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**SAP3PR: A Fortran Program for
Calculating Equivalent Nodal Loads
Resulting from Pressure on the Faces
of 8- to 20-Node Isoparametric
Elements**

D. N. Fanning

OAK RIDGE NATIONAL LABORATORY
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SAP3PR: A FORTRAN PROGRAM FOR CALCULATING EQUIVALENT
NODAL LOADS RESULTING FROM PRESSURE ON THE FACES
OF 8- TO 20-NODE ISOPARAMETRIC ELEMENTS

D. N. Fanning

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ABSTRACT

A computer program is described for calculating the equivalent nodal loads resulting from distributed loads on a three-dimensional finite-element model. Included is a listing of the computer program, a description of the input data, and an example of the output.

INTRODUCTION

Pressure loads or distributed loads comprise at least part of the load on most structures analyzed using three-dimensional finite-element computer programs. Unfortunately, not all finite-element codes allow the user to specify pressure loads directly (e.g., NONSAP and ADINA). For codes such as these, only loads acting at the nodes are acceptable as input. Therefore, before the effects of a pressure load can be analyzed, it is necessary to convert the distributed loads into equivalent nodal loads. The computer program SAP3PR was written expressly for this purpose. SAP3PR was written for the Digital Equipment Corporation PDP-10 using the Fortran language; with minor modifications the program can be executed on the IBM 360 or 370 computer. A listing is presented in the next section, and examples of the input to and output from the program are given in the appendix.

PROGRAM INPUT

The input cards for the program are of two types: model definition cards and load case definition cards. The model definition cards define the geometry of the finite-element analytical model, while the load case cards describe the pressure loadings. The format (in parentheses), variable names, and variable definitions are given for each card.

1. Model Definition Cards

Model Control Card (4I5,4X,L1)

Columns	Variable	Definition
1-5	NUMNP	Number of nodes
6-10	NUMEL	Number of elements
11-15	NLOAD	Number of load cases
16-20	NUMLTM	Maximum number of pressure distributions for any load case
25	NONSAP	Flag indicating type of format = T for NONSAP ¹ or ADINA ² format = F for STATIC-SAP format ³

Node Cards (35X,3F10.0)

Columns	Variable	Definition
36-45	XY(1,I)	X-coordinate of the <u>I</u> th node
46-55	XY(2,I)	Y-coordinate of the <u>I</u> th node
56-65	XY(3,I)	Z-coordinate of the <u>I</u> th node

Node cards must be input consecutively and in ascending order.

Element Cards (/8I5/12I5) or (/20I4)

Columns	Variable	Definition
	LNODE(1,I)	Node 1 of element I
	LNODE(2,I)	Node 2 of element I
	LNODE(3,I)	Node 3 of element I
	LNODE(4,I)	Node 4 of element I
	LNODE(5,I)	Node 5 of element I
	LNODE(6,I)	Node 6 of element I
	LNODE(7,I)	Node 7 of element I
	LNODE(8,I)	Node 8 of element I
	LNODE(9,I)	Node 9 of element I
	LNODE(10,I)	Node 10 of element I

Element Cards (/8I5/12I5) or (/20I4) (continued)

Columns	Variable	Definition
	LNODE(11,I)	Node 11 of element I
	LNODE(12,I)	Node 12 of element I
	LNODE(13,I)	Node 13 of element I
	LNODE(14,I)	Node 14 of element I
	LNODE(15,I)	Node 15 of element I
	LNODE(16,I)	Node 16 of element I
	LNODE(17,I)	Node 17 of element I
	LNODE(18,I)	Node 18 of element I
	LNODE(19,I)	Node 19 of element I
	LNODE(20,I)	Node 20 of element I

The first format listed for the element cards is the format used by NONSAP and ADINA (NONSAP = T on the model control card); the second format is for STATIC-SAP (NONSAP = F on the model control card). The element cards must be input in ascending order with no elements omitted. The sequence of nodes defining the variable node isoparametric element is shown in Fig. 1; the finite-element codes NONSAP, ADINA, and STATIC-SAP (a modified version) use this numbering scheme for their three-dimensional isoparametric element. If a nodal sequence different from Fig. 1 is needed (such as for the 20-node element of the unmodified version of STATIC-SAP), appropriate changes could easily be made in SAP3PR.

2. Load Case Definition Cards

Input NLOAD groups of load case definition cards.

Load Control Card (4I5)

Columns	Variable	Definition
1-5	NFACE	Number of element faces which are pressurized
6-10	INT	Order of numerical integration to be used (default = 3)

Fig. 1. Three-dimensional finite-element node numbering convention.

Load Control Card (4I5) (continued)

Columns	Variable	Definition
11-15	NCUR	Number of the load curve to which this load case corresponds
16-20	NUMLT	Number of pressure distributions

In general, the pressure loads should be calculated using the same order of integration as will be used in the finite-element analysis. If

the pressurized element faces are flat and rectangular and the pressure is constant or varies linearly, INT can be reduced to 2 with no loss of accuracy. NCUR is the number of the load curve in the finite-element analysis to which this load case corresponds; NCUR is not used in SAP3PR but is placed on the nodal load cards output by SAP3PR.

Pressure Cards (8F10.0)

Columns	Variable	Definition
1-10	PRESR(1,I)	Magnitude of the <u>I</u> th pressure distribution at face node 1
11-20	PRESR(2,I)	Magnitude of the <u>I</u> th pressure distribution at face node 2
21-30	PRESR(3,I)	Magnitude of the <u>I</u> th pressure distribution at face node 3
31-40	PRESR(4,I)	Magnitude of the <u>I</u> th pressure distribution at face node 4
41-50	PRESR(5,I)	Magnitude of the <u>I</u> th pressure distribution at face node 5
51-60	PRESR(6,I)	Magnitude of the <u>I</u> th pressure distribution at face node 6
61-70	PRESR(7,I)	Magnitude of the <u>I</u> th pressure distribution at face node 7
71-80	PRESR(8,I)	Magnitude of the <u>I</u> th pressure distribution at face node 8

There should be NUMLT pressure cards, one for each pressure distribution. To properly specify surface pressures, it is necessary to sequence the six faces and the eight nodal points (NOF1, NOF2, ... , NOF8) on each face. The six faces of the element are defined according to Fig. 1 as follows: face 1 ($R = 1$), face 2 ($S = 1$), face 3 ($T = 1$), face 4 ($R = -1$), face 5 ($S = -1$), face 6 ($T = -1$). Each face contains either N1 or N7, which will be used as the first of the eight face nodes. Figure 2 shows the arrangement of the face nodes. Using Fig. 2 in conjunction

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Fig. 2. Node numbering convention of a three-dimensional element face.

with Fig. 1 results in the following nodal sequence for each face:

FACE	NOF1	NOF2	NOF3	NOF4	NOF5	NOF6	NOF7	NOF8
1	N1	N4	N8	N5	N12	N20	N16	N17
2	N1	N5	N6	N2	N17	N13	N18	N9
3	N1	N2	N3	N4	N9	N10	N11	N12
4	N7	N3	N2	N6	N19	N10	N18	N14
5	N7	N8	N4	N3	N15	N20	N11	N19
6	N7	N6	N5	N8	N14	N13	N16	N15

Face Card (3I5)

Columns	Variable	Definition
1-5	LM	Number of the pressurized element
6-10	NUMF	Number of the face which is pressurized
11-15	LODTYP	Number of the pressure distribu- tion which acts on this face (default = 1)

There should be NFACE face cards.

PROGRAM OPERATION

Equivalent nodal forces due to distributed loads are given by the following equation (Ref. 4):

$$\{F\} = - \int [N]^T \{p\} dV ,$$

with the integration being over the volume of the loaded element. The matrix $[N]$ is composed of the shape functions as follows:

$$\left. \begin{array}{l} n_{1,3i-2} = h_i \\ n_{1,3i-1} = 0 \\ n_{1,3i} = 0 \\ n_{2,3i-2} = 0 \\ n_{2,3i-1} = h_i \\ n_{2,3i} = 0 \\ n_{3,3i-2} = 0 \\ n_{3,3i-1} = 0 \\ n_{3,3i} = h_i \end{array} \right\} \quad (i = 1, 2, \dots, m) ,$$

where h_i is the shape function for node i , $n_{j,k}$ is the term in the j th row and k th column of $[N]$, and m is the number of nodes the element has. The terms of the vector $\{p\}$ are the components of the distributed load in the global coordinate directions. Since $\{p\}$ is zero except on the face which is pressurized, it is only necessary to integrate over the surface of the pressurized face, not the volume of the element. Numerical integration is used after the face has been mapped into the local two-dimensional u, v -space as shown in Fig. 3. Assuming that one of the global coordinates (x, y , or z) is a function of the other two, the

Fig. 3. Mapping of a pressurized face into a local two-dimensional space.

following expression can be obtained:

$$\{F\} = \int_{-1}^1 \int_{-1}^1 [\bar{N}]^T \{\bar{p}\} du dv ,$$

where

$$\{\bar{p}\} = \left\{ \begin{array}{c} \frac{\partial z}{\partial u} \frac{\partial y}{\partial v} - \frac{\partial y}{\partial u} \frac{\partial z}{\partial v} \\ \frac{\partial x}{\partial u} \frac{\partial z}{\partial v} - \frac{\partial z}{\partial u} \frac{\partial x}{\partial v} \\ \frac{\partial y}{\partial u} \frac{\partial x}{\partial v} - \frac{\partial x}{\partial u} \frac{\partial y}{\partial v} \end{array} \right\} p_n ,$$

and p_n is the magnitude of the pressure, a function of u and v

$$\left[p_n = \sum_{i=1}^1 p_i h_i(u,v) \right] .$$

The matrix $[\bar{N}]$ is composed of the shape functions for the nodes on the pressurized face.

The program expects the input data to be in a disk file named FOR21.DAT. After reading the model control card, the program sets up the pointers necessary for the vector storage and checks to see if sufficient space is available in blank common. The output, which is compatible with ADINA, NONSAP, or STATIC-SAP, depending upon the value of the variable NONSAP on card 1, is written into a disk file named FOR22.DAT.

PROGRAM LISTING

```

C *****
C
C DRIVER FOR PROGRAM WHICH CALCULATES NODAL LOADS EQUIVALENT
C TO PRESSURE LOADS ON 8-20 NODE 3-D ISOPARAMETRIC ELEMENTS
C
C *****
C LOGICAL NONSAP
C COMMON A(40000)
C MTCT = 40000
C
C INPUT
C   NUMNE - NO. OF NODES
C   NUMEL - NO. OF ELEMENTS
C   NLOAD - NO. OF LOAD CASES
C   NUMLTH - MAXIMUM NO. OF PRESSURE DISTRIBUTIONS
C             FOR ANY LOAD CASE
C   NONSAP - FLAG INDICATING FORMAT
C             = T FOR 'NONSAP' OR 'ADINA' FORMAT
C             = F FOR 'STATIC-SAP' FORMAT
C
C READ(21,5000) NUMNP,NUMEL,NLOAD,NUMLTH,NONSAP
5000 FORMAT(4I5,4X,I1)
C   N1 = 1
C   N2 = N1 + 2*NLOAD*3*NUMNP
C   N3 = N2 + 2*NLOAD*3
C   N4 = N3 + 2*3*NUMNP
C   N5 = N4 + 2*8*NUMLTH
C   N6 = N5 + 21*NUMEL
C   NLAST = N6 + NLOAD - 1
C   IF (NLAST .LE. MTOT) GO TO 10
C   TYPE 5010,NLAST
5010 FORMAT(1H,'MTCT MUST BE INCREASED TO',I6)
C   STOP
10   TYPE 5020,NLAST
5020 FORMAT(1H0,'MTCT MUST BE AT LEAST',I6)
C   CALL SAP3PR(A(N1),A(N2),A(N3),A(N4),A(N5),A(N6),
C             1   NUMNP,NUMEL,NLOAD,NUMLTH,NONSAP)
C   STCP
C   END
C
C SUBROUTINE SAP3PR(F,FSUM,XY,PRESR,LNODE,NC,
1   NUMNE,NUMEL,NLOAD,NUMLTH,NONSAP)
C *****
C PROGRAM TO CALCULATE NODAL LOADS EQUIVALENT TO PRESSURE LOADS
C ON 8-20 NODE 3-D ISOPARAMETRIC ELEMENTS
C
C *****
C *** DEFINITION OF VARIABLES ***
C
C F(I,J,K) - RESULTING LOAD IN 'J'TH DIRECTION ON NODE 'K' FOR
C           I.CAD CASE 'I'
C IDGEN - FLAG FOR DEGENERATE EDGES OF AN ELEMENT
C LM - ELEMENT WHICH IS LOADED
C LNCDE(I,J) - 'I'TH NODE OF THE 'J'TH ELEMENT
C LODTYP - NUMBER OF PRESSURE DISTRIBUTION ON THE FACE
C NLOAD - NUMBER OF LOAD CASES
C NODE(I) - 'I'TH NODE OF LOADED FACE
C NONSAP - FLAG INDICATING FORMAT
C           = T FOR 'NONSAP' OR 'ADINA' FORMAT
C           = F FOR 'STATIC-SAP' FORMAT

```



```

C      READ(21,5060) LE,NUMF,LODTYP
5060  FORMAT(3I5)
      IF (LODTYP.EQ. 0) LODTYP = 1
      IF (IM.LE.NUMEL .AND. NUMF.LE.6 .AND.
1      LODTYP.LE.NUMLT) GO TO 40
      TYPE 5070,LM,NUMF,LODTYP
5070  FORMAT(1H0,'*** ERROR ***',3I5)
      STCP
40    DO 50 J = 1,8
50    NODE(J) = LNCDE(NOF(J,NUMF),LM)
C
C      CHECK FOR DEGENERATE EDGES
C
      I2 = 0
      IDGEN = 0
      DO 60 I1 = 1,4
      IF ((NODE(IHM(I1)) .EQ. 0) .OR.
1      (NODE(IDGEN1(I1)) .NE. NODE(IDGEN2(I1)))) GO TO 60
      NODE(NZERO(I1)) = 0
      I2 = I2 + 1
      IDGEN = I1
60    CONTINUE
      IF (I2.LI. 2) GO TO 7C
      TYPE 5080,NUMF,IM,NODE
5080  FORMAT(1H0,'*** ERROR *** FACE',I2,' OF ELEMENT',I4,
1      ' HAS TOO MANY DEGENERATE NODES'/8I5)
      STOP
C
C      CALCULATE NODAL LOADS ON THIS FACE
C
70    CALL FORCE(FP,XY,NODE,INT,FRESR(1,LCDTYP),IDGEN)
C
C      ADD CONTRIBUTION OF THIS FACE
C
      DO 80 J = 1,8
      NODEI = NODE(J)
      IF (NCDEI .EQ. 0) GO TO 80
      F(LOAD,1,NODEI) = F(LCAD,1,NODEI) + FP(1,J)
      F(LOAD,2,NODEI) = F(LCAD,2,NODEI) + FP(2,J)
      F(LOAD,3,NODEI) = F(LCAD,3,NODEI) + FP(3,J)
80    CONTINUE
90    CONTINUE
      IF (.NOT. NONSAFE) GO TO 110
C *****
C PUNCH CARDS FOR USE AS INPUT TO 'NCNSAP' OR 'ADINA'
C *****
      I2 = 0
      DO 100 I1 = 1,NUMNP
      DO 100 J = 1,3
      FSUM(J,LOAD) = FSUM(J,LOAD) + F(LOAD,J,I1)
      IF (DABS(F(LOAD,J,I1)) .LE. 5.0D-2) GO TO 100
      I2 = I2 + 1
      WRITE(22,5090) I1,J,NC(LOAD),F(LOAD,J,I1)
5090  FORMAT(3I5,F10.1)
100   CONTINUE
      TYPE 5100,I2,NC(LOAD),(FSUM(J,LOAD),J=1,3)
5100  FORMAT(1H0,I5,' LOAD CARDS FOR LOAD CURVE',I3/
1      1H,'SUMX =',F14.1,' SUMY =',F14.1,' SUMZ =',F14.1)
110  CONTINUE
      IF (NCNSAP) RETURN
C *****
C PUNCH CARDS FOR USE AS INPUT TO 'STATIC-SAP'
C *****
      I2 = 0
      DO 130 I = 1,NUMNP
      DO 130 LOAD = 1,NLOAD
      DO 120 J = 1,3

```

SAP3 820
 SAP3 830
 SAP3 840
 SAP3 850
 SAP3 860
 SAP3 861
 SAP3 870
 SAP3 880
 SAP3 890
 SAP3 900
 SAP3 910
 SAP3 920
 SAP3 930
 SAP3 940
 SAP3 950
 SAP3 960
 SAP3 970
 SAP3 980
 SAP3 981
 SAP3 990
 SAP 1000
 SAP 1010
 SAP 1020
 SAP 1030
 SAP 1040
 SAP 1050
 SAP 1051
 SAP 1060
 SAP 1070
 SAP 1080
 SAP 1090
 SAP 1100
 SAP 1110
 SAP 1120
 SAP 1130
 SAP 1140
 SAP 1150
 SAP 1160
 SAP 1170
 SAP 1180
 SAP 1190
 SAP 1200
 SAP 1210
 SAP 1220
 SAP 1230
 SAP 1240
 SAP 1250
 SAP 1260
 SAP 1270
 SAP 1280
 SAP 1290
 SAP 1300
 SAP 1310
 SAP 1320
 SAP 1330
 SAP 1340
 SAP 1350
 SAP 1360
 SAP 1361
 SAP 1370
 SAP 1380
 SAP 1390
 SAP 1400
 SAP 1410
 SAP 1420
 SAP 1430
 SAP 1440
 SAP 1450

```

120  FSUM(J,LOAD) = FSUM(J,LOAD) + F(LOAD,J,I)          SAP 1460
      OUTPUT=.FALSE.                                     SAP 1470
      IF (DABS(F(LOAD,1,I)) .GT. 5.0D-2 .OR.             SAP 1480
1      DABS(F(LOAD,2,I)) .GT. 5.0D-2 .OR.               SAP 1481
2      DABS(F(LOAD,3,I)) .GT. 5.0D-2) OUTPUT=.TRUE.     SAP 1482
      IF (OUTPUT)                                         SAP 1490
1  WRITE (22,5110) I,NC(ICAD),F(LOAD,1,I),F(LOAD,2,I),F(LOAD,3,I) SAP 1491
5110 FORMAT(2I5,3F10.1)                                  SAP 1500
      IF (OUTPUT) I2 = I2 + 1                             SAP 1510
130  CONTINUE                                           SAP 1520
      TYPE 5120,I2,(NC(J),(FSUM(I,J),I=1,3),J=1,NLOAD)  SAP 1530
5120 FORMAT(1H0,'TOTAL NUMBER OF LOADED NODES =',I5//   SAP 1540
1      1H0,'LOAD CASE          SUMX          SUMY          SUMZ',//SAP 1541
2      (1H,I9,3F14.1))                                  SAP 1542
      RETURN                                             SAP 1550
      END                                                SAP 1560

```

```

C      SUBROUTINE FORCE(P,XY,NODE,INT,PRES,IDGEN)          FORCE 10
C      *****FORCE 20
C      SUBROUTINE TO CALCULATE NODAL LOADS DUE TO PRESSURE ON THE FORCE 30
C      SURFACE OF A 3-D ISOPARAMETRIC ELEMENT OF THE 'SERENDIPITY' FORCE 40
C      FAMILY                                             FORCE 50
C      FORCE 60
C      FORCE 70
C      *****FORCE 80
C      IMPLICIT REAL*8 (A-H,C-Z)                         FORCE 90
C      REAL*8 J                                           FORCE 100
C      DIMENSION XY(3,1),F(3,8),H(8),P(8,2),           FORCE 110
1      J(3,2),PL(3),PRES(8),NODE(8)                   FORCE 111
C      DO 10 I1 = 1,8                                     FORCE 120
C      DO 10 I2 = 1,3                                     FORCE 130
10  F(I2,I1) = 0.0D0                                     FORCE 140
C      DO 30 INT1 = 1,INT                                 FORCE 150
C      CALL GAUSS(R,W1,INT,INT1)                         FORCE 160
C      DO 30 INT2 = 1,INT                                 FORCE 170
C      CALL GAUSS(S,W,INT,INT2)                         FORCE 180
C      FORCE 190
C      CALCULATE JACOBIAN 'J' AND SHAPE FUNCTIONS 'H'   FORCE 200
C      FORCE 210
C      CALL JACCB(R,S,H,P,J,XY,NODE,IDGEN)              FORCE 220
C      FLCAD = 0.0D0                                     FORCE 230
C      DO 2C I = 1,8                                      FORCE 240
C      IF (NODE(I) .NE. 0) FLOAD = FLOAD + H(I)*PRES(I)  FORCE 250
20  CONTINUE                                             FORCE 260
C      WF = W*W1*FLCAD                                   FORCE 270
C      PL(1) = (J(3,1)*J(2,2)-J(2,1)*J(3,2))            FORCE 280
C      PL(2) = (J(1,1)*J(3,2)-J(3,1)*J(1,2))            FORCE 290
C      PL(3) = (J(2,1)*J(1,2)-J(1,1)*J(2,2))            FORCE 300
C      DO 30 I1 = 1,8                                     FORCE 310
C      IF (NODE(I1) .EQ. 0) GO TO 30                     FORCE 320
C      DO 30 I2 = 1,3                                     FORCE 330
30  F(I2,I1) = H(I1)*PL(I2)*WF + F(I2,I1)              FORCE 340
C      CONTINUE                                           FORCE 350
C      RETURN                                             FORCE 360
C      END                                                FORCE 370

```

```

C      SUBROUTINE JACCB(R,S,H,P,J,XY,NODE,IDGEN)        JACOB 10
C      *****JACOB 20
C      JACOB 30
C      SUBROUTINE TO CALCULATE SHAPE FUNCTIONS, PARTIAL DERIVATIVES JACOB 40
C      OF SHAPE FUNCTIONS, AND THE JACOBIAN AT THE POINT (R,S) JACOB 50
C      JACOB 60
C      *****JACOB 70

```

```

IMPLICIT REAL*8 (A-H,C-Z)
REAL*8 J
DIMENSION H(8),P(8,2),J(3,2),XY(3,1),NODE(8),
1      IHM(4),HMOD(4),IMOD(4),IEFFECT(2,4)
EQUIVALENCE (HMOD(1),SM),(HMOD(2),RP),(HMOD(3),SP),(HMOD(4),RM)
DATA IHM/7,8,5,6/,IMCI/2,1,2,1/,IEFFECT/1,2,2,3,3,4,4,1/
RP = 1.0D0 + R
RM = 1.0D0 - R
R2 = 1.0D0 - R*R
SP = 1.0D0 + S
SM = 1.0D0 - S
S2 = 1.0D0 - S*S

C
C
C      FUNCTIONS 1 - 4
H(1) = 0.25D0*RP*SP
H(2) = 0.25D0*RM*SP
H(3) = 0.25D0*RM*SM
H(4) = 0.25D0*RP*SM
P(1,1) = 0.25DC*SP
P(2,1) = -P(1,1)
P(3,1) = -0.25I0*SM
P(4,1) = P(3,1)
P(1,2) = 0.25D0*RP
P(2,2) = 0.25D0*RM
P(3,2) = -P(2,2)
P(4,2) = -P(1,2)
IF (NODE(5).EQ.0) GO TC 10
H(5) = 0.5D0*R2*SP
P(5,1) = -R*SP
P(5,2) = 0.5D0*R2
10 IF (NODE(6).EQ.0) GO TC 20
H(6) = 0.5D0*RM*S2
P(6,1) = -0.5DC*S2
P(6,2) = -S*RM
20 IF (NODE(7).EQ.0) GO TC 30
H(7) = 0.5D0*R2*SM
P(7,1) = -R*SM
P(7,2) = -0.5DC*R2
30 IF (NODE(8).EQ.0) GO TC 40
H(8) = 0.5D0*RP*S2
P(8,1) = 0.5D0*S2
P(8,2) = -S*RP

C
C
C      MODIFY FUNCTIONS 5 - 8 IF ELEMENT IS DEGENERATE
40 IF (IDGEN.EQ.C) GO TC 60
IH = IHM(IDGEN)
NMCD = IMOD(IDGEN)
TEMP = HMOD(IDGEN)*0.5D0
H(IH) = TEMP*H(IH)
DO 50 I2 = 1,2
50 P(IH,I2) = TEMP*P(IH,I2)
P(IH,NMOD) = 2.0D0*P(IH,NMOD)

C
C
C      MODIFY FUNCTIONS 1 - 4 IF ANY OF NODES 5 - 8 ARE PRESENT
60 DO 80 I1 = 5,8
IF (NODE(I1).EQ.0) GO TO 80
DO 70 I2 = 1,2
IH = IEFFECT(I2,I1-4)
H(IH) = H(IH) - 0.5D0*H(I1)
DO 70 I3 = 1,2
70 P(IH,I3) = P(IH,I3) - 0.5D0*P(I1,I3)
80 CONTINUE

C
C
C      EVALUATE JACCEIAN AT (R,S)

```

```

JACOB 80
JACOB 90
JACO 100
JACO 101
JACO 110
JACO 120
JACO 130
JACO 140
JACO 150
JACO 160
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JACO 520
JACO 530
JACO 540
JACO 550
JACO 560
JACO 570
JACO 580
JACO 590
JACO 600
JACO 610
JACO 620
JACO 630
JACO 640
JACO 650
JACO 660
JACO 670
JACO 680
JACO 690
JACO 700
JACO 710
JACO 720
JACO 730
JACO 740

```

	DO 110 I1 = 1,3	JACO 750
	DO 110 I2 = 1,2	JACO 760
	TEMP = 0.0D0	JACO 770
	DO 90 I3 = 1,4	JACO 780
90	TEMP = TEMP + XY(I1,NODE(I3)) * P(I3,I2)	JACO 790
	DO 100 I3 = 5,8	JACO 800
	IF (NODE(I3).NE.0) TEMP = TEMP + XY(I1,NODE(I3)) * P(I3,I2)	JACO 810
100	CONTINUE	JACO 820
110	J(I1,I2) = TEMP	JACO 830
	RETURN	JACO 840
	END	JACO 850

[illegible]

CONCLUSION

SAP3PR provides an easy way of calculating equivalent nodal loads resulting from distributed pressure loadings. The code can be easily modified to calculate nodal loads for elements with a nodal ordering which differs from that used by ADINA, NONSAP, or STATIC-SAP.

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APPENDIX

This appendix contains an example of the input necessary to run SAP3PR and the resulting output. The finite-element model used for this example consists of four 20-node elements as shown in Fig. A.1. Equivalent nodal loads are calculated for two load cases: one for a uniform pressure of 1000 in the negative x-direction and the other for a pressure in the negative y-direction which varies linearly with respect to the z-direction (Fig. A.2).

FA.1

FA.2

The input is shown first followed by the output to the teletype and disk file FOR22.DAT. [Note that the NONSAP = T format option is being used.] The input for load case 1 requires only one pressure card since the pressure on each element face is the same constant 1000. Load case 2 needs four pressure cards because the pressure distribution on all four elements differ. The summation of forces given by the teletype output is useful as a check on the input data. The load cards are output on unit 22.

Fig. A.1. Finite-element model of example structure.

Fig. A.2. Pressure loadings on example structure.

EXAMPLE OF INPUT

[illegible]

EXAMPLE OF TELETYPE OUTPUT

MTOT MUST BE AT LEAST 1170

23 LOAD CARDS FOR LOAD CURVE 1					
SUMX =	-4000.0	SUMY =	-0.0	SUMZ =	0.0
23 LOAD CARDS FOR LOAD CURVE 5					
SUMX =	-0.0	SUMY =	-8000.0	SUMZ =	-0.0

EXAMPLE OF UNIT 22 OUTPUT

3	1	1	83.3
4	1	1	83.3
7	1	1	-333.3
11	1	1	-333.3
12	1	1	-333.3
15	1	1	166.7
16	1	1	166.7
19	1	1	-666.7
23	1	1	-333.3
24	1	1	-333.3
27	1	1	166.7
28	1	1	166.7
31	1	1	-666.7
35	1	1	-333.3
36	1	1	-333.3
39	1	1	166.7
40	1	1	166.7
43	1	1	-666.7
47	1	1	-333.3
48	1	1	-333.3
51	1	1	83.3
52	1	1	83.3
55	1	1	-333.3
1	2	5	55.6
4	2	5	55.6
8	2	5	-111.1
9	2	5	-166.7
12	2	5	-166.7
13	2	5	166.7
16	2	5	166.7
20	2	5	-666.7
21	2	5	-500.0
24	2	5	-500.0
25	2	5	333.3
28	2	5	333.3
32	2	5	-1333.3
33	2	5	-833.3
36	2	5	-833.3
37	2	5	500.0
40	2	5	500.0
44	2	5	-2000.0
45	2	5	-1166.7
48	2	5	-1166.7
49	2	5	277.8
52	2	5	277.8
56	2	5	-1222.2

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