.
Row order (local coordinate order) of direction cosine matrix is
DX1, DX2
WHERE DX IS TRANSLATION.
Column order (global coordinate order) of direction cosine matrix is
(U, V, W) joint 1, then joint 2.
WHERE U, V, W ARE TRANSLATIONS.
Euler angle convention is global X, Y, Z permutation.
Calls form subroutines EULER, MULTR, ZIBOMB.

SUBROUTINE ARGUMENTS
CJ = INPUT MATRIX OF GLOBAL X, Y, Z COORDINATES AT ROD JOINTS.
ROWS 1, 2, 3 correspond to X, Y, Z COORDINATES.
COLUMNS 1, 2 correspond to joints 1, 2. SIZE(3, 2).
EJ = INPUT MATRIX OF EULER ANGLES (DEGREES) AT ROD JOINTS.
ROWS 1, 2, 3 correspond to global X, Y, Z permutation.
COLUMNS 1, 2 correspond to joints 1, 2. SIZE(3, 2).
Z = OUTPUT DIRECT COSINE MATRIX. SIZE(2, 6).
KCJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM.
KEJ = INPUT ROW DIMENSION OF EJ IN CALLING PROGRAM.
KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=2.

ERROR EXPLANATION
1 = DIMENSION SIZE LESS THAN 2.

IF (KZ.LT.2) GO TO 999
PX = CJ(1,2)-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(I,J)
CALL EULEP (EJ(1,2), T, 3)
CALL MULTR (P, T, 1, 3, 3, 1, 3)
DO 24 J=1,3
   24 Z(2,J+3) = T(1,J)
   RETURN
C
999 CALL ZZBOMB (6HDCOSIA,NERROR)
END
SUBROUTINE DCOS18 (CJ,EJ,Z,KCJ,KEJ,KZ)
DIMENSION CJ(KCJ,1), EJ(KEJ,1), Z(KZ,1)
DIMENSION W(3,3), T(3,3)

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

C SUBROUTINE ARGUMENTS
C CJ = INPUT MATRICES 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
to reference point to define local xy plane. SIZE(3,3).
C EJ = INPUT MATRICES OF EULER ANGLES (DEGREES) AT BAR JOINTS.
C ROWS 1,2,3 CORRESPOND TO GLOBAL X,Y,Z PERMUTATION.
C COLS 1,2 CORRESPOND TO JOINTS 1,2. SIZE(3,2).
C Z = OUTPUT DIRECTION COSINE MATRIX. SIZE(12,12).
C KCJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM.
C KEJ = INPUT ROW DIMENSION OF EJ IN CALLING PROGRAM.
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=12.
C
C NERROR EXPLANATION
C 1 = DIMENSION SIZE LESS THAN 12.
C
IF (KZ .LT. 12) GO TO 999
PX = CJ(1,2)-CJ(1,1)
PY = CJ(2,2)-CJ(2,1)
PZ = CJ(3,2)-CJ(3,1)
PL = SQRT(PX**2 + PY**2 + PZ**2)
RX = PY*(CJ(3,3)-CJ(3,1)) - PZ*(CJ(2,3)-CJ(2,1))
RY = PZ*(CJ(1,3)-CJ(1,1)) - PX*(CJ(3,3)-CJ(3,1))
RZ = PX*(CJ(2,3)-CJ(2,1)) - PY*(CJ(1,3)-CJ(1,1))
RL = SQRT(RX**2 + RY**2 + RZ**2)
QX = RX*PZ - RZ*PY
QY = RZ*PX - RX*PZ
QZ = RX*PY - RY*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 I=1,12
  DO 10 J=1,12
10  Z(I,J) = 0.0
   CALL EULEP (EJ(1,1),T,3)
   CALL MULTB (W,T, 3,3,3, 3,3)
   DC 22 J=1,3
   Z(1,J) = T(1,J)
   Z(3,J) = T(3,J)
   Z(5,J) = T(2,J)
   JP3 = J+3
   Z(3,JP3) = T(1,J)
   Z(7,JP3) = T(2,J)
22  Z(11,JP3) = T(2,J)
   CALL EULER (EJ(1,2),T,3)
   CALL MULTB (W,T, 3,3,3, 3,3)
   DO 24 J=1,3
    JP6 = J+6
   Z(2,JP6) = T(1,J)
   Z(6,JP6) = T(2,J)
   Z(10,JP6) = T(3,J)
   JP9 = J+9
   Z(4,JP9) = T(1,J)
   Z(8,JP9) = T(3,J)
24  Z(12,JP9) = T(2,J)
   RETURN
999  CALL ZZBOMB (6HDCOS1B,NERROR)
END
SUBROUTINE DCSOS (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...
DIRECTION COSINE MATRIX
FOR A COMBINED MEmbrane-PEnding TRIANGLE PLATE ELEMENT.
The DIRECTION COSINE MATRIX RELATES LOCAL COORDINATE DISPLACEMENTS
to GLOBAL COORDINATE DISPLACEMENTS.
THE LOCAL COORDINATE SYSTEM ASSUMES THE PLATE TO LIE IN AN X-Y PLANE
WITH JOINT 1 AT THE ORIGIN, JOINT 2 LIES ALONG THE positive X-axis,
AND JOINT 3 IS IN THE POSITIVE Y DIRECTION.
ROW ORDER (LOCAL COORDINATE ORDER) OF DIRECTION COSINE MATRIX IS
(sx, sy, sz) JOINT 1, THEN JOINT 2, 3, NEXT
(tx, ty, tz) JOINT 1, THEN JOINT 2, 3
WHERE sx, sy, sz ARE TRANSLATIONS AND tx, ty, tz ARE ROTATIONS.
COLUMN ORDER (GLOBAL COORDINATE ORDER) OF DIRECTION COSINE MATRIX IS
(u, v, w, p, q, r, f) JOINT 1, THEN JOINT 2, 3.
WHERE u, v, w ARE TRANSLATIONS AND p, q, r ARE ROTATIONS.
EULER ANGLE CONVENTION IS GLOBAL x, y, z PERMUTATION.
CALLS FORM SUBROUTINES EULER, MULT, ZIBOMB.
LAST REVISION BY WA BENFIELD. MARCH 1976.

SUBROUTINE ARGUMENTS
CJ = INPUT MATRIX OF GLOBAL X, Y, Z COORDINATES AT TRIANGLE JOINTS.
ROWS 1, 2, 3 CORRESPOND TO X, Y, Z COORDINATES.
COLUMNS 1, 2, 3 CORRESPOND TO JOINTS 1, 2, 3. SIZE(3,3).
EJ = INPUT MATRIX OF EULER ANGLES (DEGREES) AT TRIANGLE JOINTS.
ROWS 1, 2, 3 CORRESPOND TO GLOBAL X, Y, Z PERMUTATION.
COLUMNS 1, 2, 3 CORRESPOND TO JOINTS 1, 2, 3. SIZE(3,3).
Z = OUTPUT DIRECTION COSINE MATRIX. SIZE(18,18).
KCJ = INPUT 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.

ERROR 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(2,1)
PZ = CJ(2,3) - CJ(2,1)
PL = SQRT(PX**2 + PY**2 + PZ**2)
FX = PY*(CJ(2,3) - CJ(3,1)) - PZ*(CJ(2,3) - CJ(2,1))
RY = PZ*(CJ(1,3) - CJ(1,1)) - PX*(CJ(3,3) - CJ(3,1))
RZ = PX*(CJ(2,3) - CJ(2,1)) - PY*(CJ(1,3) - CJ(1,1))
RL = SQRT(RX**2 + RY**2 + RZ**2)
QX = PY*PZ - RZ*PY
LY = RZ*PX - RX*PZ
QZ = RX*PY - RY*PX
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) = OX/QL
W(? ,2) = OY/QL
W(? ,3) = OZ/QL
W(3,1) = RX/RX
W(3,2) = RY/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 EULER (EF(1,NW),T,3)
CALL MULT (W,T,3,3,3)
IZZ = 3+(NW-1)
JZZ = 6+(NW-1)
DO 50 JW=1,3
JZ = JZZ+JW
Z(Izz+1,j) = T(I,jW)
Z(Izz+2,j) = T(2,jW)
Z(Izz+3,j) = T(3,jW)
JZ = JZ+2
Z(Izz+4,j) = T(3,jW)
Z(Izz+11,j) = T(1,jW)
50 Z(Izz+12,j) = T(2,jW)
RETURN
C
999 CALL ZSSOME (6E4DCOS2 ,NERRROR)
END
SUBROUTINE DCOS3C (CJ,EJ,Z,KEJ,KZ)
DIMENSION CJ(KJ,1), EJ(KEJ,1), Z(KZ,1)
     DIMENSION W(2,3), T(3,3)
C
C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C DIRECTION COSINE MATRIX
C FOR A RECTANGULAR SHEET PANEL ELEMENT.
C THE DIRECTION COSINE MATRIX RELATES LOCAL COORDINATE DISPLACEMENTS
C TO GLOBAL COORDINATE DISPLACEMENTS.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE PANEL TO LIE IN AN X-Y PLANE
C WITH JOINT 1 AT THE X-Y ORIGIN, JOINT 2 LIES ALONG THE POSITIVE
C X AXIS, JOINT 3 IS IN THE POSITIVE X, Y DIRECTION, AND JOINT 4 TIES
C ALONG THE POSITIVE Y AXIS.
C ROW ORDER (LOCAL COORDINATE ORDER) OF DIRECTION COSINE MATRIX IS
C DX,DY,DZ,DX4, DY1,DY2,DY3,DY4
C WHERE DX,DY ARE TRANSLATIONS.
C COLUMN ORDER (GLOBAL COORDINATE ORDER) OF DIRECTION COSINE MATRIX IS
C (U,V,W) JOINT 1, THEN JOINT 2, 3, 4.
C WHERE U,V,W ARE TRANSLATIONS.
C EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
C CALLS FORMA SUBPROCESSES EULER,MULT,ZZBOMB.
C DEVELOPED BY RL WOHLN. APRIL 1974.
C LAST REVISION BY WA RENFIELD. MARCH 1976.
C
C SUBROUTINE: ARGUMENTS
C CJ = INPUT MATRIX OF GLOBAL X,Y,Z COORDINATES AT PANEL JOINTS.
C ROWS 1,2,3 CORRESPOND TO X,Y,Z COORDINATES.
C COLS 1,2,3,4 CORRESPOND TO JOINTS 1,2,3,4. SIZE(3,4).
C EJ = INPUT MATRIX OF EULER ANGLES (DEGREES) AT PANEL JOINTS.
C ROWS 1,2,3 CORRESPOND TO GLOBAL X,Y,Z PERMUTATION.
C COLS 1,2,3,4 CORRESPOND TO JOINTS 1,2,3,4. SIZE(3,4).
C Z = OUTPUT DIRECTION COSINE MATRIX. SIZE(3,3).
C KJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM.
C KEJ = INPUT ROW DIMENSION OF EJ IN CALLING PROGRAM.
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=8.
C
C NEPRER: EXPLANATION
C 1 = DIMENSION SIZE TOO SMALL.
C
C IF (KZ .LT. E) CC 10 999
C PX = CJ(1,1)- CJ(1,1)
C PY = CJ(1,2)- CJ(2,1)
C PZ = CJ(1,3)- CJ(3,1)
C PL = SQRT(PX**2 + PY**2 + PZ**2)
C CX = CJ(1,4)- CJ(1,1)
C CY = CJ(2,4)- CJ(2,1)
C CZ = CJ(3,4)- CJ(3,1)
C CL = SQRT(CX**2 + CY**2 + CZ**2)
C W(1,1) = PX/PL
C W(1,2) = PY/PL
C W(1,3) = PZ/PL
C W(2,1) = CX/CL
C W(2,2) = CY/CL
C W(2,3) = CZ/CL
DO 10 J=1,12
50 I=1,8
10 Z(I,J) = 0.0
DO 50 IJNT=1,4
CALL EULEF (EJ(1,IJNT),T,3)
CALL MULTF (W,T, 2,3,3, 2,3)
JZZ = 2*(IJNT-1)
DO 50 JW=1,3
JZ = JZZ+JW
Z(IJNT,JZ) = T(1,JW)
50 Z(IJNT+4,JZ) = T(2,JW)
RETURN

999 CALL ZZ60MB (6:DCOS3C:ERROR)
END
SUBROUTINE EULER (E, R, KR)
DIMENSION E(1), R(KR,1)

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

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

C D1CR = ATAN2(1.,1.)/45.

C C1 = COS(E(1)*D1CR)
C C2 = COS(E(2)*D1CR)
C C3 = COS(E(3)*D1CR)
C S1 = SIN(E(1)*D1CR)
C S2 = SIN(E(2)*D1CR)
C S3 = SIN(E(3)*D1CR)

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

C RETURN
END
SUBLROUTINE FINEL (XY2, JDFF, EUL, NUTEL, NJ, * NUTM, NUTK, NUTLT, NUTST, NUTE, V, LV, KV, * KRX, KRC, KRE, NUTMX, NUTKY, NUT1, NUT2, NUT3)
DIMENSION XYZ(KRX,1), JDFF(KRE,1), EUL(KRE,1), W(1), LV(1)
DIMENSION WI(24,24), W2(24,24), W3(24,24)
DATA KWX/24/, IFLANK/6/
DATA NIT, NDT/5, 6/
C
SUBLROUTINE TO CALCULATE (ON OPTION) FINITE ELEMENT...
C 
ASSEMBLED MASS MATRIX (ON NUTM),
C ASSEMBLED STIFFNESS MATRIX (ON NUTK),
C ELEMENT LOCAL LOAD TRANSFORMATION MATRICES, IVECS (ON NUTLT),
C ELEMENT GLOBAL LOAD TRANSFORMATION MATRICES, IVECS (ON NUTXK),
C ELEMENT STRESS TRANSFORMATION MATRICES, IVECS (ON NUTST),
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 CONSTRAINTS
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 NUTLT, NUTXK, NUTST, NUTE FOR EACH FINITE
C ELEMENT (WRITTEN IN SUBROUTINE AXIAL, BAR, ETC) IS
C WRITE (NUTM) NAMEW, NEL, INF, NC, NAMEL (IBLANK, I=1,5),
C (W(I,J), I=1, N), J=1, NC) (IVEC(I), I=1, NC)
C NAMEW = NAMELT, NAMEXX, NAMEST, OR NAMES.
C NAMEL = AXIAL, PAR, ETC.
C LAST RECORD TO DENOTE TERMINATION IS,
C WRITE (NUTM) IFLANK, (11, I=1, 36)
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 (BECAUSE THEY USE BUFFER IN, BUFFER OUT).
C NUTLT, NUTST, NUTXK, NUTX, NUTE.
C THE FOLLOWING UTILITY TAPES USE FORMA YIN, YOUT.
C NUTM, NUTK, NUTE, NUT2, NUT3.
C CALLS FORMA SUBROUTINES AXIAL, BAR, FLUID, GRAVITY, PAGEHDIQUO, QUAD, C RECTSP, TANGL, YRVAD, Z26CMB.
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 50 NAMEL FORMAT (A6)
C IF (NAMEL 6EQ. 0) RETURN
C IF (NAMEL 6EQ. 6) AXIAL ) CALL AXIAL (SEE SUBRT FOR INPUT)
C IF (NAMEL 6EQ. 6) BAR ) CALL BAR (SEE SUBRT FOR INPUT)
C IF (NAMEL 6EQ. 6) FLUID ) CALL FLUID (SEE SUBRT FOR INPUT)
C IF (NAMEL 6EQ. 6) GRAVITY ) CALL GRAVITY (SEE SUBRT FOR INPUT)
C IF (NAMEL 6EQ. 6) QUAD ) CALL QUAD (SEE SUBRT FOR INPUT)
C IF (NAMEL 6EQ. 6) RECTSP ) CALL RECTSP (SEE SUBRT FOR INPUT)
C IF (NAMEL 6EQ. 6) TRNGL ) CALL TRNGL (SEE SUBRT FOR INPUT)
C GO TO 50
C
C DEFINITION OF INPUT VARIABLES.
**FINEL -- 2/5**

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C NAMEL = AXIAL, BAR, ETC AS SHOWN ABOVE. GIVES SUBROUTINE CALLED.
C EXPLANATION OF INPUT FORMATS. NUMBER INDICATES CARD COLUMNS USED.
C A = ANY KEYPUNCH SYMBOL.
C X = CARD COLUMNS SKIPPED.

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

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 MAY BE EQUIVALENCED TO VI(1) IN CALLING PROGRAM.
C JDOF = MATRIX OF JOINT LOCAL 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 MAY BE EQUIVALENCED TO LV(1) IN CALLING PROGRAM.
C EUL = MATRIX OF JOINT EULER ANGLES (DEGREES). ROWS CORRESPOND
C TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE
C LOCAL X,Y,Z PERMUTATION. SIZE(NJ,3). MAY BE
C EQUIVALENCED TO VIKRX*(XYZ COL DIM)+1) IN CALLING PROGRAM.
C NUTEL = LOGICAL NUMBER OF TAPE CONTAINING ELEMENT INPUT DATA FOR
C THIS SUBROUTINE AND SUBROUTINES AXIAL, ETC GIVEN BY NAMEL.
C IF NUTEL = 5, DATA WILL BE READ FROM CARDS.
C NJ = NUMBER OF JOINTS OR ROWS IN MATRICES (XYZ), (JDOF), (EUL).
C NUTM = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ASSEMBLED
C MASS MATRIX IS OUTPUT IN SPARSE NOTATION.
C NUTM MAY BE ZERO IF MASS MATRIX IS NOT FORMED.
C USES FORTRAN READ, WRITE.
C NUTK = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ASSEMBLED
C STIFFNESS MATRIX IS OUTPUT IN SPARSE NOTATION.
C NUTK 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.
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 NUTB = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT UNIT LOAD
C RUCKLING MATRICES AND IVECS ARE OUTPUT.
C NUTB MAY BE ZERO IF RUCKLING MATRICES ARE NOT FORMED.
C USES FORTRAN READ, WRITE.
C V = VECTOR WORK SPACE.
C LV = VECTOR WORK SPACE.
C KV = DIMENSION SIZE OF V, LV IN CALLING PROGRAM.
C KRX = ROW DIMENSION OF XYZ IN CALLING PROGRAM.
C KRE = ROW DIMENSION OF JDOF IN CALLING PROGRAM.
C KRE = ROW DIMENSION OF EUL IN CALLING PROGRAM.
C NUTMX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
C MASS MATRICES AND IVECS ARE STORED.
C NUTMX MAY BE ZERO IF MASS MATRIX IS NOT FORMED.
C USES FORTRAN READ, WRITE.
FINEL -- 3/5

C NUTKX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
C STIFFNESS MATRICES (SAME AS GLOBAL LOADS TRANSFORMATION
C MATRICES) AND INVECS 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 25JOINT DATA USED IN SUBROUTINE FINEL)
2002 FORMAT (/35X 4THJOINT DATA USED IN SUBROUTINE FINEL (CONTINUED))
2003 FORMAT (/16X .8HDEGREES OF FREEDOM
* 1FX 2HGLOBAL CARTESIAN COORDINATES
* 12X 22HHEULER ANGLES (DEGREES)
* /14X 11HTRANSLATION 8X 8ROTATION
* /2X5HJOINT 6X1HV 5X1HV 5X1HP 5X1HQ 5X1HR
* IIX1HX IIIX1HY I1X1HZ 14X1HX 10X1HY 10X1HZ /)
2004 FORMAT (1X IS, 3X 6I6, 3X 3F12.4, 4X 3F11.4)
C
IF (NUTMX .GT. 0) REWIND NUTMX
IF (NUTKX .GT. 0) REWIND NUTKX
IF (NUT2 .GT. 0) REWIND NUT2
IF (NUTLT .GT. 0) REWIND NUTLT
IF (NUTST .GT. 0) REWIND NUTST
C
C DETERMINE SIZE OF FINAL MASS-STIFFNESS MATRIX FROM THE MAXIMUM DOF
C NUMBER IN JDOF.
D0 35 I=1,NJ
D0 35 J=1,NJ
IF (JDOF(I,J) .GT. NDCF) NDCF=JDOF(I,J)
35 CONTINUE
C
C PRINT JOINT DOF, XYZ COORDINATES, EULER ANGLES.
CALL PAGEHD
WRITE (NCT,2001)
WRITE (NCT,2003)
NLINE = 0
D0 40 IJ=1,NJ
NLINE = NLINE+1
IF (NLINE .LE. 42) GO TO 40
CALL PAGEHD
WRITE (NCT,2002)
WRITE (NCT,2003)
NLINE = 1
40 WRITE (NCT,2004) IJ, (JDOF(IJ,J), J=1,6), (XYZ(IJ,J)), J=1,3),
* (EUL(IJ,J), J=1,3)
C
C READ FINITE ELEMENT TYPE.
50 READ (NUTEL,1001) NAMEL
IF (NAMEL .EQ. 6HRETURN) GO TO 50C
IF NERROR = 1
GO TO 999

C @AR
FINITE ELEMEK (AXIAL ONLY).
110 CALL AXIAL (XYZ, JDCF, EUL, NUTEL, NJ,
* NUTMX, NUTKX, NULT, NUTST,
* W1, W2, W3, KRX, KRE, KW)
GO TO 50

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

C TRIANGULAR PLATE ELEMENT.
150 CALL TRKNG (XYZ, JDCF, EUL, NUTEL, NJ,
* NUTMX, NUTKX, NULT, NUTST,
* W1, W2, W3, KRX, KRE, KW)
GO TO 50

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

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

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

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

C TERMINATE FINITE ELEMENT DATA ON STORAGE DISKS.
500 IF (NUTMX .GT. 0) WRITE (NUTMX) IBLANK, (I1, I=1, 30)
IF (NUTKX .GT. 0) WRITE (NUTKX) IBLANK, (I1, I=1, 30)
IF (NUTP .GT. 0) WRITE (NUTP) IBLANK, (I1, I=1, 30)
IF (NULT .GT. 0) WRITE (NULT) IBLANK, (I1, I=1, 30)
IF (NUTST .GT. 0) WRITE (NUTST) IBLANK, (I1, I=1, 30)

C SUM FINITE ELEMENT MATRICES.
IF (NUTMX.GT.0) CALL YZER0 (NUTM, NDCF, NDCF)
IF (NUTKX.GT.0) CALL YZER0 (NUTK, NDCF, NDCF)
IF (NUTMX .GT. 0) CALL YRVA2D [NUTMX, NUTM, NDOF, W1, KW, V, LV, KV, NUT1, NUT2, NUT3] * IF (NUTKX .GT. 0) CALL YRVA2D [NUTKX, NUTK, NDOF, W1, KW, V, LV, KV, NUT1, NUT2, NUT3] * RETURN

999 CALL ZEROM (6HFINEL, NERROR)
END
SUBROUTINE FLUID (XYZ, JD, FY, EU, NEL, NJ,
*   NUTMX, NUTKX, NUTLT, NUST, 
*   W, T, S, KX, KJ, KE, KW)
DIMENSION XYZ(KX,1), JD, FY(KJ,1), EU(KE,1), W(KW,1),
*   T(KW,1), S(KW,1)
DIMENSION CJ(3,8), Ej(3,6), I1(24), I1VET(12), JM(4,16), VL(10),
*   D(l1(12), DIST(12,12), TV(24)
DATA N1W1NRST/24,1/; IBLNK/6H   //, I1ST /6/ 
DATA NIT,NUT/ 5,6/ 
DATA NAME1 /6HFLUID/ 
DATA K,CJ, /3,/ KJN /4/ 
DATA KDIST /12/, IFBAD /1/ 
DATA JM/1,2,3,4, 3,6,4,2, 2,6,4,5, 3,5,1,2/ 
*   1,3,6,5, 1,6,4,5, 2,1,4,5, 1,2,4,5, 
*   4,7,6,5, 5,2,7,6, 4,2,3,7, 1,3,9,6, 
*   1,6,8,5, 1,3,4,8, 1,2,3,6, 8,7,7,6 
C
C SUBROUTINE TO CALCULATE (ON OPTION) FINITE ELEMENT ... 
C MASS MATRICES AND DVECS (ON NUTMX), 
C STIFFNESS MATRICES (SAME AS GLOBAL LOAD TRANSFORMATION MATRICES) 
C AND DVECS (ON NUTKX), 
C PRESSURE TRANSFORMATION MATRICES AND DVECS (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)=0OMITS 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 (NUXM) NAME=N, NEL, NP, NC,NAMG,(IBLNX,I=1,5), 
C ((W(I,J),I=1,MR),J=1, NC),(IVEC(I),I=1, NC) 
C CALLS FORMA SUBROUTINES TEGFM,VCRSS,VDOO ,ZIBOM. 
C DEVELOPED BY CS EDDLEY. FEBRUARY 1974. 
C LAST REVISION BY WA BENFIELD. MARCH 1976. 
C
C INPUT DATA READ IN THIS SUBROUTINE FROM NUTEL. IF NUTEL = NIT, DATA IS 
C READ FROM CARDS. 
C NAME=N, NAMEK=NAMEL=NAMEST  FORMAT (4(A6,4X) 
C RC, EK  FORMAT (2(5X,E10)) 
C ZC NEL,J1,J2,J3,J4,J5,J6,J7,J8  FORMAT (915) 
C IF (J1 .EQ. 0) RETURN 
C GC TO 20 
C
C DEFINITION OF INPUT VARIABLES. 
C NAME=N = TYPE OF MASS MATRIX WANTED. 
C = M1, LUMPED MASS MATRIX.
C = M2, QUASI-IRRATIONAL CONSISTENT MASS MATRIX.
C = M3, IRRATIONAL MASS MATRIX.
C = 6P, OR 6HNOmass, NO MASS MATRIX CALCULATED.
C NAMEK = TYPE OF STIFFNESS MATRIX WANTED.
C = K1, LINEAR DISPLACEMENT ASSUMED.
C = 6H OR 6HNOstif, NO STIFFNESS MATRIX CALCULATED.
C NAMEFL = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES, (NOT YET).
C NAMEST = IDENTIFICATION NAME FOR PRESSURE TRANSFORMATION MATRICES.
C = 6H OR 6HNOst, NO PRESSURE TRANSFORMATIONS CALCULATED.
C R0 = MASS DENSITY.
C BKM = BULK MODULUS.
C NEL = FINITE ELEMENT NUMBER, FOR REFERENCE ONLY, NOT USED IN
C 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
C VIEWED FROM OUTSIDE THE ELEMENT.
C J5 = JOINT NUMBER AT ELEMENT VERTEX 5. (USED FOR PENTAHEDRON AND
C HEXAHEDRON).
C J6 = JOINT NUMBER AT ELEMENT VERTEX 6. (USED FOR PENTAHEDRON AND
C HEXAHEDRON).
C FOR A PENTAHEDRON, FACE 1,2,3 MUST BE NUMBERED CLOCKWISE AS
C VIEWED FROM OUTSIDE THE ELEMENT. FACE 4,5,6 IS NUMBERED IN
C THE SAME ORDER AS FACE 1,2,3. A LINE JOINING JOINTS 1 AND 4
C 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
C AS VIEWED FROM OUTSIDE THE ELEMENT. FACE 5,6,7,8 IS NUMBERED
C IN THE SAME ORDER AS FACE 1,2,3,4. A LINE JOINING JOINTS 1
C 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
C TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE JOINT
C X,Y,Z LOCATIONS RESPECTIVELY. SIF(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. SIF(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. SIF(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 NUTMX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
C MASS MATRICES AND IVECS ARE OUTPUT.
NUTMX MAY BE ZERO IF MASS MATRIX IS NOT FORMED.
USES FORTRAN READ, WRITE.

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

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

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

W = MATRIX WORK SPACE. MIN SIZE(24,24).
T = MATRIX WORK SPACE. MIN SIZE(24,24).
S = MATRIX WORK SPACE. MIN SIZE(24,24).

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

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

1001 FORMAT (5(A6,4X))
1002 FORMAT (3(I5,E10.0))
1003 FORMAT (9(I5))
2001 FORMAT (/25X,'INPUT DATA FOR FLUID (TETRA, PENTA, OR
* 21H HEXAHEDRON) ELEMENTS')
2002 FORMAT (/20X,'INPUT DATA FOR FLUID (TETRA, PENTA, OR
* 33H HEXAHEDRON) ELEMENTS (CONTINUED)')
2003 FORMAT (/12X,'MSS = A6, 13X7HSTIF = A6, 6X13HLOAD TRANS = A6,
* 3X15HSTRESS TRANS = A6, 3X
* /15X4HR = E10.3, 13X7HULKM = E10.3,
*//9X7HELEMENT 6 HJOINT 1 6X7HJOINT 2 6X7HJOINT 3 6X7HJOINT 4
* 6X7HJOINT 5 6X7HJOINT 6 6X7HJOINT 7 6X7HJOINT 8
* / 9X6HNUMBER)
2004 FORMAT (3X,9(I8,X,15))
3001 FORMAT (51H,*,*,*,*, *, UNCONVENTIONAL JOINT NUMBERING *,*,*,*,*,/, *
* 915)

C

IF (IIIST .LT. 1) GO TO 3
I1ST = 1
DO 4 I=1,4
II = 3*I - 2
DO 4 J=1,4
JJ = 3*J - 2
4 CALL UNITY (IIST,II),3,K1ST)
C
3 NLINE = 0
CALL PAGEHD
WRITE (NOT,2001)
READ (NUTE,L,1001) NAME,F,NAMEK,NAMELT,NAMEST
READ (NUTE,L,1002) RO, BKM
WRITE (NOT,2003) NAME,F,NAMEK,NAMELT,NAMEST,
* RO, BKM
IF (NAMEF .NE. 6) GO TO 20
DO 2 I=1,12
2 DIST(I,1) = 2.
C
20 READ (NUTE,L,1003) NEL, J1, J2, J3, J4, J5, J6, J7, J8
C
IF (J1 .LE. 0 .AND. IFRAD.EQ.-1) GO TO 999
IF (J1 .LE. 0) RETURN
NLNF = NLINE + 1
IF (NLF .LE. 42) GO TO 30
CALL PAGEHD
WRITE (NOT,2002)
WRITE (NOT,2003) NAME,F,NAMEK,NAMELT,NAMEST,
* RO, BKM
NLF = 0
30 WRITE (NOT,2004) NEL, J1, J2, J3, J4, J5, J6, J7, J8
NERRD=1
C
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,NCRL
DO 5 J=1,NCRL
W(I,J) = 0.
S(I,J) = 0.
5 T(I,J) = 0.

C
DO 40 I=1,3
CJ(I,1) = XYZ(J1,I)
CJ(I,2) = XYZ(J2,I)
CJ(I,3) = XYZ(J3,I)
CJ(I,4) = XYZ(J4,I)
EJ(I,1) = EUL(J1,I)
EJ(I,2) = EUL(J2,I)
EJ(I,3) = EUL(J3,I)
EJ(I,4) = EUL(J4,I)
IV1(I ) = JDOSF(J1,I)
IV1(I+3) = JDOSF(J2,I)

C

FLUID -- 4/ 6

-----------
IVL(I+6) = JDCF(J3, I)
40 IVL(I+9) = JDCF(J4, I)
  IF (LR .EQ. 1) GO TO 50
C
DO 42 J=1,3
  CJ(I,5) = XYZ(J5, I)
  CJ(I,6) = XYZ(J6, I)
  EJ(I,5) = EUL(J5, I)
  EJ(I,6) = EUL(J6, I)
IVL(I+12) = JDCF(J5, I)
42 IVL(I+15) = JDCF(J6, I)
  IF (LP .EQ. 6) GO TO 50
C
DO 44 J=1,3
  CJ(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)
44 IVL(I+21) = JDCF(J8, I)
C
50 DO 52 L=1,LR
  LA = L
  IF (LR .EQ. 10) LA=L+6
C
52 DO 55 I=1,NAMEM
  JNO = JM(I,LA)
  LI = 3#I - 2
  IVTET(L1) = 5#JNC - 2
  IVTET(L1+1) = 3#JNC - 1
  53 IVTET(L1+2) = 3#JNC
C
CALL TEGEOM (CJ, JM(I, LA), VL(L), DV, KCJ, IFEAD)
  IF (IFBAD .NE. 0) GO TO 51
  WRITE (NAMEM, 3001) NEL, J1, J2, J3, J4, J5, J6, J7, J8
  IFBAD = -1
  51 SM = RO*VL(L)/16.0
  IF (NAMEM .EQ. 6) SM=RO*VL(L)/20.0
  IF (LR .GT. 1) SM = SM/2.
  CALL REVADD (1*DV, L, IVTET, T, 12, LR, NCOL, I, KW)
  52 CALL REVADD (SM, DIST, IVTET, IVTET, W, 12, 12, NCOL, NCOL, KDIST, KW)
C
  IF (NAMEM .NE. 6) GO TO 220
  DO 210 I=1,NAMEM
    SAVE = 0.0
  DO 215 J=1,NAMEM
      SAVE = SAVE + W(I, J)
  215 W(I, J) = 0.0
  210 W(I, I) = SAVE
C
220 IF (LR .EQ. 1) GO TO 60
  DO 55 I=2,LR
    VL(I) = VL(I) + VL(I)
  DO 55 J=1,NAMEM
    55 T(I, J) = T(I, J) + T(I, J)
    VL(I) = VL(I)/2.
DC 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,NJN
   J1 = 3*J - 2
65 CALL EULE : (EJ(I,J),S(J1,J1),KW)
   IF (NAMEST .EQ. 6H .OR. NAMEST .EQ. 6HNOSTRS) GO TO 90
   CALL PRESS (CJ,T,KJN,NCOL,KCJ,KW)
   CALL MULTA (T5,T5,JN,NCOL,NCOL,KW,KW)
90 CALL RTAPA (W5,S,NCOL,NCOL,KW,KW)
   CALL MULTA (TV5,T5,NCOL,NCOL,1,KW)
   BOV = EKM/VL(I)
   DO 70 I=1,NCOL
   DO 70 J=1,NCOL
   S(I,J) = BOV*TV(I)*TV(J)
70 S(I,J) = S(I,J)

C IF (NAMEM .EQ. 6H .OR. NAMEM .EQ. 6HNCHammer) GO TO 110
   NERROR=3
   IF (NUMMX .LE. 0) GO TO 999
   WRITE (NUMMX) NAMEM,NEL,NCOL,NCOL,NAMEL,(I=1,5),
   * (W(I,J),J=1,NCOL), (V(I)),IV(I),I=1,NCOL)

C 110 IF (NAMEK .EQ. 6H .OR. NAMEK .EQ. 6HNOSTIF) GO TO 120
   NERROR=4
   IF (NUMTK .LE. 0) GO TO 999
   WRITE (NUMTK) NAMEK,NEL,NCOL,NCOL,NAMEL,(I=1,5),
   * (S(I,J),J=1,NCOL), (IV(I)),I=1,NCOL)

C 120 IF (NAMEST .EQ. 6H .OR. NAMEST .EQ. 6HNOSTRS) GO TO 20
   NERROR=5
   IF (NUMST .LE. 0) GO TO 999
   NJNP1 = NJN + 1
   CALL MULT (T5,S,T(NJNP1,NJN,NCOL,NCOL,KW,KW)
   CALL MULTA (TV5,T5,NCOL,NCOL,KW,KW)
   NRST = 2*KJN
   WRITE (NUMST) NAMEST,NEL,NRST,NCOL,NAMEL,VL(I),J=1,4,
   * (T(I,J),J=1,NRST), (IV(I)),I=1,NCOL)
   GO TO 20

C 999 CALL ZZBOMF (6HFLUID,NERROR)
END
SUBROUTINE GRAVITY (XYZ, JDOF, EUL, NUTEL, NJ,  
* NUTKX,  
* W, T, S, RX, KJ, KE, KW)  
DIMENSION XYZ(KX,1), JDOF(KJ,1), EUL(KE,1), W(KW,1),  
* (KW,1), S(KW,1)  
DIMENSION CJ(3,4), EJ(3,4), IVL(12), IVTRI(9), JM(3,4), GV(3), EV(3)  
DATA IBLNK/6H /  
DATA NIT, NIT/5, 6 /  
DATA NAMEL/6HGRAVITY /  
DATA KCEM/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- GL021-. 300R49-1T 4IR 090-5B  
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 CONSTRAINS  
C ELEMENT DOF 3 TO ZERO MOTION.  
C DATA ARRANGEMENT ON NUTKX FOR EACH FINITE ELEMENT IS  
C (W=K)  
C WRITE (NUTWX) NAMEN,NLEM,NRL,NC,NAMEL,(IBLNK,I=1,5),  
C (((W(J),J=1,NP),J=1,NC),(IVEC(I),I=1,NC)  
C CALLS FORMA SUBROUTINES KGRAV, MULTA, MULTS, VGRASS, ZZBOMB.  
C DEVELOPED BY C S BODLEY. FEBRUARY 1974.  
C LAST REVISION BY WA BENFIELD. MARCH 1976.  
C  
C*********************************************************************  
C INPUT DATA READ IN THIS SUBROUTINE FROM NUTEL. IF NUTEL = NIT, DATA IS  
C READ FROM CARDS.  
C NAMEN,NAMEN  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 (5I5)  
C IF (J1 = E0, 0) RETURN  
C GO TO 20  
C  
C DEFINITION OF INPUT VARIABLES.  
C NAMEN = TYPE OF MASS MATRIX WANTED.  
C = 6H OR 6HNOMASS, 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 J4 = JOINT NUMBER AT ELEMENT VERTEX 4. (USED FOR QUADRILATERAL).
C THE ELEMENT MUST BE NUMBERED CLOCKWISE AS VIEWED FROM THE FLUID SIDE
C OF THE ELEMENT.
C
C EXPLANATION OF INPUT FORMATS. NUMBER INDICATES CARD COLUMNS USED.
C I = INTEGER DATA, RIGHT ADJUSTED.
C F = DECIMAL POINT DATA, ANYWHERE IN FIELD. EXPONENT RIGHT ADJUSTED.
C X = CARD COLUMNS SKIPPED.
C
C SUBROUTINE ARGUMENTS (ALL INPUT)
C
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
C JDOF = MATRIX OF JOINT GLOBAL DEGREES OF FREEDOM. ROWS CORRESPOND
C TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE JOINT
C ROTATION DOFS AND COLUMNS 4,5,6 CORRESPOND TO THE JOINT
C T R A N S L A T I O N D O F S. SIZE(NJ,6).
C
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
C NUTEL = LOGICAL NUMBER OF TAPE CONTAINING ELEMENT INPUT DATA FOR
C THIS SUBROUTINE. IF NUTEL = NIT, DATA IS READ FROM CARDS.
C
C NJ = NUMBER OF JOINTS OR ROWS IN MATRICES (XYZ), (JDOF), (EUL).
C
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
C NUTKX MAY BE ZERO IF STIFFNESS MATRIX IS NOT FORMED.
C
C USES FORTRAN READ, WRITE.
C
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
C KX = ROW DIMENSION OF XYZ IN CALLING PROGRAM.
C KJ = ROW DIMENSION OF JDOF IN CALLING PROGRAM.
C KE = ROW DIMENSION OF EUL IN CALLING PROGRAM.
C KW = ROW DIMENSION OF W, T, AND S IN CALLING PROGRAM. MIN=12.
C
C NERDC'O EXPLANATION
C 1 = INPUT JOINT NUMBER EXCEEDS MAXIMUM ALLOWABLE NUMBER OF JOINTS.
C 2 = NUTKX NOT POSITIVE.
C
C 1001 FORMAT (5(A6,4X))
C 1002 FORMAT (3(5X,E10.0))
C 1003 FORMAT (5(I5))
C 2001 FORMAT (//25X,45HINPUT DATA FOR GRAVITY STIFFNESS (TRIANGLE OR
C * 24H QUADRILATERAL) ELEMENTS)
C 2002 FORMAT (//20X,45HINPUT DATA FOR GRAVITY STIFFNESS (TRIANGLE OR
C * 36H QUADRILATERAL) ELEMENTS (CONTINUED))
C 2003 FORMAT (/12X7HMACS = A6,13X7HSTIF = A6,6X
C * / 15X,4HRG = E10.3, 13X5HGXX = E10.3, 13X5HGYY = E10.3,
C * 13X5HGZV = E10.3,
C * //15X7HFLEMENT 13X7HJOINT 1 13X7HJOINT 2 13X7HJOINT 3
C * 13X7HJOINT 4
C * //15X6HNUMPER)
C 2004 FORMAT (16X,9(15,15X))
C
C NLINE = 0
CALL PAGEHD
WRITE (NOT,2001)
READ (NUTEL,1001) NAMEK,NNAMEK
READ (NUTEL,10C2) RO
READ (NUTEL,1002) (GV(I),I=1,3)
WRITE (NOT,2003) NAMEK,NNAMEK,
*       RC, (GV(I),I=1,3)

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,NNAMEK,
*       RC, (GV(I),I=1,3)
   NLINE = 0
30 WRITE (NOT,2004) NEL,J1,J2,J3,J4

   NERRDR=1
   IF (JL.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

   DO 40 I=1,3
    CJ(I,1) = XYZ(J1,I)
    CJ(I,2) = XYZ(J2,I)
    CJ(I,3) = XYZ(J3,I)
    EJ(I,1) = FUL(J1,I)
    EJ(I,2) = FUL(J2,I)
    EJ(I,3) = FUL(J3,I)
    IVL(I) = JDCF(J1,I)
    IVL(I+3) = JDCF(J2,I)
40 IVL(I+6) = JDCF(J3,I)
   IF (LP .GE. 1) GO TO 50

   DO 42 I=1,3
    CJ(I,4) = XYZ(J4,I)
    EJ(I,4) = FUL(J4,I)
42 IVL(I+9) = JDCF(J4,I)
C
50 G = SQRT(GV(1)**2 + GV(2)**2 + GV(3)**2)
   DO 51 I=1,3
51 EV(I) = -GV(I)/G
   DO 52 :-1,LR
       CALL KGRAV (CJ,JM(I,L1),EV,A,W,KW,KCJM)
   C
   DO 53 I=1,3
       JNO = JM(I,L1)
       L1 = 3*I - 2
       IVTRI(L1) = 2*JNO - 2
       IVTRI(L1+1) = 2*JNO - 1
53 IVTRI(L1+2) = 3*JNO
       SS = RO*G*A/24.
       IF (LR .GT. 1) SS = SS/2.
   52 CALL REVADD (SS,W,IVTRI,IVTRI,S,9,9,NCOL,NCOL,KW,KW)
   C
   DO 65 J=1,NJN
       J1 = 3*J - 2
   65 CALL EULEP (FJ(I,J),T(J1,J1),KW)
   CALL ETABA (S,T,NCOL,NCOL,KW,KW)
   C
   IF (NAMEK .EQ. '6H' .OR. NAMEK .EQ. '6HNOSTIF') GO TO 20
   NERROR=2
   IF (NUTKY .LE. 0) GC TO 999
   WRITE (NUTKY) NAMEK,NFL,NCOL,NCOL,NAMEL,(IBLNK,I=1,5),
     * ((S(I,J),I=1,NCOL),J=1,NCOL), (IV1(I),I=1,NCOL)
   C
   GO TO 20
   C
999 CALL ZZERO (6HGRAVITY,NERROR)
     END
SUBROUTINE KIA1 (A1,A2,RL,E,2,TS,KZ,KTS)
DIMENSION Z(K2,1), TS(KTS,1)

C C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C STIFFNESS MATRIX,
C STRESS TRANSFORMATION MATRIX,
C FOR AN AXIAL ROD ELEMENT WITH UNRESTRICTED BOUNDARIES.
C ROD MAY BE LINEARLY TAPERED OR UNIFORM.
C CONSTANT FORCE ASSUMED.
C STIFFNESS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C STRESS TRANSFORMATION MATRIX RELATES STRESS AT ROD ENDS IN LOCAL
C COORDINATE SYSTEM TO DEFLECTIONS IN LOCAL COORDINATE SYSTEM.
C ROW ORDER IN STRESS TRANSFORMATION MATRIX IS
C SIGMA-X1, SIGMA-X2
C WHERE SIGMA X: NORMAL STRESS.
C SX1(-), SX2(+) IS TENSION. SX1(+), SX2(-) IS COMPRESSION.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE ROD TO LIE ALONG THE X AXIS
C WITH JOINT 1 AT THE ORIGIN, JOINT 2 ALONG THE POSITIVE X AXIS.
C LOCAL COORDINATE ORDER IS
C DX1,DX2
C WHERE DX IS TRANSLATION.
C DEVELOPED BY RL WOHLEN. SEPTEMBER 1972.
C LAST REVISION BY RL WOHLEN. SEPTEMBER 1973.
C
C 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 (AMS(R-1.) .GT. .01) S = (A2-A1)*E / (RL*ALOG(R))

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

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

C RETURN
END
SUBROUTINE KIP1 (B11,B12,C1,C2,A1,A2, SF,RL,E,G,Z,TS,K2,KTS)
DIMENSION Z(K2,1), 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 UNRESTRANDED BOUNDARIES.
C BEAM MAY BE LINEARLY TAPERED OR UNIFORM.
C UNIFORM SHEAR AND LINEAR BENDING MOMENT VARIATION IS ASSUMED.
C SHEAR STIFFNESS USES SF*A1*G AND SF*A2*G. IF ANY OF THESE VARIABLES
C ARE ZERO, THERE IS NO SHEAR DEFORMATION IN BENDING.
C STIFFNESS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C STRESS TRANSFORMATION MATRIX RELATES STRESS AT BEAM ENDS IN LOCAL
C COORDINATE SYSTEM TO DEFLECTIONS IN LOCAL COORDINATE SYSTEM.
C ROW ORDER IN STRESS TRANSFORMATION MATRIX IS
C TAU-X1,TAU-X2, SIGMA-X1, SIGMA-X2
C WHERE SIGMA IS NORMAL STRESS (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 D1,D2,TY1,TY2
C WHERE D1 IS TRANSLATION AND TY IS ROTATION.
C DEVELOPED BY RL WOHLER. FEBRUARY 1973.
C LAST REVISION BY RL WOHLER. 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 PL = INPUT ROD LENGTH.
C E = INPUT YOUNG'S MODULUS OF ELASTICITY.
C G = INPUT SHEAR MODULUS OF ELASTICITY. CAN BE ZERO FOR NO SHEAR
C DEFORMATION IN BENDING.
C Z = OUTPUT STIFFNESS MATRIX. SIZE(4,4).
C TS = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(4,4).
C 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.
  PPI = F12/F11
  REIM1 = PPI-1.
  IF (ARCSIN(REIM1) *.LT. .01) GO TO 15
  ERR = F*REIM1*P*IM1
  REILN = ALOG(ERR)
F11 = (r - 1.*)/(RIM1 + RIM1/R(1)**2) * (R(1)**3) / EBR
F12 = (1. - RIM1/R(1)**4) * (R(1)**2) / EBR
F22 = RL/RIM1 / EBR
GO TO 20
15 F11 = R(1)**3 / (3.*E*B11)
F12 = R(1)**2 / (2.*E*E*B11)
F22 = RL/ (E*B11)

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.101) 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) = C*0
TS(2,J) = C*0
IF (A1*.GT.0.0) TS(1,J) = Z(1,J)/A1
IF (A2*.GT.0.0) TS(2,J) = Z(2,J)/A2
TS(3,J) = Z(3,J)*C1/B11
55 TS(4,J) = Z(4,J)*C2/E12
C
RETURN
END
SUBROUTINE KIC1 (TJ1, TJ2, R1, R2, RL, G, Z, TS, K2, KTS)
DIMENSION Z(KZ,1), TS(KTS,1)
C
C SUBROUTINE TO CALCULATEFINITE ELEMENT...
C STIFFNESS MATRIX,
C STRESS TRANSFORMATION MATRIX,
C FOR A TORSION ROD ELEMENT WITH UNESTRAINED BOUNDARIES.
C ROD MAY BE LINEARLY TAPERED OR UNIFORM.
C CONSTANT TORQUE ASSUMED.
C STIFFNESS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C STRESS TRANSFORMATION MATRIX RELATES STRESS AT ROD ENDS IN LOCAL
C COORDINATE SYSTEM TO ROTATIONS IN LOCAL COORDINATE SYSTEM.
C ROW ORDER IN STRESS TRANSFORMATION MATRIX IS
C TAU-X1, TAU-X2
C WHERE TAU IS SHEAR STRESS.
C STRESS IS + CR - AS RIGHT HAND AXI SS BETWEEN END F. INTS 1 AND 2.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE ROD TO LIE ALONG THE X AXIS
C WITH JOINT 1 AT THE ORIGIN, JOINT 2 ALONG THE POSITIVE X AXIS.
C LOCAL COORDINATE ORDER IS
C TX1, TX2
C WHERE TX IS ROTATION.
C LAST REVISION BY RL WOHLEN. 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*R1**3 FOR A THIN WALLED CIRCULAR
C CYLINDER.
C TJ2 = INPUT CROSS-SECTION SAINT VENANTS TORSION CONSTANT (J) IN JG
C AT ROD END 2.
C R1 = INPUT DISTANCE FROM TORSION AXIS TO CUTER FIBER AT ROD END 1.
C R2 = INPUT DISTANCE FROM TORSION AXIS TO CUTER 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 = OUTPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=2.
C KTS = OUTPUT 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
C STRESS TRANSFORMATION MATRIX.
TS(1,1) = Z(1,1)*R1/TJ1
TS(1,2) = Z(1,2)*R1/TJ1
TS(2,1) = Z(2,1)*R2/TJ2
TS(2,2) = Z(2,2)*R2/TJ2
C
RETURN
END
DIMENSION Z(KZ,1),T(KT,1),R(KR,1)
DIMENSION XT(3),ET(3)

C
SUBROUTINE TO CALCULATE FINITE ELEMENT...
C
STIFFNESS MATRIX,
C
STRESS TRANSFORMATION MATRIX,
C
FOR A MEMBRANE TRIANGLE PLATE ELEMENT WITH UNRESTRAINED BOUNDARIES.
C
QUADRATIC DISPLACEMENT (LINEAR STRAIN) FIELD IS USED.
C
STIFFNESS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C
STRESS TRANSFORMATION MATRIX RELATES STRESS AT TRIANGLE VERTICES
C
IN LOCAL COORDINATE SYSTEM TO DEFORMATIONS IN THE LOCAL SYSTEM.
C
ROW ORDER IN STRESS TRANSFORMATION MATRIX IS
C
(SIGMA-X,SIGMA-Y,TAU-XY) JOINT 1, THEN JOINT 2, 3.
C
WHERE SIGMA IS NORMAL STRESS AND TAU IS SHEAR STRESS.
C
THE LOCAL COORDINATE SYSTEM ASSUMES THE PLATE TO BE IN AN X-Y PLANE
C
WITH JOINT 1 AT THE X-Y ORIGIN, JOINT 2 LIES ALONG THE POSITIVE
C
X AXIS, AND JOINT 3 IS IN THE POSITIVE Y DIRECTION.
C
LOCAL COORDINATE ORDER IS
C
(DX,DY,DZ) JOINT 1, THEN JOINT 2, 3.
C
WHERE DX,DY ARE TRANSLATION, AND DZ IS ROTATION.
C
CALLS FOPMA SUBROUTINES ETAEA AND MULTA.
C
DEVELOPED BY CS EDDLEY, WA EENFIELD. MARCH 1973.
C
C
C
SUBROUTINE ARGUMENTS
C
X2 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 2.
C
X3 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 3.
C
Y3 = INPUT LOCAL Y COORDINATE LOCATION OF JOINT 3.
C
TH = INPUT PLATE THICKNESS.
C
E = INPUT YOUNG'S MODULUS OF ELASTICITY.
C
ANU = INPUT POISSON'S RATIO. (E/2G)-1.
C
Z = OUTPUT STIFFNESS MATRIX. SIZE(9,9).
C
T = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(9,9).
C
R = OUTPUT MATRIX WORK SPACE. SIZE(8,9).
C
KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=9.
C
KT = INPUT ROW DIMENSION OF T IN CALLING PROGRAM. MIN=9.
C
KR = INPUT ROW DIMENSION OF R IN CALLING PROGRAM. MIN=8.
C
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.ge.E-6) RETURN
X22 = X2*X2
Y32 = Y3*Y3
X2Y3 = X2*Y3
SE1 = X3/Y2
G = E/(2.*(1.-ANU**2))
DD = E*TH/(1.-ANU**2)
DNU = DD*ANU
DG = G*TH
DO 15 I = 1, 8
DC 15 J = 1, 9
15 R(I, J) = 0.

C

F00 = X2Y3/2.
F10 = X2Y3*(1. + SE1)/6.
F01 = X2Y3/6.
F20 = X2Y3*(1. + SE1 + SE1**2)/12.
F11 = X2Y3*(1. + 2.*SE1)/24.
F02 = X2Y3/12.

C

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

C

R(1, 1) = -1.
R(1, 1) = 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, 9) = -Y3
R(5,2) = -1.  
R(5,3) = X2  
R(5,5) = 1.  
R(5,6) = -X2  
R(6,2) = 5E1 - 1.  
R(6,5) = -5E1  
R(6,6) = X3  
R(6,8) = 1.  
R(6,9) = -X3  
R(7,3) = -X2  
R(7,6) = X2  
P(8,3) = X2*(5E1 - 1.)  
R(5,y0) = -X3  
R(8,9) = X2

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

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

C
D'11 = DC/TH
D12 = ANU*D11
D33 = G
XE(1) = 0.  
XE(2) = 1.  
XF(3) = 5E1  
ET(1) = 0.  
ET(2) = 0.  
ET(3) = 1.  
DC 20 I=1,3
K1 = 3*I - 2
K2 = K1 + 1
K3 = K1 + 2
T(K1,1) = D11/X2
T(K1,5) = D11*ET(1)/X2
T(K1,6) = D12/Y3
T(K1,9) = D12*XF(1)/Y3
T(K2,1) = D12/X2
T(K2,3) = D12*ET(1)/X2
T(K2,6) = D11/Y3
T(K2,9) = D11*XF(1)/Y3
T(K3,2) = D33/Y2
T(K3,3) = D33*XF(1)/Y3
T(K3,5) = 2.*D33*ET(1)/Y3
T(K3,7) = 2.*D33*XE(1)/X2
50 T(K3,9) = .*:ET(1)/X2

CALL MULT. (T,R,9,8,9,KT,KR)

C
RETURN
END
SUBROUTINE K261 (X2,X3,Y3,Th,E,ANU,Z,TS,T,KZ,KTS,KT)
DIMENSION Z(KZ,1),TS(KTS,1),T(KT,1)
DIMENSION PC(10,10),IVEG(10),CCEF(9),XE(3),ET(3)
C
C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C
C STIFFNESS MATRIX.
C STRESS TRANSFORMATION MATRIX.
C FOR A BENDING TRIANGLE PLATE ELEMENT WITH UNPRESSED BOUNDARIES.
C CUBIC DISPLACEMENT (LINEAR CURVATURE) FIELD IS USED.
C STIFFNESS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C STRESS TRANSFORMATION MATRIX RELATES STRESS AT JOINTS IN LOCAL
C COORDINATE SYSTEM TO DEFLECTIONS IN THE LOCAL SYSTEM.
C ROW ORDER IN STRESS TRANSFORMATION MATRIX IS
C (SIGMA-X,SIGMA-Y,TAU-XY) FOR (Z-TH/2) AT JOINT 1, THEN JOINT 2, 3,
C (SIGMA-X,SIGMA-Y,TAU-XY) FOR (Z-TH/2) AT JOINT 1, THEN JOINT 2, 3.
C WHERE SIGMA IS NORMAL STRESS AND TAU IS SHEAR STRESS.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE PLATE TO LIE IN AN X-Y PLANE
C WITH JOINT 1 AT THE X-Y ORIGIN, JOINT 2 LIES ALONG THE POSITIVE
C X AXI.S, AND JOINT 3 IS IN THE POSITIVE Y DIRECTION.
C LOCAL COORDINATE ORDER IS
C (XZ,TX,TY) JOINT 1, THEN JOINT 2, 3.
C WHERE DZ IS TRANSLATION AND TX, TY ARE ROTATIONS.
C CALLS FORMA SUBROUTINES ETAEA AND MLATA.
C DEVELOPED BY CS EDDLEY. MARCH 1973.
C
C SUBROUTINE ARGUMENTS
C X2 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 2.
C X3 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 3.
C Y3 = INPUT LOCAL Y COORDINATE LOCATION OF JOINT 3.
C Th = INPUT PLATE THICKNESS.
C E = INPUT YOUNG'S MODULUS OF ELASTICITY.
C ANU = INPUT POISSON RATIO. (E/2G)-1.
C Z = OUTPUT STIFFNESS MATRIX. SIZE(9,9).
C TS = OUTPUT LOCAL STRESS TRANSFORMATION MATRIX. SIZE(18,9).
C T = OUTPUT MATRIX WORK SP. CF. SIZE(10,10).
C K2 = INPUT FLOW DIMENSION OF 2 IN CALLING PROGRAM. MIN=9.
C KTS = INPUT FLOW DIMENSION OF TS IN CALLING PROGRAM. MIN=18.
C KT = INPUT FLOW DIMENSION OF T IN CALLING PROGRAM. MIN=10.
C
DC 10 J=1,10
DC 20 J=1,10
10 Z(J+1,1)= 0.0
DC 10 J=1,10
DC 10 J=1,10
11 TS(1,J)= 0.0
IF (Th .LE. 0.0) UTURN
C
DC 12 J=1,10
DC 12 J=1,10
12 T(J+1,1)= 0.0
X22 = X2*X2
Y24 = Y2*Y2
Y32 = Y3*Y3
Y34 = Y32*Y32
\[
\begin{align*}
SE1 &= X3/X2 \\
SE2 &= SE1*SE1 \\
SE3 &= SE2*SE1 \\
SE4 &= SE3*SE1 \\
SC1 &= (1. + SE1)/3. \\
SEC2 &= SC1**2 \\
SEC3 &= SC1**3 \\
G &= E/(2. + 2.*ANU) \\
DD &= (E*TT)**3/(12.*(1. - ANU**2)) \\
DNU &= DD*ANU \\
DG &= (G*TH**3)/12. \\
AL &= DD/Y: \\
FE &= DNU/(X22+Y32) \\
GA &= CD/Y34 \\
DE &= 4.*DG/(X22+Y32) \\
\end{align*}
\]

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</tr>
<tr>
<td>T(9,10)</td>
<td>2.*</td>
</tr>
<tr>
<td>T(9,2)</td>
<td>1.</td>
</tr>
<tr>
<td>T(9,5)</td>
<td>2.*SE1</td>
</tr>
<tr>
<td>T(9,6)</td>
<td>1.</td>
</tr>
<tr>
<td>T(9,7)</td>
<td>2.*SE2</td>
</tr>
<tr>
<td>T(9,4)</td>
<td>2.*SE1</td>
</tr>
<tr>
<td>T(9,9)</td>
<td>1.</td>
</tr>
<tr>
<td>T(10,1)</td>
<td>1.</td>
</tr>
<tr>
<td>T(10,2)</td>
<td>SE1</td>
</tr>
<tr>
<td>T(10,3)</td>
<td>1.</td>
</tr>
<tr>
<td>T(10,4)</td>
<td>SE2</td>
</tr>
</tbody>
</table>
$T(10,5) = \sec 1/3$.
$T(10,6) = 1./9$.
$T(10,7) = \sec 2$.
$T(10,8) = \sec 2/3$.
$T(10,9) = \sec 1/9$.
$T(10,10) = 1./27$.

C
DO 5 I=1,10
DO 7 J=1,10

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

C
DC 160 L=1,10
JEIG = 1
A1 = ABS(T(L,1))
DC 15 J=2,10
A2 = ABS(T(L,J))
IF (A2 .LT. A1) GO TO 15
A1 = A2
JEIG = J

15 CONTINUE
IVEC(L) = JEIG
ALJIEG = T(L,JEIG)
DC 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 ("*".EQ."L") GC 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 55 J=1,10

50 R(I,J) = T(I,J)

C
DC 26 I=1,10
R(I,2) = Y2*X(I,2)
R(I,3) = -Y2*X(I,3)
R(I,4) = Y2*X(I,4)
R(I,5) = -Y2*X(I,5)
R(I,6) = Y2*X(I,6)
R(I,7) = Y2*X(I,7)
20 R(I,8) = -Y2*X(I,8)

C
COEFF(1) = 1./2.
COEFF(2) = Y2./1.
COEFF(3) = -(X2+X2)/1E-
COEFF(4) = 1./2.
COEF(5) = Y3/18.
COEF(6) = (2.0*X2 - X3)/18.
COEF(7) = 1.0/2.
COEF(9) = (2.0*X3 - X2)/18.
DO 80 I=1,10
DO 80 J=1,9
80 R(I,J) = R(I,J) + R(I,10)*COEF(J).
C
DC 55 I=1,10
DO 55 J=1,10
55 T(I,J) = 0.
C
F00 = X2*Y3/2.
F10 = X2*Y3*(1.0 + SE1)/6.
F01 = X2*Y3/6.
F20 = X2*Y3*(1.0 + SE1 + SE2)/12.
F11 = X2*Y3*(1.0 + 2.0*SE1)/24.
F02 = X2*Y3/12.
C
T(4,4) = 4.*AL*F00
T(4,6) = 4.*EE*F00
T(4,7) = 12.*AL*F10
T(4,8) = 4.*AL*F01
T(4,9) = 4.*EE*F10
T(4,10) = 12.*EE*F01
T(5,5) = DF*F00
T(5,8) = 2.*DE*F10
T(5,9) = 2.*DE*F01
T(6,6) = 4.*GA*F00
T(6,7) = 12.*EE*F10
T(6,8) = 4.*EE*F01
T(6,9) = 4.*GA*F10
T(6,10) = 12.*GA*F01
T(7,7) = 26.*AL*F20
T(7,8) = 12.*AL*F11
T(7,9) = 12.*EE*F20
T(7,10) = 36.*EE*F11
T(8,8) = 4.*AL*F02 + 4.*DE*F20
T(8,9) = 4.*EE*F11 + 4.*DE*F11
T(8,10) = 12.*EE*F02
T(9,9) = 4.*GA*F20 + 4.*DE*F02
T(9,10) = 12.*GA*F11
T(10,10) = 26.*GA*F02
C
DC 60 I=1,10
DC 60 J=1,10
60 T(I,J) = T(I,J)
CALL ETAFA(T,10,4,K1,10)
DC 85 I=1,6
DC 85 J=1,6
85 Z(I,J) = T(I,J)
C
DC 73 I=1,9
DC 73 J=1,10
73 T(I,J) = 0.0
D11 = -6.0*DD/((X2*TH)**2)
D21 = ANU*0.11
D22 = -6.0*DD/((Y3*TH)**2)
D12 = ANU*0.22
D33 = -12.0*DD/((X2*Y3)*TH**2)
XE(1) = C
XE(2) = 1
XE(3) = SE1
ET(1) = 0
ET(2) = 0
ET(3) = 1
DO 75 I = 1, 3
K1 = 3*I - 2
K2 = K1 + 1
K3 = K1 + 2
T(K1,4) = 2.*D11
T(K1,6) = 2.*D12
T(K1,7) = 6.*D11*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)
75 T(K3,9) = 2.*D33*ET(I)
CALL MULTA(T,K3,10,9,KT,16)
DO 77 I = 1, 9
IF9 = I + 9
DO 77 J = 1, 9
T5(I,J) = T(I,J)
77 T5(IP0,J) = -T5(I,J)
C
RETURN
END
SUBROUTINE K3C1 (X3,Y3,TH,G,Z,T,KZ,KT)
DIMENSION Z(KZ,1), T(KT,1)

C
C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C STIFFNESS MATRIX,
C STRESS TRANSFORMATION MATRIX,
C FOR A RECTANGULAR SHEAR PANEL ELEMENT WITH UNRESTRAINED BOUNDARIES.
C LINEAR DISPLACEMENT (CONSTANT STRAIN) FIELD IS USED.
C STIFFNESS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C STRESS TRANSFORMATION MATRIX RELATES PANEL SHEAR STRESS (CONSTANT)
C IN LOCAL COORDINATE SYSTEM TO DEFLECTIONS IN THE LOCAL SYSTEM.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE PANEL TO LIE IN AN X-Y PLANE
C WITH JOINT 1 AT THE X-Y ORIGIN, JOINT 2 LIES ALONG THE POSITIVE
C X AXIS, JOINT 3 IS IN THE POSITIVE X,Y DIRECTION, AND JOINT 4 LIES
C ALONG THE POSITIVE Y AXIS.
C LOCAL COORDINATE ORDER IS
C DX1,DX2,DX3,DY4, DY1,DY2,DY3,DY4
C WHERE DX,DY ARE TRANSLATIONS.
C DEVELOPED BY RL WOHLER, APRIL 1974.
C
C SUBROUTINE ARGUMENTS
C X3 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 3.
C Y3 = INPUT LOCAL Y COORDINATE LOCATION OF JOINT 3.
C TH = INPUT PANEL THICKNESS.
C G = INPUT SHEAR MODULUS OF ELASTICITY.
C Z = OUTPUT STIFFNESS MATRIX. SIZE(F,B).
C T = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(T,B).
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=8.
C KT = INPUT ROW DIMENSION OF T IN CALLING PROGRAM. MIN=1.
C
C STIFFNESS MATRIX.
C = TH*G/4.
A = 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(2,1) = A
Z(2,2) = A
Z(2,3) = -A
Z(2,4) = -A
Z(2,5) = C
Z(2,6) = -C
Z(2,7) = -C
Z(2,8) = C
Z(3,1) = A
Z(3,2) = A
Z(3,3) = -C
Z(3,4) = C
Z(3,5) = -C
Z(3,6) = C
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) = -F
Z(5,8) = F
Z(6,6) = E
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(JM,1), EV(1),
DIMENSION F(3,3), R12(3), R13(3), VN(3), F(3,3)
DATA KEF / 3 /
C
C SUBROUTINE TO DERIVE STIFFNESS MATRIX FOR A TRIANGULAR GRAVITY ELEMENT.
C CALLS SUBROUTINES MULTA, MULTB, VCRoss.
C DEVELOPED BY C S EDDLEY. FEBRUARY 1974.
C LAST REVISION BY C S EDDLEY. NOVEMBER 1974.
C SUBROUTINE ARGUMENTS
C CJ = INPUT MATRIX OF JOINT COORDINATES. SIZE (3,4).
C JM = INPUT MATRIX OF JOINTS DEFINING A TRIANGLE. SIZE (3).
C EV = INPUT VECTOR NORMALIZED GRAVITY. SIZE = 3.
C A = OUTPUT AREA.
C W = OUTPUT STIFFNESS MATRIX.
C KW = INPUT ROW DIMENSION SIZE OF W IN CALLING PROGRAM. MIN=9.
C KCJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM. MIN=3.
C
J1 = JM(1 )
J2 = JM(2 )
J3 = JM(3 )
DO 5 I=1,9
DO 5 J=1,2
W(I,J) = 0.
5 E(J,I) = 0.
DO 7 I=1,3
R12(I) = CJ(I,J2) - CJ(I,J1)
R13(I) = CJ(I,J3) - CJ(I,J1)
DO 8 J=1,3
8 F(I,J) = 1.
7 F(I,1) = 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
II = 3*I - 3
ACUM = ACUM + VN(I)*EV(I)
DO 15 J=1,2
E(I,II+J) = VN(I)
15 W(II+J,1) = VN(I)
C
CALL MULTB (F,E,3,2,9,KEF,KEF)
CALL MULTA (W,E,3,9,KW,KEF)
A = A*ACUM*ACUM*ACUM
C
RETURN
END
SUBROUTINE MIA1 (A1,A2,RL,RO,Z,KZ)
DIMENSION 2(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 FLOW DIMENSION OF Z IN CALLING PROGRAM. MIN=2.
C
W1 = A1*RL*RO/6.
W2 = A2*RL*RO/6.
Z(1,1) = 2*W1 + W2
Z(1,2) = 0.
Z(2,1) = 0.
Z(2,2) = W1 + 2*W2
C
RETURN
END
SUBROUTINE M1A2  (A1,A2,RL,RC,Z,KZ)
DIMENSION Z(KZ,1)

SUBROUTINE TO CALCULATE FINITE ELEMENT...
CONSISTENT MASS MATRIX
FOR AN AXIAL ROD ELEMENT WITH UNRESTRAINED BOUNDARIES.
ROD MAY BE LINEARLY 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.
ROL = 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 C LUMPED MASS MATRIX
C C FOR A BENDING BEAM ELEMENT WITH UNRESTRAINED BOUNDARIES.
C C BEAM MAY BE LINEARLY TAPERED OR UNIFORM.
C C MASS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C C THE LOCAL COORDINATE SYSTEM ASSUMES THE BEAM TO LIE IN THE X-Z PLANE
C C WITH JOINT 1 AT THE ORIGIN, JOINT 2 ALONG THE POSITIVE X AXIS.
C C LOCAL COORDINATE ORDER IS
C C D21, D22, TY1, TY2
C C WHERE D2 IS TRANSLATION AND TY IS ROTATION.
C C LAST REVISION BY RL WCHLEN. SEPTEMBER 1975.
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 RO = INPUT MASS DENSITY.
C Z = OUTPUT MASS MATRIX. SIZE(4,4).
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=4.
C
W1 = A1*FL*RO/6.
W2 = A2*FL*RO/6.
DO 10 J=1,4
DO 10 I=1,4
10 Z(I,J) = 0.0
Z(1,1) = 2.0*W1 + W2
Z(1,2) = W1 + 2.*W2
Z(4,4) = (A2*RO*RL*Z**3)/24.

RETURN
END
SUBROUTINE M182 (A1,A2,RL,K0,Z,KZ)
DIMENSION Z(KZ,1)

C
C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C CONSISTENT MASS MATRIX
C FOR A BENDING BEAM ELEMENT WITH UNRESTRAINED BOUNDARIES.
C BEAM MAY BE LINEARLY TAPERED OR UNIFORM.
C CUBIC DISPLACEMENT FUNCTION ASSUMED.
C MASS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE BEAM TO LIE IN THE X-Z PLANE
C WITH JOINT 1 AT THE ORIGIN, JOINT 2 ALONG THE POSITIVE X AXIS.
C LOCAL COORDINATE ORDER IS
C DZ1,DZ2,TY1,TY2
C WHERE DZ IS TRANSLATION AND TY IS ROTATION.
C DEVELOPED BY RL WOLLEN, 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 K0 = INPUT MASS DENSITY.
C Z = OUTPUT MASS MATRIX, SIZE(4,4).
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM, MIN=4.
C
W1 = A1*RL*K0/4.0
W2 = A2*RL*K0/4.0
RL2 = RL**2
Z(1,1) = 240.*W1 + 72.*W2
Z(1,2) = 54.*W1 + 54.*W2
Z(2,2) = 72.*W1 + 240.*W2
Z(1,3) = -( 30.*W1 + 12.*W2)*RL
Z(1,4) = ( 12.*W1 + 14.*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)

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*PL*RO/6.*
W2 = PI2*PL*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, Z, KZ)
DIMENSION Z(KZ, 1)

C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C CONSISTENT MASS MATRIX
C FOR A TORSION FOD 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 TY IS ROTATION.
C LAST REVISION BY RL WOHLEN. SEPTEMBER 1973.

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

W1 = PI1*RO*RO/12.
W2 = PI2*RL*RO/12.
Z(1, 1) = 3*W1 + W2
Z(1, 2) = W1 + W2
Z(2, 1) = Z(1, 2)
Z(2, 2) = W1 + 3*W2

RETURN
END
SUBROUTINE M2A1 (X2,Y3,TH,RC,Z,KZ)
DIMENSION Z(KZ,1)

C C SUBROUTINE 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 Y-Y ORIGIN, JOINT 2 LIES ALONG THE POSITIVE
C X AXIS, AND JOINT 3 IS IN THE POSITIVE Y DIRECTION.
C LOCAL COORDINATE ORIGIN IS
C (EX,EY,TZ) JOINT 1, THEN JOINT 2, 3.
C WHERE EX,EY ARE TRANSLATIONS AND TZ IS ROTATION.
C DEVELOPED BY WZ BENFIELD. FEBRUARY 1972.
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 = (RC*TH)/AREA/3.0
DO 10 IC = 1,6
    DO 10 I = 1,6
         10 Z(I,J) = CM
    DO 20 IC = 1,6
         20 Z(I,J) = CM
RETURN
END


SUBROUTINE M2A2 (X2, X3, Y3, TH, PNC, Z, T, R, KZ, KT, KR)
DIMENSION Z(KZ, 1), T(KT, 1), R(KR, 1)

CONSISTENT MASS MATRIX,
FOR A REGULAR 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
OX, OY, OZ; JOINT 1, THEN JOINT 2, 3.
WHERE OX, OY ARE TRANSLATIONS AND OZ IS ROTATION.
CALLED FROM SUBROUTINES E111A.
DEVELOPED BY CF EKELLY. MARCH 1973.
LAST REVISION BY WA BIRKINFIELD. 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.
RHC = INPUT MASS DENSITY.
Z = OUTPUT MASS MATRIX. SIZE(9,9).
T = OUTPUT MATRIX WORK SPACE. SIZE(10,10).
R = OUTPUT MATRIX WORK SPACE. SIZE(10,10).
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
X2Y3 = X2*Y3*TH:

DO 10 I=1,16
   DO 10 J=1,16
   T(I,J) = 0.
   R(I,J) = 0.
10 CONTINUE

FCC = Y2Y3/2.
F10 = X2Y3**3(1. + SE1)/6.
F11 = X2Y3**3/6.
F20 = X2Y3**3(1. + SE1 + SE2)/12.
F11 = X2Y3**3(1. + 2.*SE1)/24.
F20 = X2Y3**3/12.
F50 = X2Y3**3(1. + SE1 + SE2 + SE3)/20.
F21 = X2Y3**3(1. + 2.*SE1 + 3.*SE2)/60.
F12 = X2Y3**3(1. + 3.*SE1)/60.
F22 = X2Y3**3/20.
F44 = X2Y3**3(1. + SE1 + SE2 + SE3 + SE4)/30.
F51 = X2Y3**3(1. + 2.*SE1 + 3.*SE2 + 4.*SE3)/120.
F22 = X2Y3**3(1. + 3.*SE1 + 6.*SE2)/180.
\[
F_{13} = x_2 y_3 (1 + 4 * S E_1) / 120
\]
\[
F_{04} = x_2 y_3 / 30
\]

| T(1, 1) | F0C       |
| 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) | F10       |
| T(5, 5) | F04       |
| T(6, 6) | F10       |
| T(6, 7) | F01       |
| T(6, 8) | F01       |
| T(6, 9) | F20       |
| T(6, 10) | F11      |
| T(7, 7) | F20       |
| T(7, 8) | F11       |
| T(7, 9) | F20       |
| T(8, 10) | F21     |
| T(8, 10) | F22     |
| T(9, 10) | F22     |
| DC 20 J=1, 10 |
| DO 30 J=1, 10 |

3C T(J+1, 1) = T(J, 1)
\begin{align*}
R(0,5) &= -x_1 \\
R(0,6) &= x_3 \\
R(0,8) &= 1. \\
R(0,9) &= -x_2 \\
R(0,10) &= x_5 \\
R(10,2) &= y_2*(x_1 - 1.) \\
R(11,6) &= -x_3 \\
R(10,9) &= x_2 \\
\end{align*}

C

\textbf{CALL PTAEA (T,R,10,9,KT,KP)}

DC 40 I=1,0

DC 40 J=1,0

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

C

\textbf{RETURN}

\textbf{END}
SUBROUTINE M261 (X2, Y3, TH, RO, Z, KZ)
DIMENSION Z(KZ,1)

SUBROUTINE TO CALCULATE FINITE ELEMENT...
LUMPED MASS MATRIX.
FOR A HINGED TRIANGLE PLATE ELEMENT WITH UNRESTRAINED BOUNDARIES.
MASS MATRIX IS IN LOCAL COORDINATE SYSTEM.
THE LOCAL COORDINATE SYSTEM ASSUMES THE PLATE TO LIE IN AN X-Y PLANE.
WITH JOINT 1 AT THE X-Y ORIGIN, JOINT 2 LIES ALONG THE POSITIVE X AXIS, AND JOINT 3 IS IN THE POSITIVE Y DIRECTION.
LOCAL COORDINATE ORDER IS
(D2, TX, TY) JOINT 1, THEN JOINT 2, 3.
WHERE D2 IS TRANSLATION AND TX, TY ARE ROTATIONS.
DEVELOPED BY WA BINFIELD, FEBRUARY 1973.

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

AREA = 0.5*X2*Y3
CM = (RO*TH*AREA)/3.0
DO 10 I=1,9
DO 10 J=1,9
10 Z(I,J) = 0.0
DO 20 I=1,9
20 Z(I,1) = CM
RETURN
END
SUBROUTINE M2F2 (X2, X3, Y3, TH, FHO, Z, T, P, KZ, KT, KR)
DIMENSION Z(KZ, 1), T(KT, 1), P(KR, 1)
DIMENSION IVEC(10), CCEF(19)

C C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C C CONSISTENT MASS MATRIX,
C FOR A BENDING TRIANGLE PLATE ELEMENT WITH UNRESTRAINED BOUNDARIES.
C CUBIC DISPLACEMENT (LINEAR CURVATURE) FIELD IS USED.
C THIS IS NOT THE S' CALLED STRICKLAND ELEMENT.
C MASS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE PLATE TO LIE IN AN X-Y PLANE
C WITH JOINT 1 AT THE X-Y ORIGIN, JOINT 2 LIES ALONG THE POSITIVE
C X AXIS, AND JOINT 3 IS IN THE POSITIVE Y DIRECTION.
C LOCAL COORDINATE CHECK IS
C (D2, TX, TY) JOINT 1, THEN JOINT 2, 3.
C WHERE D2 IS TRANSLATION AND TX, TY ARE ROTATIONS.
C CALLS FROM SUBROUTINES GATAE,
C DEVELOPED BY CAFI POOLEY MARCH 1973.
C LAST REVISION BY WA BENFIELD. SEPTEMBER 1973.

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

C SE1 = X2/X3.
C SE2 = SE1*SE1
C SE3 = SE2*SE2
C SE4 = SE2*SE3
C SE5 = SE3*SE3
C SE6 = SE5*SE3
C SE7 = (1. + SE1)/3.
C SE8 = SE7*SE7
C SE9 = SE1*SE8
C
C CC 10 J=1,10
CC 10 J=1,10
10 T(J, J) = 0.

C T(1, 1) = 1.
C T(2, 2) = 1.
C T(3, 3) = 1.
C T(4, 4) = 1.
C T(4, 4) = 1.
C T(4, 7) = 1.
C 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(10,10) = 1./27.

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

C
DO 100 L=1,16
JREG = 1
A1 = AER(T(L,1))
DO 15 J=2,16
A2 = AER(T(L,J))
IF (A2 .LE. A1) GO TO 15
A1 = A2
JREG = J
15 CONTINUE
IVEC(L) = JREG
ALREG = T(L,JREG)
DO 17 J=1,10
T(L,J) = T(L,J)/AJJFIG
17 R(L,J) = R(L,J)/AJJBIG
DC 25 I=1,10
AJJFIG = T(I+1,J+1)
 IF (I .EQ. L) GO TO 25
 DO 30 J=1,10
 T(I,J) = T(I,J) - AJJBIG*T(L,J)
30 R(I,J) = R(I,J) - AJJBIG*R(L,J)
25 CONTINUE
100 CONTINUE

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

C
DO 20 I=1,9
R(I+2) = Y3*R(I+2)
R(I+3) = -X2*R(I+3)
R(I+5) = Y3*R(I+5)
R(I+6) = -X2*R(I+6)
R(I+8) = Y3*R(I+8)
20 R(I+4) = -X2*R(I+4)

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 60 I=1,10
DO 60 J=1,9
60 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
FG0 = X2Y3/2.
F10 = X2Y3*(1. + SE1)/6.
FG1 = X2Y3/6.
F20 = Y2*Y3*(1. + SE1 + SE2)/12.
F11 = X2Y3*(1. + 2.*SE1)/24.
FG2 = Y2*Y3/12.
F30 = X2Y3*SE1 + SE2 + SE3)/20.
F21 = X2Y3*(1. + 2.*SE1 + 3.*SE2)/60.
F12 = X2Y3*(1. + 3.*SE1)/60.
FG3 = X2Y3/20.
F40 = X2Y3*(1. + SE1 + SE2 + SE3 + SE4)/30.
F31 = X2Y3*(1. + 2.*SE1 + 3.*SE2 + 4.*SE3)/120.
F22 = X2Y3*(1. + 3.*SE1 + 6.*SE2)/180.
F13 = X2Y3*(1. + 4.*SE1)/120.
F04 = X2Y3/30.
F50 = X2Y3*(1. + SE1 + SE2 + SE3 + SE4 + SE5)/42.
F32 = X2Y3*(1. + 3.*SE1 + 6.*SE2 + 10.*SE3)/420.
F23 = X2Y3*(1. + 4.*SE1 + 10.*SE2)/420.
F14 = X2Y3*(1. + 5.*SE1)/210.
F05 = X2Y3/42.
F60 = X2Y3*(1. + SE1 + SE2 + SE3 + SE4 + SE5 + SE6)/56.
F42 = X2Y3*(1. + 3.*SE1 + 6.*SE2 + 10.*SE3 + 15.*SE4)/840.
F33 = X2Y3*(1. + 4.*SE1 + 10.*SE2 + 20.*SE3)/1120.
F24 = X2Y3*(1. + 5.*SE1 + 15.*SE2)/840.
F15 = X2Y3*(1. + 6.*SE1)/336.
F06 = X2Y3/56.

T(1,1) = F00
T(1,2) = F10
T(1,3) = F01
T(1,4) = F20
T(1,5) = F11
T(1,6) = F02
T(1,7) = F30
T(1,8) = F21
T(1,9) = F12
T(1,10) = F03
T(2,2) = F20
T(2,3) = F11
T(2,4) = F03
T(2,5) = F21
T(2,6) = F12
T(2,7) = F40
T(2,8) = F31
T(2,9) = F22
T(2,10) = F13
T(3,3) = F02
T(3,4) = F21
T(3,5) = F12
T(3,6) = F03
T(3,7) = F31
T(3,8) = F22
T(3,9) = F13
T(3,10) = F04
T(4,4) = F40
T(4,5) = F31
T(4,6) = F22
T(4,7) = F50
T(4,8) = F41
T(4,9) = F32
T(4,10) = F23
T(5,5) = F22
T(5,6) = F13
\[ T(5,7) = F41 \]
\[ T(5,8) = F32 \]
\[ T(5,9) = F23 \]
\[ T(5,10) = F14 \]
\[ T(6,6) = F64 \]
\[ T(6,7) = F22 \]
\[ T(6,8) = F23 \]
\[ T(6,9) = F14 \]
\[ T(6,10) = F05 \]
\[ T(7,7) = F66 \]
\[ T(7,8) = F51 \]
\[ T(7,9) = F42 \]
\[ T(7,10) = F33 \]
\[ T(8,8) = F42 \]
\[ T(8,9) = F33 \]
\[ T(8,10) = F24 \]
\[ T(9,9) = F24 \]
\[ T(9,10) = F15 \]
\[ T(10,10) = F06 \]

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(1,J) = T(1,J)
C
RETURN
END
SUBROUTINE M3C1 (X3,Y3,TH,RO,Z,KZ)
DIMENSION Z(2,1)

C SUBROUTINE TO CALCULATE FINITE ELEMENT ...
C LUMPED MASS MATRIX
C FOR A RECTANGULAR SHEET PANEL ELEMENT WITH UNRESTRAINED BOUNDARIES.
C MASS MATRIX IS IN LOCAL COORDINATE SYSTEM.
C THE LOCAL COORDINATE SYSTEM ASSUMES THE PANEL TO LIE IN AN X-Y PLANE.
C WITH JOINT 1 AT THE X-Y ORIGIN, JOINT 2 LIES ALONG THE POSITIVE
C X AXIS, JOINT 3 IS IN THE POSITIVE X,Y DIRECTION, AND JOINT 4 LIES
C ALONG THE POSITIVE Y AXIS.
C LOCAL COORDINATE ORDER IS
C DX1,DX2,DY2,DY4, DY1, DY2, DY3, DY4
C WHERE DX, DY ARE TRANSLATIONS.
C DEVELOPED BY RL WOHLLEN. APRIL 1974.
C
C SUBROUTINE ARGUMENTS
C X3 = INPUT LOCAL X COORDINATE LOCATION OF JOINT 3.
C Y3 = INPUT LOCAL Y COORDINATE LOCATION OF JOINT 3.
C TH = INPUT PANEL THICKNESS.
C RO = INPUT MASS DENSITY.
C Z = OUTPUT MASS MATRIX. SIZE(8,8).
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=8.
C
CM = RO*TH*X3*Y3/4.0
DO 10 J=1,8
DC 10 I=1,8
10 Z(I,J) = CM
DO 20 I=1,8
20 Z(I,1) = CM

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

DIMENSION CJ(KCJ,1), EJ(KEJ,1), Z(3,1)

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, MIA1, MIA2, ZZBOMB.

DEVELOPED BY RL WOHLEN. SEPTEMBER 1972.

LAST REVISION BY WA BENFIELD. MARCH 1976.

SUBROUTINE ARGUMENTS

CJ = INPUT MATRIX OF GLOBAL X, Y, Z COORDINATES AT ROD JOINTS.

ROWS 1, 2, 3 CORRESPOND TO X, Y, Z COORDINATES.

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

EJ = INPUT MATRIX OF EULER ANGLES (DEGREES) AT ROD JOINTS.

ROWS 1, 2, 3 CORRESPOND TO GLOBAL X, Y, Z PERMUTATION.

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

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.

NEROR EXPLANATION

1 = DIMENSION SIZE EXCEEDED (KZ).

2 = NAMEM IMPROPERLY DEFINED.

IF (KZ .LT. 6) GO TO 999

DC 5 J=1,6

DO 5 J=1,6

5 Z(I,J) = 0.0

RL = SQRT((CJ(1,2)-CJ(1,1))**2 + (CJ(2,2)-CJ(2,1))**2

* + (CJ(3,2)-CJ(3,1))**2)

IF (NAMEM .EQ. 6MM1 ) GO TO 110

IF (NAMEM .EQ. 6MM2 ) GO TO 126

GO TO 999

LUMPED.

110 CALL MIA1 (A1, A2, RL, FC, W, 2)

DC 112 I=1,5

112 Z(I,1) = W(I,1)
DO 114 I=4,6
114 Z(I,1) = W(2,2) 
RETURN 

C CONSISTENT.
120 CALL M1A2 (A1,A2,RL,RO,W,2)
   DO 122 T=1,3
122 Z(I,1) = W(1,1)
   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,1) = Z(I,1)
   DO 126 I=4,6
126 Z(I,1) = W(2,2)
   RETURN 

C 999 CALL ?ZBUMB (6HMAS1A,NERROR)
END.
SUBROUTINE MAS16 (CJ,EJ,A1,A2,P12,RO,NAMEM,Z,W,KEJ,KZ,KW)
DIMENSION CJ(KCJ,1), EJ(KEJ,1), Z(KZ,1), W(KW,1)

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

C SUBROUTINE ARGUMENTS
C CJ = INPUT MATRIX OF GLOBAL X,Y,Z COORDINATES AT BAR JOINTS.
C ROWS 1,2,3 CORRESPOND TO 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 A1 = INPUT CROSS-SECTION AREA AT BAR END 1.
C A2 = INPUT CROSS-SECTION AREA AT BAR END 2.
C P11 = INPUT CROSS-SECTION POLAR AREA MOMENT OF INERTIA AT END 1.
C P12 = 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 = INPUT WORK SPACE MATRIX. SIZE(12,12).
C KEJ = 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.

C LREF PROP EXPLANATION
C 1 = DIMENSION SIZE EXCEEDED KZ,KW).
C 2 = NAMEM IMPROPERLY DEFINED.

C
IF (KZ .LT. 12 .OR. KW .LT. 12) GO TO 999
DI 5 J=1,12
DO 9 J=1,12
5 7(I,J)=CO
9 RL = SOFT((CJ(1,1)-CJ(1,1))**2 + (CJ(1,2)-CJ(2,1))**2
* + (CJ(3,2)-CJ(3,1))**2)
IF (NAMEM .EQ. 'M1') GO TO 110
IF (NAMEM .EQ. 'M2') TC 120

ERRCR=1
C AXIAL=M1A1 (LUMPED), TORSION=M1C1 (LUMPED), BENDING=M1B1 (LUMPED).
110 CALL M1A1 (A1, A2, RL, PC, Z, KZ)
  CALL M1C1 (PI1, PI2, RL, PC, Z(3, 3), KZ)
  CALL M1B1 (A1, A2, RL, PC, Z(5, 5), KZ)
  CALL M1R1 (A1, A2, RL, PC, Z(9, 9), KZ)
  GO TO 330

C AXIAL=M1A2 (LINEAR DISP), TORSION=M1C2 (LINEAR DISP),
C BENDING=M1F2 (CURIC DISP).
120 CALL M1A2 (A1, A2, RL, PC, Z, KZ)
  CALL M1C2 (PI1, PI2, RL, PC, Z(3, 3), KZ)
  CALL M1F2 (A1, A2, RL, PC, Z(5, 5), KZ)
  DO 125 J=7,8
  DO 125 I=5,6
  Z(I, J) = -Z(I, J)
  125 Z(J, I) = -Z(J, I)
  CALL M1F2 (A1, A2, RL, PC, Z(9, 9), KZ)

C 300 CALL DCOS1F (CJ, EJ, KW, KCJ, KEJ, KW)
  CALL NTABA (Z, W, 12, 12, KZ, KW)
  RETURN

C 999 CALL Z2EPPX (6, MASIE, NERPOP)
  END
SUBROUTINE MAS2 (CJ,EJ,TMAS,RO,NAMEM,Z,W1,W2,KCJ,KEJ,KZ,KW1,KW2)

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

DIMENSION IVEC(11)

DATA IVEC/C1,2,6,7,8,12,13,14,18, 3,4,5,9,10,11,15,16,17/

C
C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C 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) JOINT 1, THEN JOINT 2, 3.
C WHERE U,V,W ARE TRANSLATIONS AND P,Q,R ARE ROTATIONS.
C EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
C CALLS FOR SUBROUTINES ETAE,DCCE2,M2A1,M2A2,M2B1,M2B2,ZZBOMB.
C DEVELOPED BY WA FENWICK, FL WOCHEN. FEBRUARY 1973.
C LAST REVISION BY KS 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 TMAS = INPUT EFFECTIVE MASS THICKNESS.
C RO = INPUT MASS DENSITY.
C NAMEM = INPUT TYPE OF MASS MATRIX WANTED.
C = M1, LUMPED.
C = M2, CONSISTENT.
C Z = OUTPUT MASS MATRIX. SIZE(18,18).
C W1 = INPUT WORK SPACE MATRIX. SIZE(18,18).
C W2 = INPUT WORK SPACE MATRIX. SIZE(10,10).
C KCJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM. MIN=3.
C KEJ = INPUT ROW DIMENSION OF EJ IN CALLING PROGRAM. MIN=3.
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=18.
C KW1 = INPUT ROW DIMENSION OF W1 IN CALLING PROGRAM. MIN=18.
C KW2 = INPUT ROW DIMENSION OF W2 IN CALLING PROGRAM. MIN=10.
C
C NEPROP EXPLANATION
C 1 = DIMENSION SIZE EXCEEDED (KZ,KW1,KW2).
C 2 = NAMEM IMPROPERLY DEFINED.
C
NEPROP=1

IF (KZ LT. 1E OR. KW1 LT. 1E OR. KW2 LT. 10) GO TO 999
DC S,J=1,1P
DC $ I=1,1P
S Z(I,J) = C* (*
SL12 = SQRT((CJ(1,2)-CJ(1,1))**2 + (CJ(2,2)-CJ(2,1))**2
  + (CJ(3,2)-CJ(3,1))**2)
SL23 = SQRT((CJ(1,1)-CJ(1,2))**2 + (CJ(2,3)-CJ(2,2))**2
  + (CJ(3,3)-CJ(3,2))**2)
SL13 = SQRT((CJ(1,2)-CJ(1,1))**2 + (CJ(2,3)-CJ(2,2))**2
  + (CJ(3,3)-CJ(3,1))**2)
X3 = (SL12**2 + SL12**2 + SL23**2)/(2.0*SL12)
Y3 = SQRT(SL13**2-X3**2)
IF (NAMEEM .EQ. 6HM1) GO TO 110
IF (NAMEEM .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=1,10
IZ = IVFC(IW)
115 Z(IZ,IZ) = W1(IW,IW)
RETURN

C MEMERANE = M2A2 (CONSISTENT), BENDING = M2E2 (CONSISTENT).
120 CALL M2A2 (SL12,X3,Y3,TMAS,KC,Z,W1,W2,KZ,KW1,KW2)
CALL M2E2 (SL12,X3,Y3,TMAS,P0,Z(10,10),W1,W2,KZ,KW1,KW2)
CALL DCOS2 (CJ,EJ,W1,KCJ,KEJ,KW1)
CALL RTABA (Z,W1,18,1F,KZ,KW1)
RETURN

C 999 CALL ZZCMB (*HMAS2 , NEFDR) 
END
SUBROUTINE MAS3 (CJ,EJ,TMAS,RC,NAMEM,Z,W1,2,KCJ,KEJ,KZ,KW1,KW2) 
DIMENSION (JJKCJ,1),EJ(KEJ,1),Z(KZ,1),W1(KW1,1),W2(KW2,1) 
DIMENSION CW13,3), CW13,1), IV118), IV218), IV318), IV418), 
* W311,1) 
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 
UNRESTRAINED BOUNDARIES. 
MASS MATRIX IS IN GLOBAL COORDINATE DIRECTIONS. 
GLOBAL COORDINATE ORDER IS 
(U,V,W,P,Q,R) JOINT 1, THEN JOINT 2, 3, 4. 
WHERE U,V,W ARE TRANSLATIONS AND P,Q,R ARE ROTATIONS. 
EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION. 
CALLS FORMA SUBROU TINES MAS2,FFVADD,ZZPOMP. 
DEVELOPED BY WA BENEFIELD, RL WOHLLEN. FEBRUARY 1973. 
LAST REVISION BY W. BENEFIELD. MARCH 1976. 

SUBROUTINE ARGUMENTS 
CJ = INPUT MATRIX OF GLOBAL X,Y,Z COORDINATES AT QUAD JOINTS. 
RCWS 1,2,3 CORRESPOND TO X,Y,Z COORDINATES. 
CCWS 1,2,3,4 CORRESPOND TO JOINTS 1,2,3,4 SIZE(3,4). 
EJ = INPUT MATRIX OF EULER ANGLES (DEGREES) AT QUAD JOINTS. 
RCWS 1,2,3 CORRESPOND TO GLOBAL X,Y,Z PERMUTATION. 
CCWS 1,2,3,4 CORRESPOND TO JOINTS 1,2,3,4 SIZE(3,4). 
TMAS = INPUT EFFECTIVE MASS THICKNESS. 
RD = INPUT MASS DENSITY. 
NAMEM = INPUT TYPE OF MASS MATRIX WANTED. 
= M1, LUMPED. 4 TRIANGLES, OVERLAP AVERAGE. 
= M2, CONSISTENT. 4 TRIANGLES, OVERLAP AVERAGE. 
C = 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. 

NERRCR = ERROR CONDITION 
1 = DIMENSION SIZE EXCEEDED (KZ,KW1,KW2). 
2 = NAMEM IMPROPERLY DEFINED. 

IF (KZ .LT. 24 .OR. KW1 .LT. 18 .OR. KZ .LT. 18) GO TO 999 
00 5 = 1,24 
00 6 = 1,24 
5 ( I,J ) = 0,0 
IF (NAMEMEQK1,6,6) GO TO 110 
IF (NAMEMEQK1,6,6) GO TO 110 
NERRCR=1 
999 
GO TO 110 
NERRCR=2
GO TO 990

C

110 DO 112 I=1,3
   CW(I,1) = CJ(I,1)
   EW(I,1) = EJ(I,1)
   CW(I,2) = CJ(I,2)
   EW(I,2) = EJ(I,2)
   CW(I,3) = CJ(I,3)
112 EW(I,3) = EJ(I,3)
   CALL MAS2 (CW,EW,THAS,RO,NAMEM,W1,W2,W3,3,3,KW1,KW2,10)
   CALL REVADD (.5,W1,IV1,IV1,2, 18,18,24,24, KM1,KZ)
   DC 113 I=1,3
   CW(I,1) = CJ(I,1)
   EW(I,1) = EJ(I,1)
   CW(I,2) = CJ(I,2)
   EW(I,2) = EJ(I,2)
   CW(I,3) = CJ(I,3)
113 EW(I,3) = EJ(I,4)
   CALL MAS2 (CW,EW,THAS,RC,NAMEM,W1,W2,W3,3,3,KW1,KW2,10)
   CALL REVADD (.5,W1,IV2,IV2,2, 18,18,24,24, KM1,KZ)
   DC 114 I=1,3
   CW(I,1) = CJ(I,1)
   EW(I,1) = EJ(I,1)
   CW(I,2) = CJ(I,2)
   EW(I,2) = EJ(I,2)
   CW(I,3) = CJ(I,4)
114 EW(I,3) = EJ(I,4)
   CALL MAS2 (CW,EW,THAS,RC,NAMEM,W1,W2,W3,3,3,KW1,KW2,10)
   CALL REVADD (.5,W1,IV3,IV3,2, 18,18,24,24, KM1,KZ)
   DC 115 I=1,3
   CW(I,1) = CJ(I,2)
   EW(I,1) = EJ(I,2)
   CW(I,2) = CJ(I,3)
   EW(I,2) = EJ(I,2)
   CW(I,3) = CJ(I,4)
115 EW(I,2) = EJ(I,4)
   CALL MAS2 (CW,EW,THAS,RC,NAMEM,W1,W2,W3,3,3,KW1,KW2,10)
   CALL REVADD (.5,W1,IV4,IV4,2, 18,18,24,24, KM1,KZ)
   RETURN

C

999 CALL ZZ6CM8 (SHMAS3 ,NERROR)
END
SUBROUTINE MAS3A (CJ, EJ, TMAS, RO, NAMEN, Z, W1, W2, KCJ, KEJ, KZ, KW1, KW2)
DIMENSION CJ(KCJ, 1), EJ(KEJ, 1), Z(KZ, 1), W1(KW1, 1), W2(KW2, 1)
C
C 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) Joints 1, then Joint 2, 3, 4.
C WHERE U, V, W ARE TRANSLATIONS.
C EULER ANGLE CONVERSION IS GLOBAL X, Y, Z PERMUTATION.
C CALLS FEM SUBROUTINES M3C1, Z1C0ME.
C DEVELOPED BY RL WOHLEN, APRIL 1974.
C LAST REVISION BY RL WOHLEN, 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 NAMEN = INPUT TYPE OF MASS MATRIX WANTED.
C = M1, LUMPED.
C Z = OUTPUT MASS MATRIX. SIZE(12, 12).
C W1 = INPUT WORK SPACE MATRIX. SIZE(12, 12).
C W2 = INPUT WORK SPACE MATRIX. SIZE(12, 12).
C KCJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM. MIN=3.
C KEJ = INPUT ROW DIMENSION OF EJ IN CALLING PROGRAM. MIN=3.
C KZ = INPUT ROW DIMENSION OF Z IN CALLING PROGRAM. MIN=3.
C KW1 = INPUT ROW DIMENSION OF W1 IN CALLING PROGRAM. MIN=3.
C KW2 = INPUT ROW DIMENSION OF W2 IN CALLING PROGRAM. MIN=3.
C
C NERROR EXPLANATION
C 1 = DIMENSION SIZE EXCEEDED (K2, KW1, KW2).
C 2 = NAMEN IMPROPERLY DEFINED.
C
C IF (KZ .LT. 12 .OR. KW1 .LT. 12 .OR. KW2 .LT. 0) 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 (NAMEN .EQ. 'C', 'LUMPED') GO TO 110
NERROR=1
C
C LUMPED.
110 FO 112 J=1,12
DC 112 J=1,12
112 Z(L,L,J) = 0.
CALL M3C1 (SL12, SL14, TMAS, RO, W1, W2)
GO TO 999
C
C NERROR=2
GO TO 999
C
C
IZ = 3*(IW-1)
Z(IZ+1,IZ+1) = W1(IW,IW)
Z(IZ+2,IZ+2) = W1(IW,IW)
115 Z(IZ+3,IZ+3) = W1(IW,IW)
RETURN

C
999 CALL ZZBOMB (6HAM3A ,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(9)

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

C

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

C

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

C

DO 20 N=1,NTF
LOC = N + LC
J1 = JNM(1,LOC)
J2 = JNM(2,LOC)
J3 = JNM(3,LOC)
VN(1) = (CJ(2,J2)-CJ(2,J1))*CJ(3,J3)-CJ(3,J1)
* -(CJ(3,J2)-CJ(3,J1))*CJ(2,J3)-CJ(2,J1)
VN(2) = (CJ(3,J2)-CJ(3,J1))*CJ(1,J3)-CJ(1,J1)
* -(CJ(1,J2)-CJ(1,J1))*CJ(3,J3)-CJ(3,J1)
VN(3) = (CJ(1,J2)-CJ(1,J1))*CJ(2,J3)-CJ(2,J1)
* -(CJ(2,J2)-CJ(2,J1))*CJ(1,J3)-CJ(1,J1)
C = SCNRF(VN(1)*VN(1) + VN(2)*VN(2) + VN(3)*VN(3))
20 DC 25 I=1,3
25 VN(1) = VN(1)/AC
AC = AC/4F.
IF (LC + LT 6) AC = 2*AC
DO 30 I=1,2
IV(I) = JNM(1,LOC)
DC 30 J=1,3
J1 = 3*1 - 3 + J
JL = (IV(I) - 1)*3 + J
30 JV(J1) = JL

C

DC 25 L=1,3
DC 35 L=1-2
IL = I + 2*(L - 1)
DO 35 J=1,3
   F = 1.
   IF (L .GE. J) F = 2.
35 C(J,IL) = F*VNI(I)
   CALL REVADD (AC,C,IV,JV,T,3,9,NJN,NCOL,3,KW)
20 CONTINUE
C
   DO 40 I=1,NJN
   DO 40 J=1,NJN
      A(I,J) = 0.
   DO 40 K=1,NCOL
40   A(I,J) = A(I,J) + T(I,K)*T(J,K)
   CALL INVINV (A,A,NJN,8)
   CALL MULTE (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 (IN NUTMX),
UNIT LOAD EUCKLING MATRICES AND IVECS (ON NUTBX), (NOT YET)
LOCAL LOAD TRANSFORMATION MATRICES AND IVECS (ON NUTLT), (NOT YET)
STRESS TRANSFORMATION MATRICES AND IVECS (ON NUTST), (NOT YET)

FOR COMBINED MEMBE-ENDING QUADRILATERAL PLATE ELEMENTS.

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

GLOBAL COORDINATE ORDER IS

(UV,VW,FX,GP) JOINT 1, THEN JOINT 2, 3, 4.
WHERE UV ARE TRANSLATIONS AND PC,G Are ROTATIONS.
IVEC GIVES ELEMENT DCO INTO GLOBAL DDO. EXAMPLES...

IVEC(6)=834 PLACES ELEMENT DCO 6 INTO GLOBAL DDO 834.
IVEC(3)=0 OMITS ELEMENT DDO 3 FROM GLOBAL DDO. THIS CONSTRAINTS
ELEMENT DDO 3 TO ZERO MOTION.

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

(PP,PU,PW,MP,PK) JOINT 1, THEN JOINT 2, 3, 4.
WHERE P IS FORCE AND M IS MOMENT.
LOCAL LOAD TRANSFORMATION MATRICES RELATES LOAD AT QUAD VERTICES IN
LOCAL COORDINATE SYSTEM TO DEFORMATIONS IN THE GLOBAL COORDINATE
DIRECTIONS.

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

DATA ARRANGEMENT ON NUTMX, NUTEX, NUTEX, NUTLT, NUTST FOR EACH FINITE
ELEMENT IS (W=M,K,P,L,T,S)
WRITE (NUTMX) NAMEW,NFL,NTK,NTC,NAMEL,(IBLNK,I=1,5),
((W(J,J),J=1,NTC),J=1,NTC)
IVES FOR ROUTINES M33, PAGEH, SF3, ZPOMP.

DEVELOPED BY WA FENFIELD, CS HODLEY, RL WHLLEN. MARCH 1973.
LAST REVISION BY RL WHLLEN. MAY 1976.

**************INPUT DATA READ IN THIS SUBROUTINE FROM NUTEL. IF NUTEL = 5, DATA IS
READ FROM CARDS.**************

NAMEX,NAMEK,NAMELT,NAMEST,NAMEE FORMAT (5(A6,4X)
PC,EP,NU FORMATTER (3(5X,E10)
TMSX,TMSY,TMNC
20 NEX,JE,J2,JE,TMNC
IF (J1 = 0 . U) RETURN
G0 TO 20

---------
C DEFINITION OF INPUT VARIABLES.
C NAMEM = TYPE OF MASS MATRIX WANTED.
C       = M1, DIAGONAL LUMPED, OVERLAP AVERAGE OF FOUR
C       = M2, CONSISTENT, OVERLAP AVERAGE OF FOUR
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 6HCSTIF, NO STIFFNESS MATRIX CALCULATED.
C NAMELT = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES.
C       = 6H OR 6HCLOAD, NO LOAD TRANSFORMATIONS CALCULATED.
C NAMEST = IDENTIFICATION NAME FOR STRESS TRANSFORMATION MATRICES.
C       = 6H OR 6HCSTRES, NO STRESS TRANSFORMATIONS CALCULATED.
C NAMEB = TYPE OF BUCKLING MATRIX WANTED.
C       = 6H OR 6HCBUCK, NO BUCKLING MATRIX CALCULATED.
C RC = MASS DENSITY.
C E = YOUNG'S MODULUS OF ELASTICITY.
C ANU = POISSON'S RATIO (E/(2G)).
C TMASC = EFFECTIVE MASS THICKNESS, (CONSTANT).
C TMASV = EFFECTIVE MASS THICKNESS, (VARIABLE).
C IF .LE. 0., TMASC IS USED.
C TMEMC = EFFECTIVE MEMBRANE THICKNESS, (CONSTANT).
C TMENV = EFFECTIVE MEMBRANE THICKNESS, (VARIABLE).
C IF .LE. 0., TMEMC IS USED.
C TBENC = EFFECTIVE BENDING THICKNESS, (CONSTANT).
C TEENV = EFFECTIVE BENDING THICKNESS, (VARIABLE).
C IF .LE. 0., TBENC IS USED.
C NEL = FINITE ELEMENT NUMBER, FOR REFERENCE ONLY, NOT USED IN
C       CALCULATIONS. WRITTEN ON NUTMX, ETC.
C J1 = JOINT NUMBER AT QUADRILATERAL VERTEX 1.
C J2 = JOINT NUMBER AT QUADRILATERAL VERTEX 2.
C J3 = JOINT NUMBER AT QUADRILATERAL VERTEX 3.
C J4 = JOINT NUMBER AT QUADRILATERAL VERTEX 4.
C C EXPLANATION OF INPUT ... MATS. NUMER INDICATES CARD COLUMNS USED.
C I = INTEGER DATA, RIGHT ADJUSTED.
C E = DEcimal POINT DATA, ANYWHERE IN FIELD, EXPONENT RIGHT, ADJUSTED
C X = CARD COLUMNS SKIPPED.
C ***************************************************************************
C C SUBROUTINE ARGUMENTS (ALL INPUT)
C XYZ = MATRIX OF JOINT GLOBAI 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 DEGREES AND COLUMNS 4,5,6 CORRESPOND TO THE JOINT
C ROTATION DEGREES. 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 COUNTER CLOCKWISE PERMUTATION. SIZE(NJ,3).
C NUTEL = LOGICAL NUMBER OF TAPE CONTAINING ELEMENT INPUT DATA FOR
C THIS SUBROUTINE. IF NUTEL = 5, DATA IS READ FROM CARDS.
C NJ = NUMBER OF JOINTS IF ROWS IN MATRICES (XYZ), (JDOP), (EUL).
C NUTMX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
C MASS MATRICES AND INVECS 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 NULT = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT LOCAL
C LOAD TRANSFORMATION MATRICES AND IVECS ARE OUTPUT.
C NULT MAY BE ZERO IF LOAD TRANSFORMATIONS ARE NOT FORMED.
C USES FORTRAN READ, WRITE.
C NUST = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
C STRESS TRANSFORMATION MATRICES AND IVECS ARE OUTPUT.
C NUST 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 XX = 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 ERROR EXPLANATION
C 1 = JOINT NUMBER GREATER THAN NUMBER OF JUNTS.
C 2 = MASS MATRIX FORMED, NUTMX .LE. ZERO.
C 3 = STIFFNESS MATRIX FORMED, NUTKX .LE. ZERO.
C 4 = LT MATRIX FORMED, NUTLT .LE. ZERO.
C 5 = ST MATRIX FORMED, NUST .LE. ZERO.

1001 FORMAT (5(A6,4X))
1002 FORMAT (5(A6,4X))
1003 FORMAT (5(A6,4X))
1004 FORMAT (5(A6,4X))
1005 FORMAT (5(A6,4X))

2001 FORMAT (//25X 40+INPUT DATA FOR COMBINED MEMBRANE-BENDING
C * 29H QUADRILATERAL PLATE ELEMENTS)
2002 FORMAT (//25X 40+INPUT DATA FOR COMBINED MEMBRANE-BENDING
C * 41H QUADRILATERAL PLATE ELEMENTS (CONTINUED))
2003 FORMAT (// 13X7MASS = A6, 13X7STIF = A6, 6X13LOAD TRANS = A6,
C * 3X15STRESS TRANS = A6, 3X11BUCKLING = A6,
C * / 15X4H = E10.3, 13X3H = E10.3,
C * / 10X44T(MASS) = E10.3, 12X44+NU = E10.3,
C * / 32X13H(MEMBRANE) = E10.3,
C * / 32X13H(BENDING) = E10.3,
C * / /25X 7H-ELEMENT 5X 7HJJOINT 1 5X 7HJOINT 2 5X 7HJOINT 3
C * 5X 7HJOINT 4 5X 7H(TRANS) 6X 11H(TRANS) 10H(T(FECOND))
C * 5X 10H(T(FECOND))
C * / /25X 5NUMRES = 4X 3(5X 10H(VARIBLE) )
2004 FORMAT (12X 5(15,7X),5(10,5X),15X)
2005 FORMAT (12X 5(15,7X))

C READ AND WRITE FINITE ELEMENT DATA.
NLINE = 0
CALL PAGEHC
WRITE (NOT,2001)
READ (NUTFEL,1001) NAMEM,NAMEK,NAMELT,NAMEST,NAMEB
READ (NUTFEL,1002) RC,E,ANU
READ (NUTFEL,1002) TMASC,TMEMC,TRENC
WRITE (NOT,2003) NAMEM,NAMEK,NAMELT,NAMEST,NAMEB,
               RC,E,TMASC,ANU,TMEMC,TRENC
20 READ (NUTFEL,1003) NEL,J1,J2,J3,J4,TMASV,TMEMV,TBNV
NC THIK = 1
IF (TMASV.LE.0. AND. TMEMV.LE.0. AND. TBNV.LE.0.) NO THIK=0
IF (J1 .LE. 0) RETURN
NLINE = NLINE + 1
IF (NLINE .LE. 42) GC TO 30
CALL PAGEHC
WRITE (NOT,2002)
WRITE (NOT,2003) NAMEM,NAMEK,NAMELT,NAMEST,NAMEB,
               RC,E,TMASC,ANU,TMEMC,TRENC
NLINE = 0
30 IF (NC THIK.EQ.1)
*WRITE (NOT,2004) NEL,J1,J2,J3,J4,TMASV,TMEMV,TRENC
IF (NC THIK.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 THICKNESSES.
TMAS = TMASC
TMEM = TMEMC
TENF = TRENC
IF (TMASV.GT.0.) TMAS=TMASV
IF (TMEMV.GT.0.) TMEM=TMEMV
IF (TBENV.GT.0.) TENF=TBENV
C
C FORM FINITE ELEMENT COORDINATE LOCATIONS, EULER ANGLES, REVADD VEL.
DO 42 J=1,3
   CJ(1,J) = YZ(J1,J)
   CJ(2,J) = YZ(J2,J)
   CJ(3,J) = YZ(J3,J)
ED(1,J) = 0
ED(2,J) = 0
ED(3,J) = 0
42
42 EJ(1,J) = JL(J4,J)
DO 44 J=1,4
   IV(I,J) = JDCF(J1,J)
   IV(I+I,J) = JDCF(J2,J)
   IV(I+I+I,J) = JDCF(J3,J)
   IV(I+I+I+I,J) = JDCF(J4,J)
44
C
C FORM MASS MATRIX (M).
IF (AMS .LE. 6) 6H1H(NAMEM,CO,6HNCMASS) GO TO 110
C1 MAT = (C,J,E,J,TMAS,PL,NAMEM,W,1.,KJ,KJ,KJ,KW,KW)
NEKROR=2
IF (MNUMX .LE. 0) GO TO 609
WRITE (MNUMX) NAMEM,NEL,NPW,NFX,NAMEL,(J=PLNK,J=1,3),
C \( \{(W(I,J), I=1, NRW), J=1, NRW\}, \{(IVI(I), I=1, NRW)\} \)

C Form Stiffness matrix \( W \), local load transformation matrix \( T \),
C Stress transformation matrix \( S \).

110 IF (NAMEK .EQ. 6H .OR. NAMEK .EQ. 6HNODESTIF) GO TO 20
CALL STF3 \( (CJ,EJ,TMEM,TEEN,E,ANU,NAMEK,NAMESD,W,T,S,NRS) \),
* \( KLJ,KCJ,KW,KW,KW \)
NEROR = 3

IF (NUTKX .LE. 0) GO TO 999
WRITE (NUTKX) NAMEK,NEL,SR,SR,NAMEL,(IELNK,I=1,5),
* \( \{(W(I,J), I=1, NRW), J=1, NRW\}, \{(IVI(I), I=1, NRW)\} \)
IF (NAMELT .EQ. 6H .OR. NAMELT .EQ. 6HNODELOAD) GO TO 115
NEROR = 4

IF (NUTLT .LE. 0) GO TO 999
WRITE (NUTLT) NAMELT,MEL,SR,SR,NAMEL,(IELNK,I=1,5),
* \( \{(T(I,J), I=1, NRS)\}, J=1, NRW\), \( \{(IVI(I), I=1, NRW)\} \)
115 IF (NAMEST .EQ. 6H .OR. NAMEST .EQ. 6HNODESTRS) GO TO 20
NEROR = 5

IF (NUTST .LE. 0) GO TO 999
WRITE (NUTST) NAMEST,MEL,NRS,NRP,NAMEL,(IBLNK,I=1,5),
* \( \{(S(I,J), I=1, NRP)\}, J=1, NRW\), \( \{(IVI(I), I=1, NRW)\} \)
GO TO 20

999 CALL ZZPOMP (6HCUAD ,NEROR)
END
SUBROUTINE RECTSP (X, Y, Z, JDOF, EUL, NUTFL, NJ, 
    NUTMX, NUTKX, NUTLT, NUSTT, 
    W, T, S, KX, KJ, KE, KW) 
DIMENSION XYZ(KX,1), JDOF(KJ,1), EUL(KW,1), W(KW,1), T(KW,1), S(KW,1) 
DIMENSION CJ(13,4), EF(13,4), IV(12) 
DATA NAMEL/60FEC08/, NPW,NWL/12,8/ , IBLNK/6H/, KCJ/3/ 
DATA NIT,MIT/5,6/ 
C
SU: SUBROUTINE TO CALCULATE (ON OPTION) FINITE ELEMENT ... 
C MASS MATRICES AND IVECS (ON NUTMX), 
C STIFFNESS MATRICES (SAME AS GLOBAL LOAD TRANSFORMATION MATRICES) 
C AND IVECS (ON NUTLT), 
C LOCAL LOAD TRANSFORMATION MATRICES AND IVECS (ON NUTLT), 
C STRESS TRANSFORMATION MATRICES AND IVECS (ON NUSTT), 
C FOR RECTANGULAR SHEAR PANEL ELEMENTS. 
C MAT'S, STIFFNESS MATRICES ARE IN GLOBAL COORDINATE DIRECTIONS. 
C GLOBAL COORDINATE ORDER IS 
C (U, V, W) JOINT 1, THEN JOINT 2, 3, 4, 
C WHERE U, V, W ARE TRANSLATIONS. 
C IVEC GIVES ELEMENT DOF INTO GLOBAL DOF. EXAMPLES ... 
C IV = (6) = 634 PLACES ELEMENT DOF 6 INTO GLOBAL DOF 834. 
C IV = (3) = 6 PLACES ELEMENT DOF 3 FROM GLOBAL DOF. THIS CONSTAINS 
C ELEMENT DOF 3 TO ZERO MOTION. 
C GLOBAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT PANEL VERTICES IN 
C GLOBAL COORDINATE DIRECTIONS TO DEFORMATIONS IN THE GLOBAL COORDINATE 
C DIRECTIONS. 
C ROW ORDER IN GLOBAL LOAD TRANSFORMATION MATRIX IS 
C (PU, PV, PW) JOINT 1, THEN JOINT 2, 3, 4, 
C WHERE P IS FORCE. 
C LOCAL LOAD TRANSFORMATION MATRICES RELATES LOAD AT PANEL VERTICES IN 
C LOCAL COORDINATE SYSTEM TO DEFORMATIONS IN THE GLOBAL COORDINATE 
C DIRECTIONS. 
C STRESS TRANSFORMATION MATRICES RELATES PANEL SHEAR STRESS (CONSTANT) 
C IN LOCAL COORDINATE SYSTEM TO DEFORMATIONS IN THE GLOBAL COORDINATE 
C DIRECTIONS. 
C DATA ARRANGEMENT ON NUTMX, NUTKX, NUTLT, NUSTT FOR EACH Finite 
C ELEMENT IS (K, M, KLT, ST) 
C WRITE (NUTMX) NAME, NEL, NR, NC, NAME, (JBLNK, I=1, 5), 
C (IV(1), J, I=1, NP, J=1, NC), (IVEC(J), I=1, NC) 
C CALLS FORMA SUBROUTINES MAS3A, PAGEHD, STF3A, Z2BOMR. 
C DEVELOPED BY PL WOHLEN, APRIL 1976. 
C LAST REVISION BY WA BENFIELD, MARCH 1976. 
C
******************************************************************************
C INPUT DATA PEAD IN THIS SUBROUTINE FROM NUTEL. IF NUTEL = 5, DATA IS 
C READ FROM CPDS. 
C NAME, NAMEK, NAMELT, NAMEST FORMAT (4(A6,4X) 
C PC, 6 FORMAT (215X,E10)) 
C TMA, TST FORMAT (215X,E10)) 
C 20 NEL, J1, J2, J3, J4 FORMAT (5I5) 
C IF (J1 ,FC, 0) RETURN 
C GO TO 2C 
C
C DEFINITION OF INPUT VARIABLES. 
C NAME = TYPE OF MASS MATRIX WANTED.
C
C = M1, DIAGONAL LUMPED.
C = M2, CONSISTENT.
C = 6H OR 6H+NOMASS, NO MASS MATRIX CALCULATED.
C NAMEK = TYPE OF STIFFNESS MATRIX WANTED.
C = K1, LINEAR DISPLACEMENT (CONSTANT STRAIN).
C = 6H OR 6H+STIF, NO STIFFNESS MATRIX CALCULATED.
C NAMELT = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES.
C = 6H OR 6H+LOAD, NO LOAD TRANSFORMATIONS CALCULATED.
C NAMEST = IDENTIFICATION NAME FOR STRESS TRANSFORMATION MATRICES.
C = 6H OR 6H+STPR, NO STRESS TRANSFORMATIONS CALCULATED.
C RD = MASS DENSITY.
C G = SHEAR MODULUS OF ELASTICITY.
C TMAS = EFFECTIVE MASS THICKNESS.
C TSTF = EFFECTIVE STIFFNESS THICKNESS.
C NEL = FINITE ELEMENT NUMBER, FOR REFERENCE ONLY, NOT USED IN
C CALCULATIONS, WRITTEN ON NUTMX, ETC.
C J1 = JOINT NUMBER AT PANEL VERTEX 1.
C J2 = JOINT NUMBER AT PANEL VERTEX 2.
C J3 = JOINT NUMBER AT PANEL VERTEX 3.
C J4 = JOINT NUMBER AT PANEL VERTEX 4.
C
C EXPLANATION OF INPUT FORMATS. NUMBER INDICATES CARD COLUMNS USED.
C I = INTEGER DATA, RIGHT ADJUSTED.
C E = DECIMAL POINT DATA, ANYWHERE IN FIELD, EXPONENT RIGHT ADJUSTED.
C X = CARD COLUMNS SKIPPED.
C
C 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(N,J,3).
C JDCF = MATRIX OF JOINT GLOBAL DEGREE 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(N,J,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(N,J,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), (JDCF), (EUL).
C NUTMX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
C MASS MATRICES AND IVECS ARE OUTPUT.
C NUTMY 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 NULT = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT LOCAL
C LOAD TRANSFORMATION MATRICES AND IVECS ARE OUTPUT.
C NULT MAY BE ZERO IF LOAD TRANSFORMATIONS ARE NOT FORMED.
C USES FORTRAN READ, WRITE.
C NUST = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
STRESS TRANSFORMATION MATRICES AND IVECS ARE OUTPUT.

NUTST MAY BE ZERO IF STRESS TRANSFORMATIONS ARE NOT FORMED.
US FOR 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).

KX = 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.

NERORR EXPLANATION
1 = INPUT JOINT NUMBER EXCEEDS MAXIMUM ALLOWABLE NUMBER OF JOINTS.
2 = NUTMX NON POSITIVE.
3 = NUTKX NON POSITIVE.
4 = NUTLT NON POSITIVE.
5 = NUSTT NON POSITIVE.

1001 FORMAT (4(A6,4X))
1002 FORMAT (2(5X,F10.0))
1003 FORMAT (5(5X))
2001 FORMAT (/3EX 47HINPUT DATA FCP RECTANGULAR SHEAR PANEL ELEMENTS)
2002 FORMAT (/32X 47HINPUT DATA FOR RECTANGULAR SHEAR PANEL ELEMENTS
*   12H (CONTINUED))
2003 FORMAT (/ 14X7HMASS = A6, 14X7HSTIF = A6, 11X13HLOAD TRANS = A6,
*   8X15HSTRESS TRANS = A6,
*   16X4HRO = E10.3, 14X3HG = E10.3,
*   11X9H(MASS) = F10.3, 8X9HSTIF = E10.3,
*   18X7H-ELEMENT 13X7HJOINT 1 13X7HJOINT 2 13X7HJOINT 3
*   13X7HJCINT 4 / 18X6HNUMBER)
2004 FORMAT (1Fx,5(15,15X))

READ AND WRITE FINITE ELEMENT DATA.
NL INE = 0
CALL PAGED
WRITE (NCT,2061)
READ (NUTFI,1001) NAMEM,NAMEK,NAMET,NAMES
READ (NUTFI,1002) RO,G
READ (NUTFI,1002) TMAS,TSTF
WRITE (NCT,2063) NAMEM,NAMEK,NAMET,NAMES,RO,G,TMAS,TSTF
20 READ (NUTFI,1003) NEL,J1,J2,J3,J4
IF (J1 LE. G) RETURN
NL INE = NL INE + 1
IF (NL INE LE. 42) GO TO 30
CALL PAGED
WRITE (NCT,2002)
WRITE (NCT,2003) NAMEM,NAMEK,NAMET,NAMES,RO,G,TMAS,TSTF
NL INE = 0
30 WRITE (NCT,2004) NEL,J1,J2,J3,J4
NERORR=1
IF (J1.GT.NJ .OR. J2.GT.NJ .OR. J3.GT.NJ .OR. J4.GT.NJ) GO TO 999

FORM FINITE ELEMENT COORDINATE LOCATIONS, EULER ANGLES, REVADD IVEC.
DO 42 1=1,3
C(I,I) = YY2(J1,I)
NERROR=1
C
C FORM MASS MATRIX (W).
IF (NAMEM .EQ. 6H)  
   CR. NAMEM .EQ. 6HNCMASS) GO TO 110
CALL MAS3A (CJ,EJ,TMAS,RQ,NAMEM,W,T,S,KCJ,KCJ,KW,KW)
C NERROR=2
IF (NUTMX .LE. 0) GO TO 999
WRITE (NUTMX) NAMEM,NFL,NRW,NAMEL,(IBLNK,I=1,5),
   (W(1,J),I=1,NRW),J=1,NRW),(IVI(I),I=1,NRW)
C
C FORM STIFFNESS MATRIX (W), LOCAL LOAD TRANSFORMATION MATRIX (T),
C STRESS TRANSFORMATION MATRIX (S).
C
110 IF (NAMEK .EQ. 6H)  
   CR. NAMEK .EQ. 6HNOSTIF) GO TO 20
CALL STF3A (CJ,EJ,TSTF,G,NAMEK,NAMEST,W,T,S,NRST,
   KCJ,KCJ,KW,KW)
C NERROR=3
IF (NUTKX .LE. 0) GO TO 999
WRITE (NUTKX) NAMEK,NEL,NRW,NAMEL,(IBLNK,I=1,5),
   (W(1,J),I=1,NRW),J=1,NRW),(IVI(I),I=1,NRW)
IF (NAMELT .EQ. 6H)  
   CR. NAMELT .EQ. 6HNOLOAD) GO TO 115
C NERROR=4
IF (NULTX .LE. 0) GO TO 999
WRITE (NULTX) NAMELT,NEL,NRLT,NKW,NAMEL,(IBLNK,I=1,5),
   ((IVI(1),I=1,NRLT),J=1,NRW),(IVI(I),I=1,NRW)
C
115 IF (NAMEST .EQ. 6H)  
   CR. NAMEST .EQ. 6HNOSTRS) GO TO 20
C NERROR=5
IF (NUTST .LE. 0) GO TO 999
WRITE (NUTST) NAMEST,NEL,NRST,NPW,NAMEL,(IBLNK,I=1,5),
   ((IVI(1),I=1,NRST),J=1,NRW),(IVI(I),I=1,NRW)
C
GO TO 20
C
999 CALL ZEROM (6HRECTSP,NERROR)
END
SUBROUTINE SF1A (CJ,EJ,A1,A2,E,NAMEK,NAMEN,ST,TL,TS,NRST, *
       * DIMENSION C(J(KCJ,1)), E(JKEJ,1), S(KS,1), TL(KTL,1), TS(KTS,1))

C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C STIFFNESS MATRIX (SAME AS GLOBAL LOAD TRANSFORMATION MATRIX),
C LOCAL LOAD TRANSFORMATION MATRIX,
C STRESS TRANSFORMATION MATRIX,
C FOR AN AXIAL ROD ELEMENT WITH 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 POD ENDS IN LOCAL
C COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE DIRECTIONS.
C ROW ORDER IN LOCAL LOAD TRANSFORMATION MATRIX IS
C PX1, PX2
C WHERE PX IS AXIAL FORCE.
C PX1(-), PX2(+) IS TENSION. PX1(+), PX2(-) IS COMPRESSION.
C STRESS TRANSFORMATION MATRIX RELATES STRESS AT POD ENDS IN LOCAL
C COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE DIRECTIONS.
C ROW ORDER IN STRESS TRANSFORMATION MATRIX IS
C SIGMA-X1, SIGMA-X2
C WHERE SIGMA IS NORMAL STRESS.
C SX1(-), SX2(+) IS TENSION. SX1(+), SX2(-) IS COMPRESSION.
C EULER ANGLE CONVENTION IS GLOBAL X, Y, Z PERMUTATION.
C CALLS FORMA SUBROUTINES ATXBAI, DCOS1A, K1A1, MULTA, ZZ60MB.
C DEVELOPED BY RL WOHLKEN. SEPTEMBER 1972.
C LAST REVISION BY WA BENFIELD. MARCH 1976.

C SUBROUTINE ARGUMENTS
C CJ = INPUT MATRIX OF GLOBAL X, Y, Z COORDINATES AT ROD JOINTS.
C ROWS 1, 2, 3 CORRESPOND TO X, Y, Z COORDINATES.
C COLS 1, 2 CORRESPOND TO JOINTS 1, 2. SIZE(3,2).
C EJ = INPUT MATRIX OF EULER ANGLES (DEGREES) AT POD JOINTS.
C ROWS 1, 2, 3 CORRESPOND TO GLOBAL X, Y, Z PERMUTATION.
C COLS 1, 2 CORRESPOND TO JOINTS 1, 2. SIZE(3,2).
C A1 = INPUT CROSS-SECTION AREA AT POD END 1.
C A2 = INPUT CROSS-SECTION AREA AT POD END 2.
C E = INPUT YOUNG'S MODULUS OF ELASTICITY.
C NAMEK = INPUT TYPE OF STIF MATRIX WANTED.
C = K1, CONSTANT AXIAL FORCE ASSUMED.
C NAMEN = INPUT OPTION FOR STRESS TRANSFORMATION.
C = 6H OR 6HNOST!S, 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).  

STF1A -- 2/2

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

NRST = 2

IF (KS .LT. 6 .OR. KTL .LT. 2 .OR. KTS .LT. NRST) GO TO 999
PL = SQRT((101, 1, 2, 1, 1)**2 + (CJ(2, 2, 1, 2, 1)**2
* + (CJ(3, 2, 1, 3, 1)**2)
IF (NAMEK .EQ. 6HK1 ) GO TO 110

GO TO 999
110 CALL KIA1 (A1, A2, PL, E, TL, TS, KTL, KTS) TL=K
C
CALL DCOS1A (CJ, E, S, KCJ, KEJ, KS)
CALL MULA (TL, S, 2, 2, 6, KTL, KS)
IF (NAMEST .EQ. 6P .OR. NAMEST .EQ. 6HNOSTRS) GO TO 210
CALL MULA (TS, S, NRST, 2, 6, KTS, KS)
210 CALL ATXBA1 (S, TL, 2, 6, KS, KTL)
RETURN

C
999 CALL ZBORM (6HSTF1A , NERROR) END
SUBROUTINE STF1F (CJ, L2, K2D, A1, A2, T1, T2, R1Z1, B1Z2, B1Y1, B1Y2, 
* K1, R2, CY1, CY2, CZ1, CZ2, SF, E, G, NAMEK, NAMEST, 
* S, TL, TS, NST, KC, KEJ, KS, KTL, KTS) 
DIMENSION CJ(KC, 1), E(JK, EJ), KODE(1), S(KS, 1), TL(KTL, 1), TS(KTS, 1)

C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C STIFFNESS MATRIX (SAME AS GLOBAL LOAD TRANSFORMATION MATRIX),
C LOCAL LOAD TRANSFORMATION MATRIX,
C STRESS TRANSFORMATION MATRIX,
C FOR A COMBINED AXIAL-TORSION-BENDING BAR ELEMENT WITH UNRESTRAINED
C BOUNDFARIES.
C BAR MAY BE LINEARLY TAPERED OR UNIFORM.
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
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 DEFLECTIONS IN THE GLOBAL COORDINATE
C DIRECTIONS.
C ROW ORDER IN GLOBAL LOAD TRANSFORMATION MATRIX IS
C {P1, P2, P3, P4, P5, P6} JOINT 1, THEN JOINT 2
C WHERE P IS FORCE AND M IS MOMENT.
C LOCAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT BAR ENDS IN LOCAL
C COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE DIRECTIONS.
C ROW ORDER IN LOCAL LOAD TRANSFORMATION MATRIX IS
C {P1, P2, P3, P4, P5, P6} JOINT 1, THEN JOINT 2
C WHERE P IS FORCE AND M IS MOMENT.
C STRESS TRANSFORMATION MATRIX RELATES STRESS AT BAR ENDS IN LOCAL
C COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE DIRECTIONS.
C ROW ORDER IN STRESS TRANSFORMATION MATRIX IS
C {P1, A1, A2, A3} INTERNATIONAL X-Y-Z PERMUTATION
C WHERE P IS FORCE AND M IS MOMENT.
C EULER ANGLE CONVENTION IS GLORAL X, Y, Z PERMUTATION.
C CALLS FORMA SUBROUTINES ATXPA1,DCOS1B,KIA1,KIB1,KIC1,MULTA,ZZBOMB.
C LAST REVISION BY RL WOHLEN. APRIL 1976.

C SUBROUTINE ARGUMENTS
C CJ = INPUT MATRIX OF GLOBAL X, Y, Z COORDINATES AT BAR JOINTS.
C FOWS 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 EF = INPUT MATRIX OF EULER ANGLES (DEGREES) AT BAR JOINTS.
C FOWS 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 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) = BZ, LOCAL STIFFNESS MATRIX IS CALCULATED
FOR BENDING (ABOUT LOCAL Z-AXIS).

KODE(4)=6Y, LOCAL STIFFNESS MATRIX IS CALCULATED
FOR BENDING (ABOUT LOCAL Y-AXIS).

A1 = INPUT CROSS-SECTION AREA AT BAR END 1.

A2 = INPUT SAME AS A1 AT BAR END 2.

TJ1 = INPUT CROSS-SECTION SAINT VENANTS TORSION CONSTANT (J) IN

TJ2 = INPUT SAME AS TJ1 AT BAR END 2.

BI21 = INPUT CROSS-SECTION AREA MOMENT OF INERTIA ABOUT LOCAL

2-AXIS (FOR BENDING) AT BAR END 1.

RI22 = INPUT SAME AS BI21 AT BAR END 2.

BIY1 = INPUT CROSS-SECTION AREA MOMENT OF INERTIA ABOUT LOCAL

Y-AXIS (FOR BENDING) AT BAR END 1.

PY2 = INPUT SAME AS EIY1 AT BAR END 2.

R1 = INPUT DISTANCE FROM LOCAL X-AXIS TO OUTER FIBER FOR

TORSION STRESS CALCULATION AT BAR END 1.

R2 = INPUT SAME AS R1 AT BAR END 2.

CY1 = INPUT DISTANCE FROM XZ PLANE TO OUTER FIBER FOR BENDING

STRESS CALCULATION AT BAR END 1. LOCAL Y DIRECTION.

CY2 = INPUT SAME AS CY1 AT BAR END 2.

CZ1 = INPUT DISTANCE FROM XY PLANE TO OUTER FIBER FOR BENDING

STRESS CALCULATION AT BAR END 1. LOCAL Z DIRECTION.

CZ2 = INPUT SAME AS CZ1 AT BAR END 2.

SF = INPUT SHAPE FACTOR (K) FOR SHEAR IN KAG.

USE SF=0.0 FOR NO SHEAR DEFORMATION IN BENDING.

SF=1.0 FOR A SOLID CIRCULAR CYLINDER.

SF=0.5 FOR A THIN WALLED CIRCULAR CYLINDER.

E = INPUT YOUNG'S MODULUS OF ELASTICITY.

G = INPUT SHEAR MODULUS OF ELASTICITY.

NAMEK = INPUT TYPE OF STIF MATPIX WANTED.

= K1, USES K1A1 FOR AXIAL, K1C1 FOR TORSION,

K1E1 FOR BENDING.

NAMEST = INPUT OPTION FOR STRESS TRANSFORMATION.

= 6H OR 6HNCSTRS ,NO STRESS TRANS CALCULATED.

S = OUTPUT STIFFNESS MATRIX (SAME AS GLOBAL LOAD TRANSFORMATION

MATRIX), SIZE(12,12).

TL = OUTPUT LOCAL LOAD TRANSFORMATION MATRIX, SIZE(12,12).

TS = OUTPUT STRESS TRANSFORMATION MATRIX, SIZE(NPST,12).

NRST = OUTPUT NUMBER OF ROWS IN STRESS TRANSFORMATION MATRIX.

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

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

KS = INPUT ROW DIMENSION OF S IN CALLING PROGRAM, MIN=12.

KTL = INPUT ROW DIMENSION OF TL IN CALLING PROGRAM, MIN=12.

KTS = INPUT ROW DIMENSION OF TS IN CALLING PROGRAM, MIN=NRST.

NAMEST = NAMEST EXCEEDED.

= 1, SIZE LIMITATION EXCEEDED.

= 2, NAMEK IMPROPERLY DEFINED.

NRST = 12

1F (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) .EQ. 2H .AND. KODE(4) .EQ. 2H ) GO TO 10
IF (KODE(1) .NE. 1HA ) KODEA = 0
IF (KODE(2) .NE. 1HT ) KODET = 0
C LAST HALF OF NEXT TWO CARDS ALLOW FOR OLD DATA. INSERTED APRIL 1976.
IF (KODE(3) .NE. 2HBZ .AND. KODE(3) .NE. 2HBY ) KODEBZ = 0
IF (KODE(4) .NE. 2HBY .AND. KODE(4) .NE. 2HBZ ) KODEBY = 0
10 IF (NAMEK .EQ. 6HK1 ) GO TO 110

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 (BI21,BI22,CY1,CY2,A1,A2,SL,RL,E,G,
   * TL(5,5),TS(5,5),KTL,KTS)

DC 115 J=7,8
DD 115 I=5,6
TL(I,I) = -TL(I,I)
TS(I,I) = -TS(I,I)
TL(J,J) = -TL(J,J)
TS(J,J) = -TS(J,J)
115 IF (KODEBY .EQ. 1) CALL K1P1 (PIY1,PIY2,CZ1,CZ2,A1,A2,SF,RL,E,G,
   * TL(9,9),TS(9,9),KTL,KTS) 

C CALL DCOS1F (CJ,EJ,S,KJ,KEJ,KS)  S=DC
CALL MULTA (TL,S,12,12,12,12,KTL,KS)
IF (NAMEST .EQ. 0H .OR. NAMEST .EQ. 6HNOSTRS) GO TO 210
CALL MULTA (TS,S,12,12,12,12,KT1,KS)
210 CALL ATX6A1 (S,TL,12,12,KS,KTL)
RETURN

C 999 CALL ZZECME (6HSTF1B ,NERROR)
   END
SUBROUTINE STF2 (CJ, EJ, TMEM, T, FN, E, ANU, NAMEK, NAMEST, S, TL, TS, NRST, * 
  KCI, KEJ, KS, KTL, KTS)

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

SUBROUTINE TO CALCULATE FINITE ELEMENT...

STIFFNESS MATRIX (SAME AS GLOBAL LOAD TRANSFORMATION MATRIX),
LOCAL LOAD TRANSFORMATION MATRIX,
STRESS TRANSFORMATION MATRIX,
FOR A COMBINED MEMBRANE-BENDING TRIANGLE PLATE ELEMENT WITH
UNRESTRAINED BOUNDARIES.

STIFFNESS MATRIX IS IN GLOBAL COORDINATE DIRECTIONS.
GLOBAL COORDINATE ORDER IS
(U,V,W,P,Q,R) JOINT 1, THEN JOINT 2, 3.
WHERE U,V,W ARE TRANSLATIONS AND P,Q,R ARE ROTATIONS.
GLOBAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT TRNGL VERTICES IN
GLOBAL COORDINATE DIRECTIONS TO DEFLECTIONS IN THE GLOBAL COORDINATE
DIRECTIONS.
ROW ORDER IN GLOBAL LOAD TRANSFORMATION MATRIX IS
(PU,PV,PW,MP,MQ,MR) JOINT 1, THEN JOINT 2,3.
WHERE P IS FORCE AND M IS MOMENT.
LOCAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT TRNGL VERTICES IN
LOCAL COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE
DIRECTIONS.
ROW ORDER IN LOCAL LOAD TRANSFORMATION MATRIX IS
(PX, PY, PZ) JOINT 1 THEN 2,3, NEXT
(PZ, MX, MY) JOINT 1 THEN 2,3.
WHERE P IS FORCE AND M IS MOMENT.
STRESS TRANSFORMATION MATRIX RELATES STRESS AT TRNGL VERTICES IN LOCAL
COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORDINATE DIRECTIONS.
ROW DEP IN STIFFNESS TRANSFORMATION MATRIX IS
(SIGMA-X, SIGMA-Y, TAU-XY) FOR (Z=TBEN/2) AT JOINT 1,
THEN JOINT 2,3.
(SIGMA-X, SIGMA-Y, TAU-XY) FOR (Z=-TBEN/2) AT JOINT 1,
THEN JOINT 2,3.
WHERE SIGMA IS NORMAL STRESS AND TAU IS SHEAR STRESS.
EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
CALLS FORMA SUBROUTINES ATXBA1, DCOS2, K2A1, K2B1, MULTA, ZZBOMB.
DEVELOPED BY WA BENVIELD, FEBRUARY 1973.
LAST REVISION BY WA BENVIELD, MARCH 1976.

SUBROUTINE ARGUMENTS
C CJ = INPUT MATRIX OF GLOBAL X,Y,Z COORDINATES AT TRIANGLE JOINTS.
ROWS 1,2,3 CORRESPOND TO X,Y,Z COORDINATES.
COLS 1,2,3 CORRESPOND TO JOINTS 1,2,3. SIZE(3,3).
C EJ = INPUT MATRIX OF EULER ANGLES (DEGREES) AT TRIANGLE JOINTS.
ROWS 1,2,3 CORRESPOND TO JOINTS 1,2,3. SIZE(3,3).
C TMEM = INPUT EFFECTIVE MEMBRANE THICKNESS.
C TBEN = INPUT EFFECTIVE BENDING THICKNESS.
C E = INPUT YOUNGS MODULUS OF ELASTICITY.
C ANU = INPUT POISSON'S RATIO. (E/2G)-1.
C NAMEK = INPUT TYPE OF STIFF MATRIX WANTED.
C = K1, USFS K2A1 FOR MEMBRANE, K2B1 FOR BENDING.
C NAMEST = INPUT OPTION FOR STRESS TRANSFORMATION.
C = 6H OR 6HNOSTRS ,NO STRESS TRANS CALCULATED.
S = OUTPUT STIFFNESS MATRIX (SAME AS GLOBAL LOAD TRANSFORMATION MATRIX), SIZE(18,18).
TL = OUTPUT LOCAL LOAD TRANSFORMATION MATRIX, SIZE(18,18).
TS = OUTPUT STRESS TRANSFORMATION MATRIX, SIZE(NRST,18).
NRST = OUTPUT NUMBER OF ROWS IN STRESS TRANSFORMATION MATRIX.
KCJ = INPUT ROW DIMENSION OF CJ IN CALLING PROGRAM.
KEJ = INPUT ROW DIMENSION OF EJ IN CALLING PROGRAM.
KS = INPUT ROW DIMENSION OF S IN CALLING PROGRAM, MIN=18.
KTL = INPUT ROW DIMENSION OF TL IN CALLING PROGRAM, MIN=18.
KTS = INPUT ROW DIMENSION OF TS IN CALLING PROGRAM, MIN=NRST.

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

NRST = 18

IF (KS < 18 OR KTL < 18 OR KTS < NRST) GO TO 999
DO 5 J=1,18
DO 5 I=1,18
TL(I,J) = 0
5 CONTINUE

SL12 = SQRT((CJ(1,1)-CJ(1,1))**2 + (CJ(2,2)-CJ(2,1))**2)
SL23 = SQRT((CJ(1,1)-CJ(1,2))**2 + (CJ(2,3)-CJ(2,2))**2)
SL13 = SQRT((CJ(1,3)-CJ(1,1))**2 + (CJ(2,3)-CJ(2,1))**2)
X3 = (SL13**2-SL12**2-SL23**2)/(2.0*SL12)
Y3 = SQRT(SL13**2-X3**2)
IF (NAMEK *EQ. 6HK1) GO TO 110

GO TO 999

C


110 CALL K2A1 (SL12,X3,Y3,THEM,F,ANU,TL,TS,KTL,KTS,KS)
CALL K2B1 (SL12,X3,THEN,E,ANU,TL(10,10),TS(1,10),S,
           KTL,KTS,KS)
DO 111 I=1,9
111 CONTINUE
DO 111 J=1,9
111 CONTINUE

CALL DCOS2 (CJ,EJ,S,KCJ,KEJ,KS)
CALL MLTA (TL,S,18,18,18,KTL,KKS)
IF (NAMEST *EQ. 6H OR NAMEST *EQ. 6HNDSTRS) GO TO 210
CALL MLTA (TS,S,NRST,18,18,KTS,KKS)

210 CALL ATXPA1 (S,TL,18,18,KS,KTL)
RETURN

C

999 CALL ZZBOMB (5HSTF2,NERRR)
END
SUBROUTINE STF3 (CJ,EJ,TMEM,TBEN,E,ANU,NAMFST,S,TL,TS,MRST, 
* KCJ,KFJ,KS,KTL,KTS) 
DIMENSION C(KCJ),E(JKEJ,J),S(KS),T(KTL,1),TS(KTS,1) 
DIMENSION CW(3,3), EW(3,3), WI(16,18) 
* IV1(18), IV2(18), IV3(18), IV4(18) 
DATA KCW,KWI / 3,18 / 
DATA IV1/ 1, 2, 3, 4, 5, 6, 7, 8, 9,10,11,12,13,14,15,16,17,18/ 
* IV2/ 1, 2, 3, 4, 5, 6,13,14,15,16,17,18,19,20,21,22,23,24/ 
* IV3/ 1, 2, 3, 4, 5, 6, 7, 8, 9,10,11,12,19,20,21,22,23,24/ 
* IV4/ 7, 8, 9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24/ 
C 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 COMINTEO 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,MO,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 FORMA SUBROUTINES STF2,PEV400,ZZROMR. 
C LAST REVISION BY WA BENFIELD. MARCH 1976. 
C C SUBROUTINE ARGUMENTS 
C CJ = INPUT MATRICES OF GLOBAL X,Y,Z COORDINATES AT QUAD JOINTS. 
C ROWS 1,2,3 CORRESPOND TO X,Y,Z COORDINATES. 
C COLS 1,2,3,4 CORRESPOND TO JOINTS 1,2,3,4. SIZE(3,4). 
C EJ = INPUT MATRICES 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 PENDING 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 = K1, USES 4 TRIANGLES, OVERLAP AVERAGE. 
C NAMEFST = INPUT OPTION FOR STRESS TRANSFORMATION. 
C = 6H OR 6HNOISTR. NO STRESS TRANS CALCULATED. 
C S = OUTPUT STIFFNESS MATRICES (SAME AS GLOBAL LOAD TRANSFORMATION 
C MATRIX). SIZE(24,24). 
C TL = OUTPUT LOCAL LOAD TRANSFORMATION MATRICES. SIZE(24,24).

STF3 --- 1/3
TS = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(NRST,24).

NRST = OUTPUT NUMBER OF ROWS IN STRESS TRANSFORMATION MATRIX.

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

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

KS = INPUT ROW DIMENSION OF S IN CALLING PROGRAM. MIN=24.

KTL = INPUT ROW DIMENSION OF TL IN CALLING PROGRAM. MIN=24.

KTS = INPUT ROW DIMENSION OF TS IN CALLING PROGRAM. MIN=NRST.

NERROREXPLANATION
1 = SIZE LIMITATION EXCEEDED.
2 = NAMEK IMPROPERLY DEFINED.

NRST = 24

IF (KS .LT. 24 .OR. KTL .LT. 24 .OR. KTS .LT. NRST) GO TO 999

DO 5 J=1,24
   DO 5 I=1,24
   S(I,J) = 0.0
   IF (NAMEK .EQ. 6*KJ) GO TO 110
   GO TO 999

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

               * K,CW,KCW,KW1,KTL,KTS)

   CALL PERVAND (*,W,I,IV1,IV1,S,18,18,24,24,18,KS)

   DO 201 I=1,3
      CW(I,1) = CJ(I,1)
      EW(I,1) = FJ(I,1)

   DO 201 I=1,3
      EW(I,1) = FJ(I,1)
      CW(I,2) = CJ(I,2)
      EW(I,2) = FJ(I,2)
      CW(I,3) = CJ(I,3)

   201 EWI(I,3) = FJ(I,3)

               * K,CW,KCW,KW1,KTL,KTS)

   CALL PERVAND (*,W,I,IV2,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,3)

   203 EWI(I,3) = FJ(I,3)

               * K,CW,KCW,KW1,KTL,KTS)

   CALL PERVAND (*,W,I,IV3,IV3,S,16,18,24,24,18,KS)

   DO 205 I=1,3
      CW(I,1) = CJ(I,2)
      EW(I,1) = FJ(I,2)
CW(I,2) = CJ(I,3)
EW(I,2) = EJ(I,3)
CW(I,3) = CJ(I,4)
EW(I,3) = EJ(I,4)
205 CALL STF2 (CW, EW, TMEM, TBEN, E, ANU, NAMEK, NAMEST, W1, TL, TS, NRSTX,*
               KCW, KCW, KW1, KTL, KTS)
CALL REVADD (S, W1, IV4, IV4, S, 18, 18, 24, 24, 18, KS)
C
  DO 300 J=1,24
  DO 300 I=1,24
  TL(I,J) = 0.0
300  TS(I,J) = 0.0
RETURN
C
999 CALL ZZROMB (4HSTF3, NERROR)
END
SUBROUTINE STF3A (CJ,EJ,TH,G,NAMES,S,TL,TS,NRST, *
   * KCI,KEJ,KS,KTL,KTS)
   * DIMENSION CJ(KCJ,1), EJ(KEJ,1), S(KS,1), TL(KTL,1), TS(KTS,1)

C SUBROUTINE TO CALCULATE FINITE ELEMENT...
C STIFFNESS MATRIX (SAME AS GLOBAL LOAD TRANSFORMATION MATRIX),
C LOCAL LOAD TRANSFORMATION MATRIX,
C STRESS TRANSFORMATION MATRIX,
C FOR A RECTANGULAR SHEAR PANEL ELEMENT WITH UNRESTRAINED BOUNDARIES
C STIFFNESS MATRIX IS IN GLOBAL COORDINATE DIRECTIONS.
C GLOBAL COORDINATE ORDER IS
C (U,V,W) JOINT 1, THEN JOINT 2, 3, 4.
C WHERE U,V,W ARE TRANSLATIONS.
C GLOBAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT PANEL VERTICES IN
C GLOBAL COORDINATE DIRECTIONS TO DEFLECTIONS IN THE GLOBAL COORD
C DIRECTIONS.
C ROW ORDER IN GLOBAL LOAD TRANSFORMATION MATRIX IS
C (PU, PV, PW) JOINT 1, THEN JOINT 2, 3, 4.
C WHERE P IS FORCE.
C LOCAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT PANEL VERTICES IN
C LOCAL COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORD
C DIRECTIONS.
C ROW ORDER IN LOCAL LOAD TRANSFORMATION MATRIX IS
C PX1, PX2, PX3, PX4, PY1, PY2, PY3, PY4
C WHERE P IS FORCE. X GOES FROM 1 TO 2, Y GOES FROM 1 TO 4.
C STRESS TRANSFORMATION MATRIX RELATES PANEL SHEAR STRESS (CONSTANT) IN
C LOCAL COORDINATE SYSTEM TO DEFLECTIONS IN THE GLOBAL COORD DIRECTIONS.
C EULER ANGLE CONVENTION IS GLOBAL X,Y,Z PERMUTATION.
C CALLS FORMA SUBROUTINES ATXBAI,DCOS3C,K3C3,MULTA,ZZBOMB.
C DEVELOPED BY RL WHEELER, APRIL 1974.
C LAST REVISION BY WA BENFIELD, MARCH 1976.

C SUBROUTINE ARGUMENTS
C CJ = INPUT MATRIX OF GLOBAL X,Y,Z COORDINATES AT PANEL JOINTS.
C ROWS 1,2,3 CORRESPOND TO X,Y,Z COORDINATES.
C COLS 1,2,3,4 CORRESPOND TO JOINTS 1,2,3,4. SIZE(3,4).
C EJ = INPUT MATRIX OF EULER ANGLES (DEGREES) AT PANEL JOINTS.
C ROWS 1,2,3 CORRESPOND TO GLOBAL X,Y,Z PERMUTATION.
C COLS 1,2,3,4 CORRESPOND TO JOINTS 1,2,3,4. SIZE(3,4).
C TH = INPUT PANEL THICKNESS.
C G = INPUT SHEAR MODULUS OF ELASTICITY.
C NAME = INPUT TYPE OF STIFF MATRIX WANTED.
C = 1, USE K3C3.
C NAMEST = INPUT OPTION FOR STRESS TRANSFORMATION.
C = 6H, USE DMOSTR NO STRESS TRANS CALCULATED.
C S = OUTPUT STIFFNESS MATRIX (SAME AS GLOBAL LOAD TRANSFORMATION
C MATRIX). SIZE(12,12).
C TL = OUTPUT LOCAL LOAD TRANSFORMATION MATRIX. SIZE(6,12).
C TS = OUTPUT STRESS TRANSFORMATION MATRIX. SIZE(1,12).
C NPS = 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=6.
C KTS = INPUT ROW DIMENSION OF TS IN CALLING PROGRAM. MIN=1.
C NERROR EXPLANATION
C 1 = SIZE LIMITATION EXCEEDED.
C 2 = NAMEK IMPROPERLY DEFINED.
C
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

GO TO 999

NERROR = 2

110 CALL K3C1 (SL12,SL14,TH,G,TL,TS,KTL,KTS) TL = K
C CALL DCOS3C (CJ, EJ, S, KCJ, KEJ, KS) S = DC
CALL MULTA (TL, S, E, & 12, KTL, KS)
IF (NAMEST .EQ. 6H .OR. NAMEST .EQ. 6HNOSTS) GO TO 210
CALL MULTA (TS, S, NRST, & 12, KTS, KS)
210 CALL ATXEAI (S, TL, E, 12, KS, KTL)
RETURN

C 999 CALL ZPCNF (6HSTF3A ,NERROR)
END
TEGEOM

SUBROUTINE TEGFOM (CJ, JM, VL, DV, KCJ, IFBAD)
DIMENSION CJ(KCJ,1), JM(1), DV(1)
DIMENSION R12(3), R13(3), R14(3)
DATA EPS / 1.E-5 /

C
C SUBROUTINE TO DETERMINE THE VOLUME AND VOLUME CHANGE COEFFICIENTS OF
C A TETRAHEDRON.
C CALLS FORMA SUBROUTINES VCROSS, VDOT.
C DEVELOPED BY C S HODLEY. FEBRUARY 1974.
C LAST REVISION BY R A PHILIPPS. 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 I=1,2
R12(I) = CJ(J1,J2) - CJ(I,J1)
R13(I) = CJ(J1,J3) - CJ(I,J1)
5 R14(I) = CJ(J1,J4) - CJ(I,J1)
C
CALL VCROSS (R12, R13, DV(10), VAMAG, VPMAG, VZMAG, SINAB)
CALL VDOT (DV(10), R14, VCL, VAMAG, VBMAG, 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, VBMAG, VZMAG, SINAB)
DC 10 I=1,3
10 DV(I) = -DV(I+3) - DV(I+6) - DV(I+9)
15 DV(I) = DV(I)/6.
C
RETURN
END
SUBROUTINE TRNGL (XYZ,JDOF,EUL,NUTEL,NJ,
   NUTMX,NUTXX,NUTBX,NULT,L,NUTST,
   W,T,S,KK,KJ,KE,KW)
DIMENSION XYZ(KX,1),JDOF(KJ,1),EUL(KE,1),W(KW,1),T(KW,1),S(KW,1)
DIMENSION CJ(3,3), FJ(3,3), IJI(18)
DATA NAMEI/6HTPRNL /, NRW,NRLT/18,18/, IBLNK/6H /, KCJ/3/
DATA NI,NGT,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 NUTRX), (NOT YET)
C LOCAL LOAD TRANSFORMATION MATRICES AND IVECS (ON NULTL),
C STRESS TRANSFORMATION MATRICES AND IVECS (ON NUTST),
C FOR CONCRETE MEMBRANE-PENDING TRIANGLE PLATE ELEMENTS.
C MASS, STIFFNESS, BUCKLING MATRICES ARE IN GLOBAL COORDINATE
C DIRECTIONS.
C GLOBAL COORDINATE ORDER IS
C (U,V,W,H,P,R) JOINT 1, THEN JOINT 2, 3.
C WHERE U,V,W APE TRANSLATIONS AND P, Q, R APE ROTATIONS.
C IVEC GIVES ELEMENT DOF INTO GLOBAL DOF. EXAMPLES...
C IVEC(6)=834 PLACES ELEMENT DOF 6 INTO GLOBAL DOF 834.
C IVEC(3)=0 Omits element DOF 3 from global DOF. This Constrains
C Element DOF 3 to zero motion.
C GLOBAL LOAD TRANSFORMATION MATRIX RELATES LOADS AT TRNGL VERTICES IN
C GLOBAL COORDINATE DIRECTIONS TO DEFORMATIONS IN THE GLOBAL COORDINATE
C DIRECTIONS.
C ROW ORDER IN GLOBAL LOAD TRANSFORMATION MATRIX IS
C (PU, PV, PW, NP, MC, MK) 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 DEFORMATIONS IN THE GLOBAL COORDINATE
C DIRECTIONS.
C ROW ORDER IN LOCAL LOAD TRANSFORMATION MATRIX IS
C (PX, PY, MZ) 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 MATRICES RELATES STRESS AT TRNGL VERTICES IN LOCAL
C COORDINATE SYSTEM TO DEFORMATIONS IN THE GLOBAL COORDINATE DIRECTIONS.
C ROW ORDER IN STRESS TRANSFORMATION MATRIX IS
C (SIGMA-X, SIGMA-Y, TAU-XY) FOR (Z=TBEN/2) AT JOINT 1,
C THEN JOINT 2, 3.
C (SIGMA-X, SIGMA-Y, TAU-XY) FOR (Z=-TBEN/2) AT JOINT 1,
C THEN JOINT 2, 3.
C WHERE SIGMA-X IS NORMAL STRESS AND TAU IS SHEAR STRESS.
C DATA ARRANGEMENT CN NUTMX, NUTXX, NUTBX, NULT, NUTST FOR EACH
C FINITE ELEMENT IS (H, M, K, L, LT, ST)
C WRITE (NUTRX) N, MEX, NF, NP, NC, NAMFL, (SLNK, I=1, 5),
C (((W(1), J=1, NR), J=1, NC), (IVEC(I), I=1, NC)
C CALLS FORMA SUBROUTINES M29, PAGEHO, STF2, Z2BOME.
C DEVELOPED BY WA HENFIELD, CS BODLEY, RL WOHLER. FEBRUARY 1973.
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 NAMFM,NAMEK,NAMELT,NAMEST,NAMEB FORMAT (5(A6,4X)
C RO,ANU FORMAT (3(5X,E10))
C TMA,TEMC,TBEN FORMAT (3(5X,E10))
C 20 NEL,J1,J2,J3,TMASC,TEMC,TBENV FORMAT (4(5,3E10)
C IF (J1 .EQ. 0) RETURN
C GO TO 20
C
C DEFINITION OF INPUT VARIABLES.
C NAMFM = TYPE OF MASS MATRIX WANTED.
C = M1, DIAGONAL LUMPED.
C = M2, CONSISTENT.
C NAMEK = OR 6H, 6HNO, NO MASS MATRIX CALCULATED.
C NAMELT = TYPE OF STIFFNESS MATRIX WANTED.
C = K1, QUADRATIC DISPLACEMENT FOR MEMBRANE, CUBIC
C DISPLACEMENT FOR BENDING.
C NAMEST = OR 6H, 6HNO, NO STIFFNESS MATRIX CALCULATED.
C NAMFM = IDENTIFICATION NAME FOR LOAD TRANSFORMATION MATRICES.
C NAMFS = OR 6H, 6HNO, NO LOAD TRANSFORMATIONS CALCULATED.
C NAMEST = IDENTIFICATION NAME FOR STRESS TRANSFORMATION MATRICES.
C NAMEST = OR 6H, 6HNO, NO STRESS TRANSFORMATIONS CALCULATED.
C NAMEST = TYPE OF DUCKLING MATRIX WANTED.
C = 6H, OR 6HNO, NO DUCKLING MATRIX CALCULATED.
C RO = MASS DENSITY.
C ANU = YOUNG'S MODULUS OF ELASTICITY.
C TMA = POISSON'S RATIO. (E/2G)-1.
C TMASC = EFFECTIVE MASS THICKNESS, CONSTANT.
C TMASC = EFFECTIVE MASS THICKNESS, VARIABLE.
C IF *E* = 0, TMASC IS USED.
C TMAE = EFFECTIVE MEMBRANE THICKNESS, CONSTANT.
C TMAE = EFFECTIVE MEMBRANE THICKNESS, VARIABLE.
C IF *E* = 0, TMAE IS USED.
C TEFC = EFFECTIVE BENDING THICKNESS, CONSTANT.
C TEFC = EFFECTIVE BENDING THICKNESS, VARIABLE.
C IF *E* = 0, TEFC 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 F = DECIMAL POINT DATA, ANYWHERE IN FIELD. EXPONENT RIGHT ADJUSTED.
C X = CARD 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 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 D.O.F. AND COLUMNS 4,5,6 CORRESPOND TO THE JOINT
C ROTATION DOFS. SIZE(NJ,6).
C EUL = MATRIX OF JOINT EULER ANGLES (DEGREES). ROWS CORRESPOND
C TO JOINT NUMBERS. COLUMNS 1,2,3 CORRESPOND TO THE
C GLOBAL X,Y,Z PERMUTATION. SIZE(NJ,3).
C NUTEL = LOGICAL NUMBER OF TAPE CONTAINING ELEMENT INPUT DATA FOR
C THIS SUBROUTINE. IF NUTEL = 5, DATA IS READ FROM CARDS.
C NJ = NUMBER OF JOINTS OR ROWS IN MATRICES (XYZ), (JDOF), (EUL).
C NUTMX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
C MASS MATRICES AND IVECS ARE OUTPUT.
C NUTMX MAY BE ZERO IF MASS MATRIX IS NOT FORMED.
C USES FORTRAN READ, WRITE.
C NUTKX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT
C STIFFNESS MATRICES (SAME AS GLOBAL LOADS TRANSFORMATION
C MATRICES) AND IVECS ARE OUTPUT.
C NUTKX MAY BE ZERO IF STIFFNESS MATRIX IS NOT FORMED.
C USES FORTRAN READ, WRITE.
C NUTBX = LOGICAL NUMBER OF UTILITY TAPE ON WHICH ELEMENT UNIT LOAD
C BUCKLING MATRICES AND IVECS ARE OUTPUT.
C NUTBX 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(18,18).
C T = MATRIX WORK SPACE. MIN SIZE(18,18).
C S = MATRIX 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 NERPSR EXPLANATION
C 1 = JOINT NUMBER GREATER THAN NUMBER OF JOINTS.
C 2 = MASS MATRIX FORMED, NUTMX .LE. ZERO.
C 3 = STIFFNESS MATRIX FORMED, NUTKX .LE. ZERO.
C 4 = LT MATRIX FORMED, NUTLT .LE. ZERO.
C 5 = ST MATRICES FORMED, NUTST .LE. ZERO.

1001 FORMAT (5(6,4X))
1002 FORMAT (3(5X,E10.0))
1003 FORMAT (4(3,5X,F10.0))
2001 FORMAT (//32X 49HINPUT DATA FOR COMBINED MEMBRANE-BENDING TRIANGLE
* 15H PLATE ELEMENTS)
2002 FORMAT (//26X 49HINPUT DATA FOR COMBINED MEMBRANE-BENDING TRIANGLE
* 27H PLATE ELEMENTS (CONTINUED))
2003 FORMAT (/ 13X7HMASS = A6, 13X7HSTIF = A6, 6X13HLOAD TRANS = A6,
* 3X13HSTIF PDESS TRANS = A6, 3X13HPUCKLING = A6,
* / 15X4HPDO = E10.3, 13X3HE = F10.3,
* / 10XCHT(MASS) = E10.3, 12X4HNU = E10.3,
* / 52X15HT(MEMBRANE) = E10.3,
* / 33X12 HT(BENDING) = E10.3,
* /18X 7 ELEMENT 5X 7HJOINT 1 5X 7HJOINT 2 5X 7HJOINT 3
* 5X 7HT(MASS) 6X 11HT(MEMBRANE) 5X 10HT(BENDING)
* /18X 6 NUMBE 36X 3(5X 10H(VARIABLE))
2004 FORMAT (1FX 4(15,7X),3(F10.3,5X))
2005 FORMAT (1S 4(15,7X))
C
C READ AND WRITE FINITE ELEMENT DATA.
   NLIN = 1;
   CALL PAGE1;
   WRITE (NO, 'C001')
   READ (NUTF, 1001) NAMEM, NAMEK, NAMELT, NAMEST, NAMEB
   READ (NUTEL, 1002) RDE, ANU
   READ (NUTEL, 1002) TMASC, TMEMC, TBENC
   WRITE (NOT, 2003) NAMEM, NAMEK, NAMELT, NAMEST, NAMEB,
   * RDE, TMASC, ANU, TMEMC, TBENC
20 READ (NUTEL, 1003) NEL, J1, J2, J3, TMASV, TMEMV, TBENV
   NO THIK = 1
   IF (TMASV.LT.0. AND. TMEMV.LT.0. AND. TBENV.LT.0.) NO THIK=0
   IF (J1 .LT. 0) RETURN
   NLIN = NLIN + 1
   IF (NLIN .LE. 42) GO TO 30
   CALL PAGE1;
   WRITE (NOT, 2002)
   WRITE (NOT, 2003) NAMEM, NAMEK, NAMELT, NAMEST, NAMEB,
   * RDE, TMASC, ANU, TMEMC, TBENC
   NLIN = 0
30 IF (NO THIK.EQ.1)
   *WRITE (NOT, 2004) NFL, J1, J2, J3, TMASV, TMEMV, TBENV
   IF (NO THIK.EQ.0) WRITE (NOT, 2005) NEL, J1, J2, J3
   NERRDR=1
   IF (J1 .GT. NJ .OR. J2 .GT. NJ .OR. J3 .GT. NJ) GO TO 999
C
C SET THICKNESSES.
   TMAS = TMASC
   TMEM = TMEMC
   TBEN = TBENC
   IF (TMASV.GT.0.) TMAS=TMASV
   IF (TMEMV.GT.0.) TMEM=TMEMV
   IF (TBENV.GT.0.) TEEN=TBENV
C
C FORM FINITE ELEMENT COORDINATE LOCATIONS, EULER ANGLES, REVADD IVEC.
   DO 42 I=1,3
      CJ(I,1) = YYZ(J1,1)
      CJ(I,2) = YYZ(J2,1)
      CJ(I,3) = YYZ(J3,1)
      EJ(I,1) = FUL(J1,1)
      EJ(I,2) = FUL(J2,1)
      EJ(I,3) = FUL(J3,1)
   DO 42 EJ(I,3) = FUL(J3,1)
42   DO 44 I=1,6
      IV(I) = JDOF(J1,1)
      IV(I+6) = JDOF(J2,1)
44    IV(I+12) = JDOF(J3,1)
C
C FORM MASS MATRIX (W).
IF (NAMEM .LT. 6) CR. NAMEM .EQ. 6HNDMASS) GO TO 110
CALL MAS2 (CJ,EJ,TMA2,PO,NAMEM,W,T,S,KCJ,KCJ,KW,KW)

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

C FORM STIFFNESS MATRIX (W), LOCAL LOAD TRANSFORMATION MATRIX (T),
C STRESS TRANSFORMATION MATRIX (S).
110 IF (NAMEM .EQ. 6H) CR. NAMEM .EQ. 6HNDSTIF) GO TO 20
CALL STF2 (CJ,EJ,TMEM,TFEN,F,FANU,NAMEM,NAMES,T,W,T,S,SRST,
* TCJ,TKCJ,KW,KW)

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

IF (NAMELT .LE. 0) CR. NAMELT .LE. 6HNOLOAD) GO TO 115

IF (NAMFLT .LE. 0) GO TO 999
WRITE (NAMFLT) NAMFLT,NEL,NLWL,NLW,NLW,NAMFL,(IBLNK,I=1,5),
* ((T(I,J),I=1,5),J=1,5),IVL(I),I=1,NRW)

115 IF (NAMES .LE. 0) CR. NAMEST .LE. 6HNOSTRS) GO TO 20

IF (NUTST .LE. 0) GO TO 999
WRITE (NUTST) NAMEST,NEL,NSRT,NSRT,NSRT,NAMFL,(IBLNK,I=1,5),
* ((S(I,J),I=1,5),J=1,5),IVL(I),I=1,NRW)
GO TO 20

C 999 CALL ZZBOM2 (6HTRNLG ,NEROR)
END