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TECHNICAL MEMORANDUM REPORT RSI-0056

DATA INPUT MANUAL FOR RSI/TEVCO:

A THERMO/VISCOELASTIC FINITE ELEMENT COMPUTER PROGRAM

Submitted To

Office of Waste Isolation
Oak Ridge, Tennessee

operated by

Union Carbide Corporation
Nuclear Division

for the

Energy Research and Development Administration

By

Gary D. Callahan
and
Arlo F. Fossum

February 1, 1977

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RE/SPEC INC.

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Rapid City, South Dakota

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FOREWORD

This report was prepared under a subcontract with Union Carbide Corporation, Nuclear Division, an ERDA contractor. The subcontract was administered by the Office of Waste Isolation and is part of the National Waste Terminal Storage (NWTs) Program. The principal objective of the NWTs Program is to provide facilities in various deep geologic formations at multiple locations in the United States which will safely dispose of commercial radioactive waste, which must be delivered to a Federal Repository for terminal storage. Some of the expected wastes produce both heat and radioactivity. This situation leads to many unique problems in rock mechanics. This report addresses a particular problem relative to the Rock Mechanics Program.

The overall objective of the OWI Rock Mechanics Program is to predict the response of a rock mass hosting a waste repository during its construction and operation, as well as the post-operational phase. The operational phase is expected to be approximately 20 years while the post-operational phase will last until the repository no longer poses any potential hazard to mankind, a period that may last several hundred thousand years. The Rock Mechanics Program is concerned with near field effects on mine stability as well as far field effects relative to the overall integrity of the geologic containment of waste.

In order to accomplish the objectives of the Rock Mechanics Program, numerical simulation, laboratory (including bench scale), and field studies are under way. The laboratory and field studies provide input to the numerical simulations and also the opportunity for validation of the predictive capabilities of the computer codes. Ultimately, the computer codes will provide the predicted response of the host rock mass and thereby form an essential part of the overall Rock Mechanics Program.

This report provides information on input data along with a FORTRAN listing of RSI/TEVCO: A Thermo/Viscoelastic Finite Element Computer Program. Documentation of computer codes used in the NWTs Program is important in order to provide for continuity in the program and acceptance by both the scientific community and the public.

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TECHNICAL MEMORANDUM REPORT RSI-0056

February 1, 1977

TO: Office of Waste Isolation
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P. O. Box Y
Oak Ridge, TN 37830

Attn.: Dr. William C. McClain

FROM: Mr. Gary D. Callahan
Dr. Arlo F. Fossum
RE/SPEC Inc.
P. O. Box 725
Rapid City, SD 57701

SUBJECT: Data Input Manual for RSI/TEVCO: A Thermo/Viscoelastic Finite
Element Computer Program (Ref.: Union Carbide Corporation,
Nuclear Division Subcontract No. 89Y-22303 (RSI-001000/FY77)).

1. INTRODUCTION

Program: RSI/TEVCO

Function: RSI/TEVCO is a plane finite element code designed to analyze elastic, thermoelastic, viscoelastic, or thermoviscoelastic problems. The basic element is the eight noded isoparametric quadrilateral element but a six noded subparametric triangular element may be used separately or for gradation purposes with quadrilateral elements.

Output: RSI/TEVCO outputs nodal (incremental and total) displacements and stresses.

The following pages illustrate the required input data with options for obtaining approximate solutions to elastic, thermoelastic, viscoelastic, or thermoviscoelastic type problems. One versed in digital computers and the finite element method (1,2)* should have little difficulty in using the computer program as a tool for analyzing complex boundary value problems of the aforementioned type. Figure 1 offers a "glossary" of terms which may be foreign to the user. The example problem and results (following the input data description) should clarify other concepts which may be misconstrued.

*Numbers in parentheses refer to references at the end of this report.

(a) Segment from a Typical Finite Element Discretization.

(b) Typical Eight-Noded Isoparametric Element.

Primary Nodes	-	i, k, m, o
Secondary Nodes	-	j, l, n, p
Global Coordinate Axes	-	x, y
Local Coordinate Axes	-	η, ξ

Figure 1. Segment of a typical finite element mesh utilizing eight noded isoparametric elements.

In Section 2, each required data card type is described. The bulk of the data required to describe a finite-element mesh is contained in data card types 5 and 6 which consists of the nodal coordinates and the elemental nodal connection array, respectively. For larger problems, one may find it advantageous to generate the coordinates and connection array automatically in a small routine and thus reduce the mesh preparation time.

In the final section, an example problem is presented to illustrate the mesh preparation, data input, and computer output. A fortran listing of the computer program is given in the Appendix.

2. INPUT DATA DESCRIPTION

The following pages illustrate and describe the required data cards for running various stress analysis type problems utilizing RSI/TEVCO. Each data card type is discussed separately and warrants no further discussion at this point.

The units on various input parameters may be any set of consistent units. For example:

nodal coordinates	- in.
Young's modulus	- lb./in. ²
specific weight	- lb./in. ³
element thickness	- in.
temperatures	- °F
thermal expansion coefficient	- 1/°F
boundary conditions	
i) point loads	- lb.
ii) tractions	- lb./in. ²
iii) displacements	- in.

Using the above set of units, displacements are output in inches and stresses are output in pounds per square inch.

In the following text, dimensions are given in terms of mass (M), length (L), time (t), and temperature (T).

Diagram illustrating the structure of the 18A4 alphanumeric header. The header is divided into two main sections: a 15-bit section (labeled 15) and a 3-bit section (labeled 3X). The alphanumeric header is labeled ALPHANUMERIC HEADER and 18A4. The diagram shows the header bits (0s and 1s) and the alphanumeric header bits (0s and 1s) arranged in a grid, with the first 15 bits in the first row and the next 3 bits in the second row. The grid is labeled with numbers 1 through 40, with the first 15 bits in the first row and the next 3 bits in the second row.

This card is echoed on the RSI/TEVCO printout to identify the computer run. Only one card is permitted.

[illegible]

where:

IVE is a solution type index.

IVE = 1 results in a thermoelastic run.

IVE = 2 results in a creep run, or an elastic run.

IVE = 3 results in a thermoviscoelastic run.

IPR is the print interval on time steps.

(Default = 1) e.g. IPR = 3 results in output every third time step.

$JTMAX$ is the number of time steps.

IF (i) IVE = 1, Set JTMAX = 2

(ii) $IVE = 2$

(a) Creep, JTMAX = desired time steps

(b) Elastic, JTMAX = 1

(iii) IVE = 3, JTMAX = desired time steps

DELT is the magnitude of the time step in years.

(Disregard for elastic and thermoelastic problems)

DATA CARD 3

[illegible]

where:

NNP is the number of nodal points (maximum = 1000)

NET is the number of elements (maximum = 400)

NMAT is the number of different material types (maximum = 5)

NSLC is the number of uniform surface load cards (i.e., one card per element side) e.g. for the following, *NSLC* = 3

1

0	0	0
8	79	80
1	1	
2	2	
3	3	
4	4	

0	0	0
8	7	8
1	1	1
2	2	2
3	3	3
4	4	4

DATA CARDS 6

where:

$I(N,1)-I(N,8)$ are the global node numbers progressing counter clockwise in element N , e.g.

MN(N) is the element material type number of element *N*
(maximum number is *NMAT*)

MSC	NS2	TRACX	TRACY
NSIC	(NSLC)	(NSLC)	(NSLC)

[illegible]

MSC is the element number on which tractions are applied.

NS2 is the number of the secondary (mid-side) node on the side of the element on which tractions are applied.

TRACX, TRACY are tractions (M/t^2L) in the X and Y directions, respectively applied to the side of an element with the element identified by MSC and the side identified by NS2.

Data card types 8, 9, and 10 that follow pertain to specification of the temperature field(s) for thermoelastic and thermovisco/elastic problems (See Notes p. 12).

NTF
I5

DATA CARD 8

NTF is the number of temperature fields to be input.

[illegible]

TM is the time of the temperature field which follows in data card type(s) 10(t).

[illegible]

$TNEW(N)$ is the temperature of nodal point N at time TM specified in card type 9 (T).

NOTES ON DATA INPUT CARD TYPESCARD TYPENOTE

- 2 If IVE = 1 (i.e. thermoelastic run), JTMAX is set equal to 2 for consideration of one temperature field. If multiple temperature fields are to be considered, JTMAX should be equal to the number of temperature fields plus one.
- When IVE = 2 and creep is being considered, one must realize that the constitutive relation is of the power law form which was derived from experimental data on rock salt.
- When IVE = 3 (i.e. thermo/viscoelastic run) all temperature fields need not be provided. Temperature fields required that are not provided are computed from those that are provided through linear interpolation.
- 5 Automatic generation of equally spaced nodal points is included for missing node numbers. For generated nodes KODE = 0 and the prescribed tractions equal zero.
- 6 Automatic element generation is possible for quadrilateral elements only if one numbers the nodes continually along a line, e.g.

In the above example, including data cards for elements 1 and 4 would result in the generation of elements 2 and 3 internally. In addition the material type number (MN), is assumed to be the same as element 1.

- 8, 9, and 10 For thermoelastic runs (IVE = 1) card types 8, 9, and 10 must be repeated sequentially for each temperature field. In each case NTF (Card 8) must be equal to one followed by the time (Card 9) and the temperature field (Cards 10).
- In thermo/viscoelastic analyses (IVE = 3), card type 8 is included only once indicating the number of temperature fields provided. Card 8 is then followed by card types 9 and 10 (i.e. 9-10, 9-10, 9-10 . . .) providing the time and temperature fields.

General

Units on input data must be consistent.

3. EXAMPLE PROBLEM UTILIZING RSI/TEVCO

3.1. Problem Description

Consider a uniform, isothermal, traction free bar (neglecting body forces) whose temperature is instantaneously elevated everywhere. Two specific cases, as depicted in Figure 2, will be considered; including (a) ends of the bar are restrained, and, (b) ends of the bar are free.

(a) Restrained Heated Bar

(b) Unrestrained Heated Bar

Figure 2. Thermoelastic Example Problem Geometry.

Since the ends of the bar are restrained in Case A, horizontal stresses will build up as the bar is heated. However, since the bar is free to expand in the vertical direction, the vertical stress component will be zero.

Case B consists of the bar being totally unrestrained and free of tractions and body forces, thus upon heating, the bar will expand but remain stress free (3).

If one considers a state of plane strain, the homogeneous thermal stress field generated by a uniform increase in temperature ΔT for Case A is (4,5)

$$\sigma_x = E\alpha\Delta T/(1-\nu) \quad (\text{Compressive})$$

where:

α = thermal expansion coefficient (1/Degree)

ν = Poisson's Ratio

E = Young's Modulus ($M/t^2 L$)

Choosing the following values:

$$\alpha = 6.0 \times 10^{-6} \quad \text{in./in./}^\circ\text{F}$$

$$\nu = 0.25$$

$$E = 1.0 \times 10^6 \quad \text{lb./in.}^2$$

$$\Delta T = 10^\circ\text{F}$$

the induced thermal stress is:

$$\sigma_x = 80 \quad \text{lb./in.}^2 \quad (\text{Compressive})$$

$$\sigma_y = 0 \quad \text{lb./in.}^2$$

As previously mentioned for Case B, free expansion of the bar results in no thermally induced stresses. However, the thermal strains generated are seen to be (4,5)

$$\epsilon_x = \epsilon_y = (1+\nu)\alpha\Delta T$$

Utilizing the aforementioned properties, the strains are computed to be

$$\epsilon_x = \epsilon_y = 7.5 \times 10^{-5}$$

Accompanying the stresses in Case A, the strains are:

$$\epsilon_x = 0$$

$$\epsilon_y = (1+\nu)\alpha\Delta T/(1-\nu)$$

which results in

$$\epsilon_y = 1 \times 10^{-4}$$

3.2. The Finite Element Discretization

In modeling the above thermoelastic example problem, the characteristic bar dimensions, h and L , are arbitrary (except when considering displacements) and chosen as one foot and twelve feet, respectively. Secondly, one must decide on the number, size, gradation, etc. regarding the elements. For this particular problem one quadrilateral element would be sufficient; however, four quadrilateral elements will be utilized for illustrative purposes. Generally, the number of triangular or quadrilateral elements to be used, gradation etc. are problem dependent and require experience along with some trial and error in order to assess the 'best' representation. Figure 3 shows the finite element models used for the two cases shown in Figure 2.

CASE A: Ends Restrained

Boundary Condition Codes

- 1 - Nodes 1, 2, 21, 22
- 2 - Nodes 5, 8, 10, 13, 15, 18, 20
- 3 - Nodes 3, 23
- 0 - All Other Nodes

CASE B: Free Expansion

Boundary Condition Codes

- 1 - Nodes 1, 2
- 2 - Nodes 5, 8, 10, 13, 15, 18, 20, 23
- 3 - Node 3
- 0 - All Other Nodes

Figure 3. Finite Element Models for the Thermoelastic Example Problem.

3.3. Input Data

After defining the specific problem, the material properties, and the mesh, one may proceed generating the input data as described in Section 2. The bulk of the information is extracted from Figure 3. The completed coding forms for the example problems are included in the following pages (cf. Section 2.).

(RSI-0056)

[illegible][illegible]

10. This application is a request for personal statements from this form.

*Number of forms per pad may vary slightly.

PROGRAMMER

GDC

DATE _____

PUNCHING
INSTRUCTIONS

GRAPHIC

PUNCH

PAGE	2	OF	3
CARD ELECTRO NUMBER:			

57

* A standard 1 and 1/2 mm. IBM electric IBM 157, is available for only \$12.95. Inquiries from this firm.

**Number of forms per pad may vary slightly

FORTRAN Coding Form

[illegible]

3.4. Results

The following pages illustrate the computer output for RSI/TEVCO including the nodal stresses and displacements for the two previously posed problems. Comparing with the results computed in Section 3.1 from the theory of elasticity, the results are seen to be essentially exact.

The first solution pass (recall $JTMAX = 2$ data card type 2 Section 2) results in zero displacements and stresses. Generally, the first pass is used for a 'gravity turn-on' analysis followed by the thermal stress analysis. Since the body forces are zero in these example problems, the stresses and displacements are zero as one would expect.

PROBLEM 2. RSI/TEVCO THERMOELASTIC EXAMPLE PROBLEM -- CASE (A)

INITIAL TIME-STEP, DELT= 0.0 YRS

INPUT TABLE 1. BASIC PARAMETERS

NUMBER OF NODAL POINTS.	23
NUMBER OF ELEMENTS.	4
NUMBER OF DIFFERENT MATERIALS	1
NUMBER OF SURFACE LOAD CARDS.	0
1 = PLANE STRAIN, 2 = PLANE STRESS.	1
BODY FORCES(1 = IN -Y DIREC., 0 = NONE)	0

TABLE 2. MATERIAL PROPERTIES

AL	MODULUS OF	POISSON'S	MATERIAL	MATERIAL	EXPANSION
IER	ELASTICITY	RATIO	DENSITY	THICKNESS	COEFFICIENT
1	0.1000D 07	0.2500D 00	0.0	0.1000D 01	0.6000D-05

INPUT TABLE 3.. NODAL POINT DATA

NODAL POINT	TYPE	X	Y	X-DISP. OR LOAD	Y-DISP. OR LOAD
1	1	0.0	0.1200D 02	0.0	0.0
2	1	0.0	0.6000D 01	0.0	0.0
3	3	0.0	0.0	0.0	0.0
4	0	0.1800D 02	0.1200D 02	0.0	0.0
5	2	0.1800D 02	0.0	0.0	0.0
6	0	0.3600D 02	0.1200D 02	0.0	0.0
7	0	0.3600D 02	0.6000D 01	0.0	0.0
8	2	0.3600D 02	0.0	0.0	0.0
9	0	0.5400D 02	0.1200D 02	0.0	0.0
10	2	0.5400D 02	0.0	0.0	0.0
11	0	0.7200D 02	0.1200D 02	0.0	0.0
12	0	0.7200D 02	0.6000D 01	0.0	0.0
13	2	0.7200D 02	0.0	0.0	0.0
14	0	0.9000D 02	0.1200D 02	0.0	0.0
15	2	0.9000D 02	0.0	0.0	0.0
16	0	0.1080D 03	0.1200D 02	0.0	0.0
17	0	0.1080D 03	0.6000D 01	0.0	0.0
18	2	0.1080D 03	0.0	0.0	0.0
19	0	0.1260D 03	0.1200D 02	0.0	0.0
20	2	0.1260D 03	0.0	0.0	0.0
21	1	0.1440D 03	0.1200D 02	0.0	0.0
22	1	0.1440D 03	0.6000D 01	0.0	0.0
23	3	0.1440D 03	0.0	0.0	0.0

SEMI-BANDWIDTH IS 16 WITH 46 EQUATIONS

NODE	INCREMENTAL DISPLACEMENTS		TOTAL DISPLACEMENTS		AT TIME . . . 0.0	YR
	X	Y	X	Y		
1	0.0	0.0	0.0	0.0		
2	0.0	0.0	0.0	0.0		
3	0.0	0.0	0.0	0.0		
			0.0	0.0		
			0.0	0.0		
			0.0	0.0		
			0.0	0.0		
			0.0	0.0		
			0.0	0.0		
			0.0	0.0		
			0.0	0.0		
			0.0	0.0		
			0.0	0.0		
			0.0	0.0		
			0.0	0.0		
			0.0	0.0		
			0.0	0.0		
			0.0	0.0		
10	0.0	0.0	0.0	0.0		
14	0.0	0.0	0.0	0.0		
15	0.0	0.0	0.0	0.0		
16	0.0	0.0	0.0	0.0		
17	0.0	0.0	0.0	0.0		
18	0.0	0.0	0.0	0.0		
19	0.0	0.0	0.0	0.0		
20	0.0	0.0	0.0	0.0		
21	0.0	0.0	0.0	0.0		
22	0.0	0.0	0.0	0.0		
23	0.0	0.0	0.0	0.0		

OUTPUT TABLE 2•• STRESSES AT NODAL POINTS

NODE	INCREMENTAL			TOTAL			PRINCIPAL I		ANGLE
	X	Y	XY	X	Y	XY	SIG-1	SIG-2	
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

NODE	INCREMENTAL DISPLACEMENTS		TOTAL DISPLACEMENTS		AT TIME . . . 0.0 YR
	X	Y	X	Y	
1	0.0	0.1200D-02	0.0	0.1200D-02	
2	0.0	0.6000D-03	0.0	0.6000D-03	
3	0.0	0.0	0.0	0.0	
4	0.1745D-18	0.1200D-02	0.1745D-18	0.1200D-02	
5	0.6107D-20	0.0	0.6107D-20	0.0	
6	0.6735D-18	0.1200D-02	0.6735D-18	0.1200D-02	
7	0.7621D-18	0.6000D-03	0.7621D-18	0.6000D-03	
8	0.8313D-18	0.0	0.8313D-18	0.0	
9	0.7648D-18	0.1200D-02	0.7648D-18	0.1200D-02	
10	0.8070D-18	0.0	0.8070D-18	0.0	
11	0.1102D-17	0.1200D-02	0.1102D-17	0.1200D-02	
12	0.1168D-17	0.6000D-03	0.1168D-17	0.6000D-03	
13	0.1255D-17	0.0	0.1255D-17	0.0	
14	0.8728D-18	0.1200D-02	0.8728D-18	0.1200D-02	
15	0.9675D-18	0.0	0.9675D-18	0.0	
16	0.8640D-18	0.1200D-02	0.8640D-18	0.1200D-02	
17	0.8504D-18	0.6000D-03	0.8504D-18	0.6000D-03	
18	0.8843D-18	0.0	0.8843D-18	0.0	
19	0.2711D-18	0.1200D-02	0.2711D-18	0.1200D-02	
20	0.1626D-18	0.0	0.1626D-18	0.0	
21	0.0	0.1200D-02	0.0	0.1200D-02	
22	0.0	0.6000D-03	0.0	0.6000D-03	
23	0.0	0.0	0.0	0.0	

(RS1-0056)

OUTPUT TABLE 2-- STRESSES AT NODAL POINTS

NOCE	INCREMENTAL			TOTAL			PRINCIPAL 1			ANGLE
	X	Y	XY	X	Y	XY	SIG-1	SIG-2		
1	-80.00	-0.00	0.00	-80.00	-0.00	0.00	-0.00	-80.00	90.00	
2	-80.00	-0.00	0.00	-80.00	-0.00	0.00	-0.00	-80.00	90.00	
3	-80.00	-0.00	0.0	-80.00	-0.00	0.0	-0.00	-80.00	0.0	
4	-80.00	0.00	-0.00	-80.00	0.00	-0.00	0.00	-80.00	-90.00	
5	-80.00	-0.00	0.00	-80.00	-0.00	0.00	-0.00	-80.00	90.00	
6	-80.00	-0.00	0.00	-80.00	-0.00	0.00	-0.00	-80.00	90.00	
7	-80.00	-0.00	0.00	-80.00	-0.00	0.00	-0.00	-80.00	90.00	
8	-80.00	-0.00	-0.00	-80.00	-0.00	-0.00	-0.00	-80.00	-90.00	
9	-80.00	0.00	0.00	-80.00	0.00	0.00	0.00	-80.00	90.00	
10	-80.00	-0.00	-0.00	-80.00	-0.00	-0.00	-0.00	-80.00	-90.00	
11	-80.00	-0.00	-0.00	-80.00	-0.00	-0.00	-0.00	-80.00	-90.00	
12	-80.00	-0.00	-0.00	-80.00	-0.00	-0.00	-0.00	-80.00	-90.00	
13	-80.00	-0.00	-0.00	-80.00	-0.00	-0.00	-0.00	-80.00	-90.00	
14	-80.00	0.00	0.00	-80.00	0.00	0.00	0.00	-80.00	90.00	
15	-80.00	0.00	-0.00	-80.00	0.00	-0.00	0.00	-80.00	-90.00	
16	-80.00	-0.00	0.00	-80.00	-0.00	0.00	-0.00	-80.00	90.00	
17	-80.00	-0.00	-0.00	-80.00	-0.00	-0.00	-0.00	-80.00	-90.00	
18	-80.00	-0.00	-0.00	-80.00	-0.00	-0.00	-0.00	-80.00	-90.00	
19	-80.00	0.00	0.00	-80.00	0.00	0.00	0.00	-80.00	90.00	
20	-80.00	-0.00	0.00	-80.00	-0.00	0.00	-0.00	-80.00	90.00	
21	-80.00	-0.00	-0.00	-80.00	-0.00	-0.00	-0.00	-80.00	-90.00	
22	-80.00	-0.00	-0.00	-80.00	-0.00	-0.00	-0.00	-80.00	-90.00	
23	-80.00	-0.00	0.0	-80.00	-0.00	0.0	-0.00	-80.00	0.0	

PROBLEM 1** RSI/TEVCO THERMOELASTIC EXAMPLE PROBLEM == CASE (B)

INITIAL TIME-STEP, DELT= 0.0 YRS

INPUT TABLE 1** BASIC PARAMETERS

NUMBER OF NODAL POINTS.	23
NUMBER OF ELEMENTS.	4
NUMBER OF DIFFERENT MATERIALS.	1
NUMBER OF SURFACE LOAD CARDS.	0
1 = PLANE STRAIN, 2 = PLANE STRESS.	1
BODY FORCES(I = IN = Y DIREC., 0 = NONE)	0

INPUT TABLE 2** MATERIAL PROPERTIES

MATERIAL NUMBER	MODULUS OF ELASTICITY	POISSON'S RATIO	MATERIAL DENSITY	MATERIAL THICKNESS	EXPANSION COEFFICIENT
1	9.1000D 07	0.2500D 00	0.0	0.1000D 01	0.6000D-05

INPUT TABLE 3.. NODAL POINT DATA

NODAL POINT	TYPE	X	Y	X-DISP. OR LOAD	Y-DISP. OR LOAD
1	1	0.0	0.12000 02	0.0	0.0
2	1	0.0	0.60000 01	0.0	0.0
3	3	0.0	0.0	0.0	0.0
4	0	0.18000 02	0.12000 02	0.0	0.0
5	2	0.18000 02	0.0	0.0	0.0
6	0	0.36000 02	0.12000 02	0.0	0.0
7	0	0.36000 02	0.60000 01	0.0	0.0
8	2	0.36000 02	0.0	0.0	0.0
9	0	0.54000 02	0.12000 02	0.0	0.0
10	2	0.54000 02	0.0	0.0	0.0
11	0	0.72000 02	0.12000 02	0.0	0.0
12	0	0.72000 02	0.60000 01	0.0	0.0
13	2	0.72000 02	0.0	0.0	0.0
14	0	0.90000 02	0.12000 02	0.0	0.0
15	2	0.90000 02	0.0	0.0	0.0
16	0	0.10800 03	0.12000 02	0.0	0.0
17	0	0.10800 03	0.60000 01	0.0	0.0
18	2	0.10800 03	0.0	0.0	0.0
19	0	0.12600 03	0.12000 02	0.0	0.0
20	2	0.12600 03	0.0	0.0	0.0
21	0	0.14400 03	0.12000 02	0.0	0.0
22	0	0.14400 03	0.60000 01	0.0	0.0
23	2	0.14400 03	0.0	0.0	0.0

INPUT TABLE *** ELEMENT DATA

ELEMENT	GLOBAL INDICES OF ELEMENT NODES								MATERIAL
	1	2	3	4	5	6	7	8	
1	1	2	3	5	8	7	6	4	1
2	6	7	8	10	13	12	11	9	1
3	11	12	13	15	18	17	16	14	1
4	16	17	18	20	23	22	21	19	1

SEMI-BANDWIDTH IS 16 WITH 46 EQUATIONS

NODE	INCREMENTAL DISPLACEMENTS		TOTAL DISPLACEMENTS		AT TIME . . . 0.00 YR	
	X	Y	X	Y		
1	0.0	0.0	0.0	0.0		
2	0.0	0.0	0.0	0.0		
3	0.0	0.0	0.0	0.0		
4	0.0	0.0	0.0	0.0		
5	0.0	0.0	0.0	0.0		
6	0.0	0.0	0.0	0.0		
7	0.0	0.0	0.0	0.0		
8	0.0	0.0	0.0	0.0		
9	0.0	0.0	0.0	0.0		
10	0.0	0.0	0.0	0.0		
11	0.0	0.0	0.0	0.0		
12	0.0	0.0	0.0	0.0		
13	0.0	0.0	0.0	0.0		
14	0.0	0.0	0.0	0.0		
15	0.0	0.0	0.0	0.0		
16	0.0	0.0	0.0	0.0		
17	0.0	0.0	0.0	0.0		
18	0.0	0.0	0.0	0.0		
19	0.0	0.0	0.0	0.0		
20	0.0	0.0	0.0	0.0		
21	0.0	0.0	0.0	0.0		
22	0.0	0.0	0.0	0.0		
23	0.0	0.0	0.0	0.0		

(RSI-0056)

OUTPUT TABLE 2•• STRESSES AT NODAL POINTS

NODE	INCREMENTAL			TOTAL			PRINCIPAL I			ANGLE
	X	Y	XY	X	Y	XY	SIG-1	SIG-2		
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

NODE	INCREMENTAL DISPLACEMENTS		TOTAL DISPLACEMENTS		AT TIME . . . 0.0 YR
	X	Y	X	Y	
1	0.0	0.9000D-03	0.0	0.9000D-03	
2	0.0	0.4500D-03	0.0	0.4500D-03	
3	0.0	0.0	0.0	0.0	
4	0.1350D-02	0.9000D-03	0.1350D-02	0.9000D-03	
5	0.1350D-02	0.0	0.1350D-02	0.0	
6	0.2700D-02	0.9000D-03	0.2700D-02	0.9000D-03	
7	0.2700D-02	0.4500D-03	0.2700D-02	0.4500D-03	
8	0.2700D-02	0.0	0.2700D-02	0.0	
9	0.4050D-02	0.9000D-03	0.4050D-02	0.9000D-03	
10	0.4050D-02	0.0	0.4050D-02	0.0	
11	0.5400D-02	0.9000D-03	0.5400D-02	0.9000D-03	
12	0.5400D-02	0.4500D-03	0.5400D-02	0.4500D-03	
13	0.5400D-02	0.0	0.5400D-02	0.0	
14	0.6750D-02	0.9000D-03	0.6750D-02	0.9000D-03	
15	0.6750D-02	0.0	0.6750D-02	0.0	
16	0.8100D-02	0.9000D-03	0.8100D-02	0.9000D-03	
17	0.8100D-02	0.4500D-03	0.8100D-02	0.4500D-03	
18	0.8100D-02	0.0	0.8100D-02	0.0	
19	0.9450D-02	0.9000D-03	0.9450D-02	0.9000D-03	
20	0.9450D-02	0.0	0.9450D-02	0.0	
21	0.1080D-01	0.9000D-03	0.1080D-01	0.9000D-03	
22	0.1080D-01	0.4500D-03	0.1080D-01	0.4500D-03	
23	0.1080D-01	0.0	0.1080D-01	0.0	

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OUTPUT TABLE 2** STRESSES AT NODAL POINTS

NODE	INCREMENTAL			TOTAL			PRINCIPAL		ANGLE
	X	Y	XY	X	Y	XY	SIG-1	SIG-2	
1	0.00	-0.00	0.00	0.00	-0.00	0.00	0.00	-0.00	0.67
2	0.00	-0.00	0.00	0.00	-0.00	0.00	0.00	-0.00	0.32
3	0.00	-0.00	0.0	0.00	-0.00	0.0	0.00	-0.00	0.0
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36
5	0.00	-0.00	0.00	0.00	-0.00	0.00	0.00	-0.00	0.16
6	0.00	0.00	-0.00	0.00	0.00	-0.00	0.00	0.00	-0.74
7	0.00	-0.00	-0.00	0.00	-0.00	-0.00	0.00	-0.00	-0.73
8	0.00	-0.00	-0.00	0.00	-0.00	-0.00	0.00	-0.00	-1.05
9	0.00	-0.00	0.0	0.00	-0.00	0.0	0.00	-0.00	0.0
10	0.00	-0.00	0.00	0.00	-0.00	0.00	0.00	-0.00	1.08
11	0.00	-0.00	-0.00	0.00	-0.00	-0.00	0.00	-0.00	-6.88
12	0.00	-0.00	-0.00	0.00	-0.00	-0.00	0.00	-0.00	-5.61
13	0.00	-0.00	-0.00	0.00	-0.00	-0.00	0.00	-0.00	-4.98
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.35
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41
16	0.00	-0.00	0.00	0.00	-0.00	0.00	0.00	-0.00	1.25
17	0.00	-0.00	-0.00	0.00	-0.00	-0.00	0.00	-0.00	-2.50
18	0.00	-0.00	-0.00	0.00	-0.00	-0.00	0.00	-0.00	-5.58
19	0.00	0.00	-0.00	0.00	0.00	-0.00	0.00	0.00	-3.81
20	0.00	-0.00	0.00	0.00	-0.00	0.00	0.00	-0.00	1.88
21	0.00	-0.00	-0.00	0.00	-0.00	-0.00	0.00	-0.00	-20.58
22	0.00	-0.00	-0.00	0.00	-0.00	-0.00	0.00	-0.00	-4.28
23	0.00	-0.00	0.00	0.00	-0.00	0.00	0.00	-0.00	11.12

IMCOC2I STGP 0

(RSI-0056)

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- (3) Boley, B. A. and Weiner, J. H.: Theory of Thermal Stresses, Wiley, 1960.
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APPENDIXFortran Listing of Computer Code RSI/TEVCO

Included in the following pages is a fortran listing of computer code RSI/TEVCO. The code is double precision and with the current dimensions the code is a Class D Job on the ORNL IBM 360/91 Computer System.

<u>ITEM</u>	<u>MAXIMUM</u>
Number of Nodes	1,000
Number of Elements	400
Number of Different Material Types	5
Semi-Bandwidth	240

COMPILER OPTIONS = NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,

SO=,MEDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,NOID,NOXREF

C PROGRAM RST IEV

C-----	COMMON BLOCKS FOR THIS SUBROUTINE -----	20
	IMPLICIT REAL*8(A-H,O-Z),INTEGER(I-N)	
	COMMON/B1/ R(2000),AK(480,240),NEG,IBAND,NUMBLK	
	COMMON/B2/ F(5),PR(5),RO(5),TH(5),ALPHA(5)	40
1,	X(1000),Y(1000),ULX(1000),VLY(1000)	
2,	IE(400,9),KODE(1000)	
3,	NNP,NEL,NMAT,NSLC,NOPT,NBODY,MTYP	70
	COMMON /ONF/ QK(16, 17), B(3, 17), C(3, 3, 5), N(8), BODYF(2)	80
1,	BT(9, 13), CF(3, 3, 5)	90
	COMMON/DELC/ DEFT,TM,JT,IPR,IVE	100
	COMMON/TSTRN/ TNEW(1000),TOLD(1000),CLST(9,9,5),EPIT(9),QPIT(24),	
1	EPI(9),QPI(24),NSTP	120
	COMMON/PRU4/ NBEG,NEND	
	COMMON/STAR/ TSTAR,LOUIE	
C-----	LOCAL DIMENSIONING -----	130
	DIMENSION NAME(18)	140
C-----		150
	REAL*8 N	
	MAXEL=400	
	MAXNP=1000	
	MAXMAT = 5	190
	MAXBW=240	
	MAXSLC = 100	210
9999	READ 100,NPROB,(NAME(I),I=1,18)	220
	IF(NPROB.LE.0) GO TO 999	230
	LOUIE = 0	
	NBEG=188	
	NEND=848	
1020	PRINT 200,NPROR,(NAME(I),I=1,18)	240
	READ 101, IVE, IPR, JTMAX, DELT, C1 ,TSTAR	
101	FORMAT(3I5,3E10.3)	
C		260
C	IVE PROBLEM CONTROL PARAMETER	270
C	1 THERMOELASTIC	280
C	2 ELASTIC OR CREEP	290
C	3 THERMOVISCOELASTIC	300
C		310
	PRINT 307,DEFT	
307	FORMAT('OINITIAL TIME=STEP, DELT=',E12.4,' YRS')	
	CALL INOUT (MAXEL,MAXNP,MAXMAT,MAXSLC,ISTOP)	330
	IF(NNP.GT.NEND) GO TO 1008	
	NBEG=1	
	NEND=NNP	
1008	CONTINUE	
	MAXDOF = 2*MAXNP	380
	MAXDIF = 0	390
	DO 1 I=1,NFI	400
	LIM=8	410
	IF(IE(I,7).EQ.0) LIM=6	420
	DO 1 J=1,LIM	430
	DO 1 K=1,LIM	440
	LL= IABS(IE(I,J)- IE(I,K))	450
	IF(LL.GT.MAXDIF) MAXDIF = LL	460
1	CONTINUE	470
	IBAND = 2*(MAXDIF + 1)	480


```

      NEQ = 2*NNP
      PRINT 777, IBAND, NEQ
777  FORMAT('05FMI-RANDWIDTH IS',I4,' WITH',I5,' EQUATIONS' )
      IF (IBAND.GT.MAXRW) GO TO 900
      IF (ISTOP.GT.0) GO TO 999
      CALL CWRITE
      REWIND 8
      CALL ASEMBL (ISTOP)
      ISTAR = 0
      REWIND 4
      IF (TSTAR.GT.0.0) GO TO 33
      IF (IVE.EQ.1 .OR. IVE.EQ.2) GO TO 2
33  CONTINUE
      CALL TEMPS(1,NNP,DELT,IVE)
      2  IF (ISTOP.GT.0) GO TO 999
      CALL BANSOL(1)

      TM=0.0
      DO 53 JT=1,ITMAX
      IF ( JT .EQ. 1)  G    0    T    0    69
      IF (JT.EQ.2) GO TO 51
      IF (C1 .LE. 0.0) GO TO 51
      DELT = C1 * DELT
      IF ( DELT .GT. 0.20 ) DELT = 0.20
51  TM= TM+ DELT
      IF (TSTAR .IF. 0.0 ) GO TO 35
      IF ((TM-TSTAR).GT.DELT) IVE= 3
35  IF ( IVE .EQ. 2 ) GO TO 999
      I1=2
      IF (IVE .EQ. 1) I1=1
      IF ( TSTAR.GT.0.0.AND.ISTAR.EQ.0) GO TO 34
      IF (JT.GT.2) GO TO 971
34  CONTINUE
      DO 972 I=1,NNP
972  TNEW(I)=0.0
      ISTAR = 1
971  DO 992 I=1,NNP
992  TOLD (I) = TNEW(I)
      CALL TEMPS(1,NNP,TM,IVE)
993  CALL INSTRN
      69  CALL BANSOL(2)
      CALL STRESS
53  CONTINUE
      GO TO 9999
900  PRINT 901, IBAND, MAXBW
      GO TO 9999
100  FORMAT(I5,3X,18A4)
151  FORMAT (8(3X,F7.0))
200  FORMAT(/8H1PROBLEM,I5,3H... ,18A4/)
300  FORMAT(37H1OUTPUT TABLE 1.. NODAL DISPLACEMENTS //
      1      13X,4HNODE, 9X, 11HU = X-DISP.,9X,11HV = Y-DISP./
      2      (5X,I12,2F20.8))
530  FORMAT (1H .//,30X,'TIME=',F12.6,2X,'YR      WITH DELT=',F12.6,/)
901  FORMAT(///12H RANDWIDTH =,I4,25H EXCEEDS MAX. ALLOWABLE =,I4//
      1 30H GO ON TO NEXT PROBLEM      )
999  STOP
      END

```

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810

820

830

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PILER OPTIONS = NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,
SOURCE,FBCDIC,NCLIST,NODECK,LOAD,MAP,NOEDIT,NOID,NOXREF
SUBROUTINE INOUT(MAXEL,MAXNP,MAXMAT,MAXSLC,ISTOP) 840
C----- COMMON BLOCKS FOR THIS SUBROUTINE ----- 850
IMPLICIT REAL*8(A-H,O-Z),INTEGER(I-N)
COMMON/B2/ F(5),PR(5),RO(5),TH(5),ALPHA(5) 860
1, X(1000),Y(1000),ULX(1000),VLY(1000)
2, TE(400,9),KODE(1000)
3, NNP,NEL,NMAT,NSLC,NOPT,NBODY,MTYP 890
C----- 900
ISTOP = 0 910
READ 1,NNP,NEL,NMAT,NSLC,NOPT,NBODY,IPRN 920
C
C IF IPRN=1 NODAL AND EL. INFO. DELETED
C
PRINT 100,NNP,NEL,NMAT,NSLC,NOPT,NBODY 930
IF(NNP.LE.MAXNP) GO TO 201 940
ISTOP = ISTOP + 1 950
PRINT 251, MAXNP 960
201 IF(NEL.LE.MAXEL) GO TO 202 970
ISTOP = ISTOP + 1 980
PRINT 252, MAXEL 990
202 IF(NMAT.LE.MAXMAT) GO TO 203 1000
ISTOP = ISTOP + 1 1010
PRINT 253, MAXMAT 1020
203 IF(NSLC.LE.MAXSLC) GO TO 204 1030
ISTOP = ISTOP + 1 1040
PRINT 254, MAXSLC 1050
204 IF(ISTOP.EQ.0) GO TO 205 1060
PRINT 255, ISTOP 1070
STOP 1080
205 READ 2,(E(I),PR(I),RO(I),TH(I),ALPHA(I),I=1,NMAT) 1090
PRINT 101 1100
PRINT 51,(TE(I),PR(I),RO(I),TH(I),ALPHA(I),I=1,NMAT) 1110
IF(IPRN.GT.0) PRINT 67
67 FORMAT('0* * * NODAL AND ELEMENTAL OUTPUT DELETED IPRN .GT.0 * *')
IF(IPRN.LE.0) PRINT 103
N=1 1130
5 READ 3,M,KODE(M),X(M),Y(M),ULX(M),VLY(M) 1140
IF(M=N)4,6,7 1150
4 PRINT 105, M 1160
PRINT 52,M,KODE(M),X(M),Y(M),ULX(M),VLY(M) 1170
ISTOP= ISTOP +1 1180
GO TO 5 1190
7 DF = M + 1 - N 1200
RX=(X(M)-X(N=1))/DF 1210
RY=(Y(M)-Y(N=1))/DF 1220
8 KODF(N)=0 1230
X(N)=X(N=1)+RX 1240
Y(N)=Y(N=1)+RY 1250
ULX(N)=0.0 1260
VLY(N)=0.0 1270
6 IF(IPRN.GT.0) GO TO 66
PRINT 52,N,KODF(N),X(N),Y(N),ULX(N),VLY(N)
66 N=N+1 1290
IF(M=N)9,6,8 1300
9 IF(N.LE.NNP) GO TO 5 1310
IF(IPRN.LE.0) PRINT 106

```

13	L=0	1330
14	READ 15, M, (IE(M,I), I=1,9)	1340
16	L=L+1	1350
	IF(M=L)117,17,18	1360
117	PRINT 118,M	1370
	PRINT 53,M, (IF(M,I), I=1,9)	1380
	ISTOP=ISTOP+1	1390
	GO TO 14	1400
18	IE(L,1)= IE(L=1,1)+2	1410
	IE(L,2)= IE(L=1,2)+2	1420
	IE(L,3)=IE(L=1,3)+2	1430
	IE(L,4)=IE(L=1,4)+1	1440
	IE(L,5)=IE(L=1,5)+2	1450
	IE(L,6)=IE(L=1,6)+2	1460
	IE(L,7)=IE(L=1,7)+2	1470
	IE(L,8)=IE(L=1,8)+1	1480
	IE(L,9)=IE(L=1,9)	1490
17	IF(IPRN.GT.0) GO TO 666	
	PRINT 53, 1, (IF(L,I), I=1,9)	
666	IF(M=L)20,20,16	1510
20	IF(NEL=L)21,21,14	1520
21	CONTINUE	1530
	IF(NSLC.EQ.0) GO TO 31	1540
30	PRINT 108	1550
31	IF(ISTOP.EQ.0) GO TO 999	1560
	PRINT 900, ISTOP	1570
1	FORMAT(7I5)	
100	FORMAT(35H)INPUT TABLE 1.. BASIC PARAMETERS //	1590
1	5X, 40H NUMBER OF NODAL POINTS., I5/	1600
2	5X, 40H NUMBER OF ELEMENTS., I5/	1610
3	5X, 40H NUMBER OF DIFFERENT MATERIALS, I5/	1620
4	5X, 40H NUMBER OF SURFACE LOAD CARDS., I5/	1630
5	5X, 40H 1 = PLANE STRAIN, 2 = PLANE STRESS. . ., I5/	1640
6	5X, 40H BODY FORCES(1 = IN -Y DIREC., 0 = NONE), I5)	1650
251	FORMAT(///,33H TOO MANY NODAL POINTS, MAXIMUM = , I5)	1660
252	FORMAT(///,30H TOO MANY ELEMENTS, MAXIMUM = , I5)	1670
253	FORMAT(///,30H TOO MANY MATERIALS, MAXIMUM = , I5)	1680
254	FORMAT(///,40H TOO MANY SURFACE LOAD CARDS, MAXIMUM = , I5)	1690
255	FORMAT(///,28H EXECUTION HALTED BECAUSE OF, I5, 13H FATAL ERRORS/)	1700
2	FORMAT(5E10,3)	
101	FORMAT(36H)INPUT TABLE 2.. MATERIAL PROPERTIES //	1720
1	10H MATERIAL, 5X, 10HMODULUS OF, 6X, 9HPOISSON'S, 7X,	1730
	28H MATERIAL, 7X, 8H MATERIAL, 6X, 9H EXPANSION, /	1740
	34X, 6H NUMBER, 5X, 10HELASTICITY, 8X, 7H RATIO, 8X, 7HDENSITY, 6X,	1750
	49H THICKNESS, 4X, 11H COEFFICIENT)	1760
51	FORMAT(110,5E15,4)	
103	FORMAT(34H)INPUT TABLE 3.. NODAL POINT DATA //	1780
1	5X, 5H NODAL, 48X, 7HX=DISP., 8X, 7HY=DISP./	1790
	25X, 5H POINT, 4X, 4H TYPE, 14X, 1HX, 14X, 1HY, 8X, 7HOR LOAD, 8X, 7HOR LOAD)	1800
3	FORMAT(2I5,4E10,3)	1810
105	FORMAT(5X, 17H ERROR IN CARD NO., I5/)	1820
52	FORMAT(2I10,4E15,4)	1830
106	FORMAT(34H)INPUT TABLE 4.. ELEMENT DATA //	1840
1	11X, 31H GLOBAL INDICES OF ELEMENT NODES/3X, 7HELEMENT,	1850
	24X, 1H1, 4X, 1H2, 4X, 1H3, 4X, 1H4, 4X, 1H5, 4X, 1H6, 4X, 1H7, 4X, 1H8, 5X, 8HMATER	1860
	3IAL)	1870
118	FORMAT(5X, 25H ERROR IN ELEMENT CARD NO., I5/)	1880
15	FORMAT(10I5)	1890

53	FORMAT(I10,R15,I10)	1900
108	FORMAT(37H1INPUT TABLE 5.. SURFACE LOADING DATA //	1910
	13X, 'ELEMENT', 4X, 'SECONDARY NODE', 4X, 'X-TRACTION', 4X, 'Z-TRAC	1920
	2TION', /)	1930
900	FORMAT(///45H ASSEMBLY AND SOLUTION WILL NOT BE PERFORMED.,I5,	1940
	121H FATAL CARD ERRORS)	1950
999	RETURN	1960
	END	1970

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COMPILER OPTIONS = NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,
SOURCE,=BCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,NOID,NOXREF
SUBROUTINE CWRITE 1980
----- COMMON BLOCKS FOR THIS SUBROUTINE ----- 1990
IMPLICIT REAL*8(A-H,O-Z),INTEGER(I-N)
COMMON/B2/ E(5),PR(5),RO(5),TH(5),ALPHA(5) 2000
1, X(1000),Y(1000),ULX(1000),VLY(1000)
2, TE(400,9),KODE(1000)
3, NNP,NEL,NMAT,NSLC,NOPT,NBODY,MTYP 2030
COMMON /ONE/ QK(16, 17), B(3, 17),CC(3, 3, 5), N(8), RODYF(2) 2040
1, BT(9, 13),CCF(3, 3, 5) 2050
C----- 2060

REAL*8 N
DIMENSION C(3,3), CF(3,3) 2070
DO 10 I = 1, NMAT 2080
DO 10 J = 1, 3 2090
DO 10 K = 1, 3 2100
CC(J,K,I) = 0.0 2110
10 CCF(J,K,I) = 0.0 2120
DO 40 NN = 1, NMAT 2130
DO 20 I = 1, 3 2140
DO 20 J = 1, 3 2150
C(I,J) = 0.0 2160
20 CF(I,J) = 0.0 2170
MTYP = NN 2180
IF(NOPT.EQ.2) GO TO 2 2190
CH = E(MTYP)/((1.0+PR(MTYP))*(1.0-2.0*PR(MTYP))) 2200
C(1,1) = CH*(1.0-PR(MTYP)) 2210
C(1,2) = CH* PR(MTYP) 2220
C(2,1) = C(1,2) 2230
C(2,2) = C(1,1) 2240
C(3,3) = CH*(1.0-2.*PR(MTYP))/2. 2250
GO TO 5 2260
2 CH = E(MTYP)/((1.0-PR(MTYP)*PR(MTYP)) 2270
C(1,1) = CH 2280
C(1,2) = PR(MTYP)*CH 2290
C(2,1) = C(1,2) 2300
C(2,2) = CH 2310
C(3,3) = CH*(1.0-PR(MTYP))/2.0 2320
5 CONTINUE 2330
CF(1,1) = DSQRT(C(1,1)) 2350
CF(1,2) = C(1,2)/CF(1,1) 2360
CF(1,3) = C(1,3)/CF(1,1)
CF(2,2) = DSQRT(C(2,2) - CF(1,2)*CF(1,2))
CF(2,3) = (C(2,3)-CF(1,2)*CF(1,3))/CF(2,2) 2380
CF(3,3) = DSQRT(C(3,3) - CF(1,3)*CF(1,3) - CF(2,3)*CF(2,3))
DO 30 I = 1, 3 2400
DO 30 J = 1, 3 2410
CC(I,J,NN) = C(I,J) 2420
30 CCF(I,J,NN) = CF(I,J) 2430
40 CONTINUE 2440
RETURN 2450
END 2460

```

```

ILER OPTIONS = NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,
SOURCE,FBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,NOID,NOXREF
SUBROUTINE ASEMBL(ISTOP)
C----- COMMON BLOCKS FOR THIS SUBROUTINE -----
IMPLICIT REAL*8(A-H,O-Z),INTEGER(I-N)
COMMON/B1/ R(2000),AK(480,240),NEG,IBAND,NUMBLK
COMMON/B2/ F(5),PR(5),RO(5),TH(5),ALPHA(5)
1,      Y(1000),Y(1000),ULX(1000),VLY(1000)
2,      TE(400,9),KODE(1000)
3,      NNP,NEL,NMAT,NSLC,NOPT,NBODY,MTYP
COMMON /ONE/ QK(16, 17), B(3, 17), C(3, 3, 5), N(8), BODYF(2)
1,      BT(9, 13), CF(3, 3, 5)
COMMON /INT/ NXY(8), NET(8)
COMMON/TSTRN/ TNEW(1000),TOLD(1000),CLST(9,9,5),EPIT(9),QPIT(24),
1 EPI(9),QPI(24),NSTP
C----- LOCAL DIMENSIONING -----
DIMENSION IP(16)
DIMENSION JOE(6)
DIMENSION PX(2), NDXM(16), NDXL(16)
C-----
REAL*8 N,NFT,NXY
DATA JOE/1,3,5,2,4,6/
DATA NDXL / 1,2,1,2,1,2,1,2,1,2,1,2,1,2,1,2/
DATA NDXM / 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8/
REWIND 10
ISTOP = 0
NB = IBAND /2
ND = IBAND
ND2 = 2* ND
NUMBLK = 0
DO 1 I=1,NEG
1 R(I)=0.0
DO 2 I = 1, ND2
DO 2 J =1,IBAND
2 AK(I,J)=0.0
NSTP=0
25 NUMBLK = NUMBLK + 1
NH = NB * ( NUMBLK + 1 )
NM = NH - NR
NL = NM - NR + 1
KSHIFT = 2*NL - 2
DO 110 NN = 1, NEL
C
LIM = 8
IF ( IE(NN, 7) .EQ. 0 ) LIM = 6
DO 40 I = 1, LIM
IF ( IE(NN, I) = NL) 40, 30, 30
30 IF ( IE(NN, I) = NM) 50, 50, 40
40 CONTINUE
GO TO 110
C
50 CALL QUAD (NN)
LIM=16
IF ( IE(NN, 7) .EQ. 0 ) LIM = 12
IF ( IE(NN, 7) .EQ. 0 ) GO TO 39
C
NSTP = 0
GO TO 38

```

39	DO 42 I=1,6	3020
	IJ=2*I-1	3030
	I1=J0E(I)	3040
	LP(IJ)=2*IF(NN, I1) - 1	3050
42	LP(IJ+1)=2*IF(NN, I1)	3060
C		3070
	GO TO 41	3080
C		3090
38	DO 45 I=2,11M,2	3100
	IJ = I/2	3110
	LP(I=1) = 2*IE(NN, IJ) - 1	3120
45	LP(I) = 2*IF(NN, IJ)	3130
C		3140
41	DO 100 LL = 1, 11M	3150
	I = LP(LL) - KSHIFT	3160
	I1 = LP(LL)	3170
	IF (I .LE. 0 .OR. I .GT. ND) GO TO 100	3180
	R(I1) = R(I1) + QK(LL, 17)	3190
	DO 101 MM = 1, 11M	3200
	J = LP(MM) - I + 1 - KSHIFT	3220
	IF(J .LE. 0) GO TO 101	
	IF (ND .GE. J) GO TO 90	3240
	PRINT 80	3250
80	FORMAT ('0', 10X, 10(' '), 'BANDWIDTH ECCEFDED ')	3260
	GO TO 110	3270
90	AK(I,J)= AK(I,J)+ QK(LL,MM)	3280
101	CONTINUE	
100	CONTINUE	3290
110	CONTINUE	3300
C		3310
	DO 120 NN = NL, NM	3320
	IF (NN .GT. NNP) GO TO 120	3330
	IF(KODE(NN).EQ.3) GO TO 120	3340
	K=2*NN	3350
	IF(KODE(NN).EQ.1) GO TO 115	3360
	R(K=1) = R(K=1) + ULX(NN)	3370
	IF(KODE(NN).NE.0) GO TO 120	3380
115	R(K) = R(K) + VLY(NN)	3390
120	CONTINUE	3400
	DO 150 M = NL, NH	3420
	IF (M .GT. NNP) GO TO 150	3430
	IF(KODE(M).GE.0.AND.KODE(M).LE.3) GO TO 130	3440
	ISTOP = ISTOP + 1	3450
	GO TO 150	3460
130	IF(KODE(M).EQ.0) GO TO 150	3470
	IF(KODE(M).EQ.2) GO TO 140	3480
	CALL GEOMBC(ND, 2*M-1, KSHIFT, ULX(M))	3490
	IF(KODE(M).EQ.1) GO TO 150	3500
140	CALL GEOMBC(ND, 2*M, KSHIFT, VLY(M))	3510
150	CONTINUE	3520
	DO 151 NN=1,ND	
151	WRITE(10) (AK(NN,M), M=1,IBAND)	
	DO 160 NN = 1, ND	3540
	K = NN + ND	3550
	DO 160 M = 1, ND	3560
	AK(NN, M) = AK(K,M)	3570
160	AK(K, M) = 0.0	3580

IF (NM .LT. NNP) GO TO 25	3590
IF (NSIC .EQ. 0) GO TO 54	3600
DO 53 I=1,NSLC	3610
READ 800, MSC, NS2, TRACX, TRACY	3620
PRINT 801, MSC, NS2, TRACX, TRACY	3630
NN = IE(MSC,9)	3640
PX(1) = TH(NN) * TRACX	3650
PX(2) = TH(NN) * TRACY	3660
DO 899 II=1,16	3670
899 QK(II,17)=0.	3680
AG1=-0.5773502692	3690
AG2= 0.5773502692	3700
AG3=-1.0	3710
AG4= 1.0	3720
DO 900 J=1,2	3730
IF(NS2 .NE. IE(MSC,2)) GO TO 898	3740
JJ=3	3750
II=J	3760
GO TO 895	3770
898 IF(NS2 .NE. IE(MSC,4)) GO TO 897	3780
II=4	3790
JJ=J	3800
GO TO 895	3810
897 IF(NS2 .NE. IE(MSC,6)) GO TO 896	3820
JJ=4	3830
II=J	3840
GO TO 895	3850
896 IF(NS2 .NE. IE(MSC,8)) GO TO 895	3860
II=3	3870
JJ=J	3880
895 CALL SHAPE(II, JJ, DETJAC, MSC, AG1, AG2, AG3, AG4, 0, 1)	3890
SX=0.0	3900
SY=0.0	3910
IF(NS2.EQ.IE(MSC,2) .OR. NS2.EQ.IE(MSC,6)) GO TO 27	3920
DO 26 LR=1,2	3930
NOD=IE(MSC,LR)	3940
SX=NET(LR)*X(NOD) + SX	3950
26 SY = NET(LR)*Y(NOD) + SY	3960
GO TO 29	3970
27 DO 28 LR=1,2	3980
NOD=IE(MSC,LR)	3990
SX=NXI(LR)*X(NOD) + SX	4000
28 SY = NXI(LR)*Y(NOD) + SY	4010
29 SX2 = SX*SX	4020
SY2 = SY*SY	4030
HYP = DSQRT(SX2 + SY2)	
NR=16	4050
DO 900 NROW=1, NR	4060
LL=NDXL(NROW)	4070
MM=NDXM(NROW)	4080
900 QK(NROW,17) = QK(NROW,17) + N(MM)*PX (LL)*HYP	4090
DO 903 LL=2,16,2	4100
IJ=LL/2	4110
LP (LL=1)=2*IF(MSC,IJ)=1	4120
903 LP(LL)=2*IF(MSC,IJ)	4130
DO 904 LL=1, NR	4140
II=LP(LL)	4150
904 R(II)=R(II) + QK(LL,17)	4160

53	CONTINUE	4170
54	CONTINUE	4180
C		4190
	IF(ISTOP.EQ.0) GO TO 81	4200
	PRINT 109, ISTOP	
20	FORMAT(/5X,17H AREA OF ELEMENT ,I5,14H IS NEGATIVE /)	4220
109	FORMAT(/////42H SOLUTION WILL NOT BE PERFORMED BECAUSE OF ,I5,	4230
1	15H DATA ERRORS /)	4240
800	FORMAT(2I5, 2E10.3)	4250
801	FORMAT(5X, I5, 13X, I5, 4X, F10.3, 4X, F10.3)	4260
81	RETURN	4270
	END	4280

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ILER OPTIONS = NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,
SOURCE,FBCDIC,NCLIST,NODECK,LOAD,MAP,NOEDIT,NOID,NOXREF
SUBROUTINE QUAD (M)
----- COMMON BLOCKS FOR THIS SUBROUTINE -----
IMPLICIT REAL*8 (A-H,O-Z),INTEGER(I-N)
COMMON/B1/ R(2000),AK(480,240),NEG,IBAND,NUMBLK
COMMON/B2/ F(5),PR(5),RO(5),TH(5),ALPHA(5)
1,      X(1000),Y(1000),ULX(1000),VLY(1000)
2,      TE(400,9),KODE(1000)
3,      NNP,NEL,NMAT,NSLC,NOPT,NBODY,MTYP
COMMON /ONF/ QK(16, 17), B(3, 17), C(3, 3, 5), N(8), BODYF(2)
1, BT(9, 13), CW(3, 3, 5)
COMMON/TSTRN/ TNEW(1000),TOLD(1000),CLST(9,9,5),EPIT(9),QPIT(24),
1 EPI(9),QPT(24),NSTP
C----- LOCAL DIMENSIONING -----
DIMENSION NDXM(16),NDXL(16)
DIMENSION CF(3,3)
DIMENSION W(3)
C-----
REAL*8 N
DATA NDXM/1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8/
DATA NDXL/1,2,1,2,1,2,1,2,1,2,1,2,1,2,1,2/
W(1) = 5./9.
W(2) = 8./9.
W(3) = W(1)
MTYP = IE(M,9)
DO 10 I = 1, 3
DO 10 J = 1, 3
10 CF(I,J) = CW(I,J,MTYP)
BODYF(1) = 0.
BODYF(2) = 0.0
IF (NOPT.EQ.1) TH(MTYP) = 1.0
IF(NBODY.EQ.0) GO TO 1
BODYF(2) = -RO(MTYP)
1 CONTINUE
IF(IE(M,7).NE.0) GO TO 4
CALL LST(M)
GO TO 31
4 CONTINUE
DO 6 K=1,16
DO 6 L=K,17
6 QK(K,L) = 0.
C GAUSS QUAD LOOP
AG1 = -0.7745966692D0
AG2 = 0.0D0
AG3 = -AG1
DO 20 II=1,3
DO 20 JJ=1,3
CALL SHAPE (II,JJ,DETJAC,M,AG1,AG2,AG3,AG2,0,0)
DO 9 K=1,3
L1=17
DO 9 L=1,L1
DUM1 = 0.
DO 8 MM =K,3
DUM1 = DUM1+CF(K,MM)*B(MM,L)
B(K,L) = DUM1
DUM1 = DETJAC*TH(MTYP) *W(II)*W(JJ)
NR=16

```

	DO 20 NROW=1,NR	4800
	L = NDXL(NROW)	4810
	MM= NDXM(NROW)	4820
	QK(NROW,L1) = QK(NROW,L1)+N(MM)*BODYF(L)*DUM1	4830
	DO 20 NCOL = NROW,L1	4840
	DUM2 = 0.	4850
	DO 18 LL=1,7	4860
18	DUM2=DUM2+A(LL,NROW)*B1(LL,NCOL)	4870
20	QK(NROW,NCOL)=QK(NROW,NCOL)+DUM1*DUM2	4880
	DO 30 K=2,NR	4890
	DO 30 L=1,K	4900
30	QK(K,L)=QK(1,K)	4910
31	RETURN	4920
	END	4930

```

PILER OPTIONS = NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,
SOURCE,FBCDIC,NCLIST,NODECK,LOAD,MAP,NOEDIT,NOID,NOXREF
SUBROUTINE SHAPE (II,JJ,DETJAC,M,A1,A2,A3,A4,IARLO,JOF) 4940
----- COMMON BLOCKS FOR THIS SUBROUTINE ----- 4950
IMPLICIT REAL*8 (A-H,O-Z),INTEGER(I-N)
COMMON/B2/ F(5),PR(5),RO(5),TH(5),ALPHA(5) 4960
1, X(1000),Y(1000),ULX(1000),VLY(1000)
2, TE(400,9),KODE(1000)
3, NNP,NEL,NMAT,NSLC,NOPT,NBODY,MTYP 4990
COMMON /ONE/ QK(16, 17), B(3, 17), C(3, 3, 5), N(8), RODYF(2) 5000
1, BT(9, 13), CF(3, 3, 5) 5010
COMMON/TSTRN/ TNEW(1000),TOLD(1000),CLST(9,9,5),EPIT(9),QPIT(24),
1 EPI(9),QPT(24),NSTP 5030
COMMON/DELC/ DFIT,TM,JT,IPR,IVE 5040
COMMON /INT/ NXT(8), NET(8) 5050
DIMENSION AA(4),JAC(2,2),EXO(8),EYO(8),EXYO(8) 5060
C----- 5070
REAL*8 N,NXT,NFT,JAC
AA(1) = A1 5090
AA(2) = A2 5100
AA(3) = A3 5110
AA(4) = A4 5120
N(1) = 0.25*(1.-AA(II))*(1.-AA(JJ))*(-AA(II)-AA(JJ)-1.) 5130
N(2) = 0.5*(1.-AA(II)*AA(II))*(1.-AA(JJ)) 5140
N(3) = 0.25*(1.+AA(II))*(1.-AA(JJ))*(AA(II)-AA(JJ)-1.) 5150
N(4) = 0.5*(1.+AA(II))*(1.-AA(JJ)*AA(JJ)) 5160
N(5) = 0.25*(1.+AA(II))*(1.+AA(JJ))*(AA(II)+AA(JJ)-1.) 5170
N(6) = 0.5*(1.-AA(II)*AA(II))*(1.+AA(JJ)) 5180
N(7) = 0.25*(1.-AA(II))*(1.+AA(JJ))*(-AA(II)+AA(JJ)-1.) 5190
N(8) = 0.5*(1.-AA(II))*(1.-AA(JJ)*AA(JJ)) 5200
NXT(1) = 0.25*(1.-AA(JJ))*(AA(JJ)+2.*AA(II)) 5210
NXT(2) = -AA(II)*(1.-AA(JJ)) 5220
NXT(3) = 0.25*(1.-AA(JJ))*(-AA(JJ)+2.*AA(II)) 5230
NXT(4) = 0.5*(1.-AA(JJ)*AA(JJ)) 5240
NXT(5) = 0.25*(1.+AA(JJ))*(AA(JJ)+2.*AA(II)) 5250
NXT(6) = -AA(II)*(1.+AA(JJ)) 5260
NXT(7) = 0.25*(1.+AA(JJ))*(-AA(JJ)+2.*AA(II)) 5270
NXT(8) = -0.5*(1.-AA(JJ)*AA(JJ)) 5280
NET(1) = 0.25*(1.-AA(II))*(AA(II)+2.*AA(JJ)) 5290
NET(2) = -0.5*(1.-AA(II)*AA(II)) 5300
NET(3) = 0.25*(1.+AA(II))*(-AA(II)+2.*AA(JJ)) 5310
NET(4) = -AA(JJ)*(1.+AA(II)) 5320
NET(5) = 0.25*(1.+AA(II))*(AA(II)+2.*AA(JJ)) 5330
NET(6) = 0.5*(1.-AA(II)*AA(II)) 5340
NET(7) = 0.25*(1.-AA(II))*(-AA(II)+2.*AA(JJ)) 5350
NET(8) = -AA(JJ)*(1.-AA(II)) 5360
C JACOBIAN, INVERSE JACOBIAN, AND DET JACOBIAN 5370
5 DO 10 I=1,2 5380
DO 10 J=1,2 5390
10 JAC(I,J) = 0. 5400
LIM=8 5410
DO 15 I=1,17 5420
NN = IE(M,I) 5430
JAC(1,1) = JAC(1,1)+NXT(I)*X(NN) 5440
JAC(1,2) = JAC(1,2)+NXT(I)*Y(NN) 5450
JAC(2,1) = JAC(2,1)+NET(I)*X(NN) 5460
15 JAC(2,2) = JAC(2,2)+NET(I)*Y(NN) 5470
IF ( JOE.GT. 0 ) GO TO 31 5480

```

	DETJAC = JAC(1,1)*JAC(2,2)-JAC(2,1)*JAC(1,2)	5490
	DUM1 = JAC(1,1)/DETJAC	5500
	JAC(1,1) = JAC(2,2)/DETJAC	5510
	JAC(1,2) = -JAC(1,2)/DETJAC	5520
	JAC(2,1) = -JAC(2,1)/DETJAC	5530
	JAC(2,2) = DUM1	5540
	LIM=8	5550
	DO 20 L=1,LIM	5560
	J=2*L	5570
	I=J-1	5580
	B(1,I) = JAC(1,1)*NXI(L)+JAC(1,2)*NET(L)	5590
	B(1,J) = 0.	5600
	B(2,I) = 0.	5610
	B(2,J) = JAC(2,1)*NXI(L)+JAC(2,2)*NET(L)	5620
	B(3,I) = B(2,J)	5630
20	B(3,J) = B(1,I)	5640
22	B(1,17) = 0.	5650
	B(2,17) = 0.	5660
	B(3,17) = 0.	5670
23	CONTINUE	5680
	LIM=8	5690
	IF(IARLO .EQ. 0) GO TO 31	5700
	IF(JT .EQ. 1) GO TO 31	5710
	DO 30 I=1,LIM	5720
	EXO(I)=QPI(I)	5730
	EYO(I)=QPI(I+8)	5740
	EXYO(I)=QPI(I+16)	5750
29	B(1,17)=B(1,17) + N(I) *EXO(I)	5760
	B(2,17)=B(2,17) + N(I)*EYO(I)	5770
30	B(3,17)=B(3,17) + N(I)*EXYO(I)	5780
31	CONTINUE	5790
	RETURN	5800
	END	5810

```

PILER OPTIONS = NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,
SOURCE,FBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,NOID,NOXREF
SUBROUTINE 1ST(M) 5820
----- COMMON BLOCKS FOR THIS SUBROUTINE ----- 5830
IMPLICIT REAL*8(A-H,O-Z),INTEGER(I-N)
COMMON/B1/ R(2000),AK(480,240),NEG,IBAND,NUMBLK
COMMON/B2/ F(5),PR(5),RO(5),TH(5),ALPHA(5) 5850
1, X(1000),Y(1000),ULX(1000),VLY(1000)
2, TE(400,9),KODE(1000)
3, NNP,NEL,NMAT,NSLC,NOPT,NBODY,MTYP 5880
COMMON /ONE/ QK(16, 17), B(3, 17), W(3, 3, 5), N(8), BODYF(2) 5890
1, BT(9, 13), CF(3, 3, 5) 5900
COMMON/TSTRN/ TNEW(1000),TOLD(1000),CLST(9,9,5),EPIT(9),QPIT(24),
1 EPI(9),QPI(24),NSTP 5920
COMMON /YEX/ D(9, 9), VOLUM(400)
COMMON/STAR/ TSTAR,LOUIE
C----- LOCAL DIMENSIONING ----- 5940
DIMENSION C(3,3), TK(12,12),BX(9,12),XQ(7),YQ(7),LC(12) 5950
DIMENSION IBH(400)
C----- 5960
REAL*8 N
IF(LOUIE.NF.0) GO TO 666
DO 661 JK=1,400
661 IBH(JK)=0
LOUIE=1
666 CONTINUE
LX=12 5980
IF(NSTP.EQ. IF(M,9)) GO TO 71 5990
DO 1 II=1,9 6000
DO 1 JJ=1,9 6010
1 CLST(II,JJ,MTYP)=0.0 6020
DO 110 I = 1, 3 6030
DO 110 J = 1, 3 6040
110 C(I,J) = W(I,J,MTYP) 6050
CLST(3,3,MTYP) = C(1,1) 6060
CLST(2,2,MTYP) = C(1,1) 6070
CLST(1,1,MTYP) = C(1,1) 6080
CLST(4,4,MTYP) = C(2,2) 6090
CLST(5,5,MTYP) = C(2,2) 6100
CLST(6,6,MTYP) = C(2,2) 6110
CLST(7,7,MTYP) = C(3,3) 6120
CLST(8,8,MTYP) = C(3,3) 6130
CLST(9,9,MTYP) = C(3,3) 6140
CLST(3,6,MTYP) = C(1,2) 6150
CLST(2,5,MTYP) = C(1,2) 6160
CLST(1,4,MTYP) = C(1,2) 6170
CLST(3,9,MTYP) = C(1,3) 6180
CLST(2,8,MTYP) = C(1,3) 6190
CLST(1,7,MTYP) = C(1,3) 6200
CLST(6,3,MTYP) = C(2,1) 6210
CLST(5,2,MTYP) = C(2,1) 6220
CLST(4,1,MTYP) = C(2,1) 6230
CLST(6,9,MTYP) = C(2,3) 6240
CLST(5,8,MTYP) = C(2,3) 6250
CLST(4,7,MTYP) = C(2,3) 6260
CLST(9,3,MTYP) = C(3,1) 6270
CLST(8,2,MTYP) = C(3,1) 6280
CLST(7,1,MTYP) = C(3,1) 6290

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CLST(9,6,MTYP) = C(3,2)	6300
CLST(8,5,MTYP) = C(3,2)	6310
CLST(7,4,MTYP) = C(3,2)	6320
NSTP=IE(M,9)	6330
71 CONTINUE	6340
LIM=3.	6350
XQ(7)=0.0	6360
YQ(7)=0.0	6370
DO 2 I=1,LIM	6380
I1=2*I-1	6390
NN=IE(M,I1)	6400
XQ(I) = X(NN)	6410
2 YQ(I) = Y(NN)	6420
DO 3 JJ=1,9	6450
DO 3 II=1,13	6460
3 BT(JJ,II) = 0.0	6470
A1 = XQ(3)-YQ(2)	6480
A2 = XQ(1)-YQ(3)	6490
A3 = XQ(2)-YQ(1)	6500
B1 = YQ(2)-YQ(3)	6510
B2 = YQ(3)-YQ(1)	6520
B3 = YQ(1)-YQ(2)	6530
AREA = (A3*A2-A2*B3)/2.0	6540
IF (AREA .LE. 0.0) PRINT 105,M	
105 FORMAT('OTRIANGLE',I5,' ZERO OR NEGATIVE AREA')	
VOLUM(M)=AREA*TH(MTYP)	6550
BT(1, 1) = 3.0 * B1	6560
BT(7, 7) = 3.0 * B1	6570
BT(1, 2) = R2	6580
BT(7, 8) = R2	6590
BT(3, 2) = R2	6600
BT(9, 8) = R2	6610
BT(1, 3) = R3	6620
BT(7, 9) = R3	6630
BT(2, 3) = R3	6640
BT(8, 9) = R3	6650
BT(1, 4) = 4.0 * B2	6660
BT(7,10) = 4.0*B2	6670
BT(3, 5) = 4.0 * B2	6680
BT(9,11) = 4.0 * B2	6690
BT(1, 6) = 4.0 * B3	6700
BT(7,12) = 4.0 * B3	6710
BT(2, 5) = 4.0 * B3	6720
BT(8,11) = 4.0 * B3	6730
BT(2, 1) = R1	6740
BT(8, 7) = R1	6750
BT(3, 1) = R1	6760
BT(9, 7) = R1	6770
BT(2, 2) = 3.0 * B2	6780
BT(8, 8) = 3.0 * B2	6790
BT(2, 4) = 4.0 * B1	6800
BT(3, 6) = 4.0 * B1	6810
BT(8,10) = 4.0 * B1	6820
BT(9,12) = 4.0 * B1	6830
BT(3, 3) = 3.0 * B3	6840
BT(9, 9) = 3.0 * B3	6850
	6860
BT(7, 1) = 3.0 * A1	6870

BT(4, 7) =	3.0 * A1	6880
BT(7, 2) =	= A2	6890
BT(4, 8) =	= A2	6900
BT(9, 2) =	= A2	6910
BT(6, 8) =	= A2	6920
BT(7, 3) =	= A2	6930
BT(4, 9) =	= A2	6940
BT(8, 3) =	= A3	6950
BT(5, 9) =	= A2	6960
BT(7, 4) =	4.0 * A2	6970
BT(4, 10) =	4.0 * A2	6980
BT(9, 5) =	4.0 * A2	6990
BT(6, 11) =	4.0 * A2	7000
BT(7, 6) =	4.0 * A3	7010
BT(4, 12) =	4.0 * A3	7020
BT(8, 5) =	4.0 * A3	7030
BT(5, 11) =	4.0 * A3	7040
BT(8, 1) =	= A1	7050
BT(5, 7) =	= A1	7060
BT(9, 1) =	= A1	7070
BT(6, 7) =	= A1	7080
BT(8, 2) =	3.0 * A2	7090
BT(5, 8) =	3.0 * A2	7100
BT(8, 4) =	4.0 * A1	7110
BT(9, 6) =	4.0 * A1	7120
BT(5, 10) =	4.0 * A1	7130
BT(6, 12) =	4.0 * A1	7140
BT(9, 3) =	3.0 * A3	7150
BT(6, 9) =	3.0 * A3	7160
C		7170
	DO 4 I=1,9	7180
	DO 4 J=1,LX	7190
4	BT(I,J)=BT(I,J)/(2.0*AREA)	7200
C		7210
	DO 5 M1=1,9	7220
	DO 5 L1=1,9	7230
b	D(M1,L1)=0.0	7240
C		7250
	DO 66 K=1,9	7260
66	D(K,K)=2.0/12.0	7270
	D(1,2)=1.0/12.0	7280
	D(1,3)=1.0/12.0	7290
	D(2,1)=1.0/12.0	7300
	D(2,3)=1.0/12.0	7310
	D(3,1)=1.0/12.0	7320
	D(3,2)=1.0/12.0	7330
	D(4,5)=1.0/12.0	7340
	D(4,6)=1.0/12.0	7350
	D(5,4)=1.0/12.0	7360
	D(5,6)=1.0/12.0	7370
	D(6,4)=1.0/12.0	7380
	D(6,5)=1.0/12.0	7390
	D(7,8)=1.0/12.0	7400
	D(7,9)=1.0/12.0	7410
	D(8,7)=1.0/12.0	7420
	D(8,9)=1.0/12.0	7430
	D(9,7)=1.0/12.0	7440
	D(9,8)=1.0/12.0	7450

C			7460
	DO 6 M1=1,9		7470
	DO 6 L1=1,9		7480
	D(M1,L1)=D(M1,1,1)*TH(MTYP)*AREA		7490
			7500
	DO 7 I=1,LX		7510
	DO 7 J=1,LX		7520
	QK(I,J)=0.0		7530
	DO 7 L1=1,9		7540
	DO 7 K1=1,9		7550
	DO 7 M1=1,9		7560
	QK(I,J)=QK(I,J) + BT(L1,I)*D(L1,K1)*CLST(K1,M1,MTYP)*BT(M1,J)		7570
7	CONTINUE		7580
	DO 14 II=1,1X		7590
14	QK(II,17)=0.0		
	IF(NBODY.EQ.0) GO TO 15		7610
	BODF=BODYF(2)/3.0		7620
	DO 99 I3=4,6		7630
	JJ=2*I3		7640
	QK(JJ,17)=QK(JJ,17)+BODF*AREA*TH(MTYP)		7650
99	CONTINUE		7660
15	CONTINUE		7670
73	CONTINUE		7680
C			7690
	DO 12 JOE=1,9		7700
	DO 12 MOR=1,9		7710
12	D(JOE,MOR) = D(JOE,MOR)/TH(MTYP)/AREA		7720
C			7730
	MX=LX/2		7740
	DO 8 II=1,MX		7750
	LC(II)=2*II-1		7760
8	LC(II+MX)=2*II		7770
C			7780
	DO 9 II=1,1X		7790
	LL=LC(II)		7800
C			7810
	DO 10 JJ=1,1X		7820
	MM = LC(JJ)		7830
10	TK(LL,MM)=QK(II,JJ)		7840
C			7850
100	DO 9 JJ=1,9		7860
9	BX(JJ,LL)=RT(JJ,II)		7870
C			7880
	DO 11 LL=1,9		7890
	DO 11 MM=1,12		7900
11	BT(LL,MM)=BX(LL,MM)		7910
C			7920
	IF(1BH(M).NE.0) GO TO 659		
	WRITE(8) ((RT(KY,LY),LY=1,12),KY=1,9)		
	1BH(M)=1		
C			7940
659	DO 13 LL=1,1X		7960
	DO 13 MM=1,1X		7970
13	QK(LL,MM)=TK(LL,MM)		7980
			7990
	RETURN		8000
	END		

```

FILED OPTIONS = NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,
SOURCE,FBCDIC,NCLIST,NODECK,LOAD,MAP,NOEDIT,NOID,NOXREF
SUBROUTINE STRESS
----- COMMON BLOCKS FOR THIS SUBROUTINE -----
IMPLICIT REAL*8(A-H,O-Z),INTEGER(I-N)
COMMON/B1/ R(2000),AK(480,240),NEG,IBAND,NUMBLK
COMMON/B2/ F(5),PR(5),RO(5),TH(5),ALPHA(5)
1,      X(1000),Y(1000),ULX(1000),VLY(1000)
2,      TE(400,9),KODE(1000)
3,      NNP,NEL,NMAT,NSLC,NOPT,NBODY,MTYP
COMMON /ONE/ QK(16, 17), B(3, 17), W(3, 3, 5), N(8), BODYF(2)
1, BT(9, 13), CF(3, 3, 5)
COMMON/DELC/ DFI,T,TM,JT,IPR,IVE
COMMON/TSTRN/ TNEW(1000),TOLD(1000),CLST(9,9,5),EPIT(9),QPIT(24),
1 EPI(9),QPI(24),NSTP
COMMON/SIGS/ SFI,AS(1000,3)
COMMON/PRU4/ NRE ,NEN
C----- LOCAL DIMENSIONING -----
DIMENSION IA(8), IB(8)
DIMENSION TDISP(2,1000),DISP(2,1000),STRAIN(1000,3),SIG(6)
1, EP(9),C(3,3),IND(1000)
EQUIVALENCE (DISP(1),R(1)),(TDISP(1),ULX(1))
INTEGER BUG(6)
C-----
INTEGER YIMVEL,YI YEX
REAL*8 N
DATA IA/1,3,2,2,2,3,1,1/
DATA IB/1,1,1,3,2,2,2,3/
DATA BUG/1,3,5,2,4,6/
NBEG=NBE
NEND=NEN
IF(JT.NE.1) GO TO 9
NBEG=1
NEND=NNP
JCNT = -1
IF(IPR.LE.0) IPR=1
DO 66 N1=1,NNP
DO 66 I=1,3
66 SELAS(N1,I) = 0.0
9 REWIND 9
REWIND 8
REWIND 12
NOLINE = 47
DO 2 I=1,NNP
IND(I) = 0
DO 2 J=1,3
2 STRAIN(I,J) = 0.0
C
DO 7 I=1,NNP
DO 7 J=1,2
IF(JT.GT.2) GO TO 7
TDISP(J,I)=0.0
7 TDISP(J,I)=TDISP(J,I)+DISP(J,I)
JCNT=JCNT+1
IF(JT.EQ.1) GO TO 422
IF(JCNT.NE.IPR) GO TO 423
422 PRINT 555,TM
555 FORMAT(///,4X,' NODE',12X,'INCREMENTAL DISPLACEMENTS',17X,'TOTAL D

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1 ISPLACEMENTS',XX,'AT TIME . . .',F9.5,2X,'YR',/ )
PRINT 501
1 FORMAT(23X,'X',20X,'Y',20X,'X',20X,'Y',/ )
DO 510 M=NRFG,NEND
510 PRINT 515, M,((DISP(J,M),J=1,2),(TDISP(J,M),J=1,2))
515 FORMAT(I10,2(5X,E15.4,5X,E15.4))
423 CONTINUE
IF(JCNT.EQ.1PR.NR.JT.EQ.1) PRINT 300
DO 1 M=1,NFI
MTYP = IE(M,9)
DO 12 IC = 1,3
DO 12 JC = 1,3
12 C(IC,JC) = W(IC,JC, MTYP)
LIM = 8
IF(IE(M,7).EQ.0) LIM=6
IF(IE(M,7).NE.0) GO TO 100
IF(JT.NE.1) GO TO 788
DO 787 II=1,9
787 EPI (II)=0.0
788 CONTINUE

C
C      T R I A N G L E S
C
DO 10 I=1,LIM
II = 2*I
I1=BUG(I)
JJ=2*IE(M,I1)
L1=17
GK(II=1,L1) = R(JJ=1)
10 GK(II,L1) = R(I1)
LX=12
READ (8) ((AT(KY,LY),LY=1,12),KY=1,9)
IF(JT.EQ.1) GO TO 781
READ(12) EPI
781 CONTINUE

C
DO1101 I1=1,9
EP(I1)=0.0
DO 99 J1=1,12
99 EP(I1)=EP(I1)+RT(I1,J1)*GK(J1,17)
1101 EP(I1)=EP(I1) - EPI (I1)
CC
DO 97 I2=1,3
I3=3-I2
JOE=IE(M,2*I2=1)
IND(JOE)=IND(JOF)+1
DO 98 II=1,3
SIG(II)=0.0
DO 98 JJ=1,3
98 SIG(II)=SIG(II)+C(II,JJ)+EP(3+JJ-I3)
DO 97 I4=1,3
97 STRAIN(JOF,I4)=STRAIN(JOE,I4)+SIG(I4)
CC
C
GO TO 1

100 CONTINUE
C

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Q U A D S

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		9230
		9240
		9250
		9260
		9270
		9280
		9290
		9300
		9310
		9320
		9330
		9340
		9350
3		9360
		9370
31		9380
C		9390
		9400
		9410
		9420
33		9430
		9440
		9450
4		9460
		9470
C		9480
11		9490
1		9500
		9510
		9520
		9530
		9540
13		9550
C		9560
		9570
		9580
		9590
		9600
		9610
		9620
		9630
		9640
		9650
		9660
		9670
34		9680

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IF(JT.NE.1) GO TO 777
DO 786 II=1,24
786 GPI(II)=0.0
777 CONTINUE
DO 101 LEO=1,8
II=2*LEO
JJ=2*IE(M,IF0)
QK(II=1,17)=R(II=1)
101 QK(II,17)=R(JJ)
LIM=8
IF(JT.NE.1) READ(9) GPI
AG1=-1.0
AG2= 1.0
AG3= 0.0
DO 11 I=1,LIM
II=IA(I)
JJ=IB(I)
CALL SHAPE(II,II,DETJAC,M,AG1,AG2,AG3,AG3,1.0)

DO 3 K=1,3
E(K)=0.0
LIM2=16
DO 3 L=1,LIM2
3 E(K) = E(K) + R(K,L)*QK(L,17)
DO 31 K=1,3
31 E(K)=E(K)-R(K,17)
C
DO 33 II=1,3
SIG(II)=0.0
DO 33 JJ=1,3
33 SIG(II)=SIG(II)+C(II,JJ)*E(JJ)
JOE=IE(M,I)
DO 4 K=1,3
4 STRAIN(JOE,K)=STRAIN(JOE,K)+SIG(K)
IND(JOE) = IND(JOE) + 1
C
11 CONTINUE
1 CONTINUE
DO 13 YIMYFI=1,NNP
DO 13 YIYFX=1,3
IF(IND(YIMYFL) .EQ. 0) GO TO 13
STRAIN( YIMYEL, YIYEX)= STRAIN( YIMYEL, YIYFX)/IND(YIMYEL)
13 CONTINUE
C
DO 35 M=1,NFL
IF(IE(M,7).NE.0) GO TO 35
DO 34 I=1,3
I1=2*I-1
NP1=IE(M,I1)
NP2=IE(M,I1+2)
NP=IE(M,I1+1)
IF(I.EQ.3) NP2=IE(M,1)
STRAIN(NP,1)=(STRAIN(NP1,1)+STRAIN(NP2,1))/2.0
STRAIN(NP,2)=(STRAIN(NP1,2)+STRAIN(NP2,2))/2.0
STRAIN(NP,3)=(STRAIN(NP1,3)+STRAIN(NP2,3))/2.0
34 CONTINUE

```

```

35  CONTINUE
C
DO 71 N1=1,NNP
DO 71 I=1,3
71  SELAS(N1,I)=SELAS(N1,I)+STRAIN(N1,I)
C
C COMPUTE PRINCIPAL STRESS AND THE ANGLE WITH THE POSITIVE X AXIS
C
IF(JT.EQ.1) GO TO 81
IF(JCNT.NE.1PR) GO TO 84
81 DO 44 N1=NRFG,NFND
SP=(SELAS(N1,1) + SELAS(N1,2))/2.
SM=(SELAS(N1,1) - SELAS(N1,2))/2.
DS = DSQRT(SM*SM + SELAS(N1,3)*SELAS(N1,3))
C
PS1=SP+DS
PS2=SP-DS
PAN=0.0
IF(SELAS(N1,3).NE.0.0.AND. SM.NE. 0.0) PAN=
1  28.648*DATA TAN2(SELAS(N1,3),SM)
C
IF(NOLINE.GT.0) GOTO 54
PRINT 1000
NOLINE=49
54 NOLINE=NOLINE+1
IF(JT.EQ.1) GO TO 43
IF(JCNT.NE.1PR) GO TO 84
43 PRINT 500, N1,(STRAIN(N1,I),I=1,3),(SELAS(N1,I),I=1,3),PS1,PS2,PAN
44 CONTINUE
JCNT=0
84 CONTINUE
300 FORMAT(47H1OUTPUT TABLE 2., STRESSES AT NODAL POINTS //,
12X'NODE',15X,'INCREMENTAL',33X,'TOTAL',29X,'PRINCIPAL', //,
215X,1HX,13X,1HY,12X,2HXY,13X,1HX,13X,1HY,12X,2HXY,
310X,'SIG=1',9X,'SIG=2',9X,'ANGLE', //)
1000 FORMAT(1H1,
11X'NODE',15X,'INCREMENTAL',33X,'TOTAL',29X,'PRINCIPAL', //,
215X,1HX,13X,1HY,12X,2HXY,13X,1HX,13X,1HY,12X,2HXY,
310X,'SIG=1',9X,'SIG=2',9X,'ANGLE', // )
500 FORMAT(1X,I4,9F14.2)
C
C ZERO DISPLACEMENT-LOAD VECTOR (R) BEFORE GOING TO INSTRN
C
DO 280 I=1,NEQ
280 R(I)=0.0
RETURN
END

```

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R OPTIONS = NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,
 SOURCE,FBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,NOID,NOXREF
 SUBROUTINE INSTRN

```

C
C----- COMMON BLOCKS FOR THIS SUBROUTINE -----
IMPLICIT REAL*8(A-H,O-Z),INTEGER(I-N)
COMMON/B1/ R(2000),AK(480,240),NEG,IBAND,NUMBLK
COMMON/B2/ F(5),PR(5),RO(5),TH(5),ALPHA(5)
1,      X(1000),Y(1000),ULX(1000),VLY(1000)
2,      TE(400,9),KODE(1000)
3,      NNP,NEL,NMAT,NSLC,NOPT,NBODY,MTYP
COMMON /ONE/ GK(16, 17), B(3, 17), C(3, 3, 5), Z(8), BODYF(2)
1, BT(9, 13), CF(3, 3, 5)
COMMON/TSTRN/ TNEW(1000),TOLD(1000),CLST(9,9,5),EPIT(9),QPIT(24),
1 EPI(9),QPI(24),NSTP
COMMON /YEX/ D(9, 9), VOLUM(400)
COMMON/DELC/ DEFT,TH,JT,IPR,IVE
C----- LOCAL DIMENSIONING -----
DIMENSION W(3)
DIMENSION RX(9,12),LC(12)
DIMENSION RHG(6)
C-----
INTEGER BUG
DATA  BUG/ 1,4,2,5,3,6/
C
C
W(1) = 5./9.
W(2) = 8./9.
W(3) = W(1)
REWIND 9
REWIND 8
REWIND 12
NSTP=0
C
DO 80 N=1,NEL
C
IT=IE(N,9)
LX=16
IF(IE(N,7) .LE. 0) GO TO 10
IF(IVE.EQ.2) GO TO 102
CALL QPIST(N)
IF(IVE.EQ.3) GO TO 102
DO 101 I=1,24
101 QPI(I)=QPI(I)
GO TO 104
102 CALL QPIS(N)
IF(IVE.EQ.2) GO TO 104
DO 103 I=1,24
103 QPI(I)=QPI(I)+QPIT(I)
104 WRITE(9) QPI
DO 5 J=1,16
5 GK(J,17) = 0.0
AG1 = -0.774596669200
AG2 = 0.000
AG3 = - AG1
DO 20 II=1,3
DO 20 JJ=1,3
CALL SHAPE (II,JJ,DETJAC,N,AG1,AG2,AG3,AG2,1,0)

```

C		10680
	DO 9 K=1,3	10690
	DO 9 L=1,17	10700
	DUM1=0.	10710
	DO 8 MM=K,3	10720
	8 DUM1=DUM1 + CF(K,MM,MTYP)*B(MM,L)	10730
	9 B(K,L)=DUM1	10740
C		10750
	MTYP=IE(N,9)	10760
	DUM1 = DET.JAC*TH(MTYP) *W(II)*W(JJ)	
C		10780
	DO 20 NROW=1,16	10790
	DUM2=0.0	10800
	DO 18 LL=1,3	10810
	18 DUM2=DUM2 + B(II,NROW)*B(LL,17)	10820
	20 QK(NROW,17) = QK(NROW,17) + DUM1*DUM2	10830
C		10840
C		10850
	GO TO 16	10860
C		10870
	10 LX=12	10880
	IF(IVE.EQ.2) GO TO 202	10890
	CALL EPIST(N)	10900
	IF(IVE.EQ.3) GO TO 202	10910
	DO 201 I=1,9	10920
	201 EPI(I)=EPI(I)	10930
	GO TO 204	10940
	202 CALL EPIS(N)	10950
	IF(IVE.EQ.2) GO TO 204	10960
	DO 203 I=1,9	10970
	203 EPI(I)=EPI(I) + EPIT(I)	10980
	204 WRITE(12) EPI	
C		11000
	READ(8) ((AT(I,J),J=1,12),I=1,9)	
C		11020
	DO 13 II=1,6	11030
	LC(II)=2*II-1	11040
	13 LC(II+6)=2*II	11050
C		11060
	DO 15 II=1,12	11070
	LL=LC(II)	11080
	DO 15 JJ=1,9	11090
	15 BX(JJ,II)=AT(JJ,LL)	11100
C		11110
	DO 19 LL=1,9	11120
	DO 19 MM=1,12	11130
	19 BT(LL,MM)=BX(LL,MM)	11140
C		11150
C		11160
	DO 50 I=1,12	11170
	QK(I,17)=0.0	11180
	DO 50 K=1,9	11190
	DO 50 L=1,9	11200
	DO 50 M=1,9	11210
	50 QK(I,17)= QK(I,17) + BT(K,I)*D(K,L)*VOLUM(N)*CLST(L,M,IT)*EPI (M)	11220
		11230
	DO 71 IM=1,6	11240
	ISH=BUG(IM)	11250

JJ=IE(N,IM)	11260
NC=2*JJ-1	11270
R(NC)=R(NC) + QK(ISH,17)	11280
71 R(NC+1)=R (NC+1) + QK(ISH+6,17)	11290
GO TO 80	11300
16 NRONOS=8	11310
IF(IE(N,7) .LE. 0) NRONOS=6	11320
DO 61 IM=1,NRONOS	11330
ISH=IM*2-1	11340
JJ=IE(N,IM)	11350
NCUBED = 2*JJ-1	11360
R(NCUBED) = R(NCUBED) + QK(ISH ,17)	11370
R(NCUBED+1) = R(NCUBED+1) + QK(ISH+1,17)	11380
61 CONTINUE	11390
IF (IF (N , 7) .NE. 0) N S T P = 0	11400
C	11410
80 CONTINUE	11420
C	11430
C	11440
DO 70 M=1,NNP	11450
2 IF(KODE(M) .EQ. 0) GO TO 70	11460
IF(KODE(M) .EQ. 1) GO TO 170	11470
IF(KODE(M) .EQ. 2) GO TO 160	11480
R(2*M-1) = 0.	11490
160 R(2*M) = 0.	11500
GO TO 70	11510
170 R(2*M-1) = 0.	11520
70 CONTINUE	11530
C	11540
RETURN	11550
END	11560


```
PILER OPTIONS = NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,  
SOURCE,FBCDIC,NCLIST,NODECK,LOAD,MAP,NOEDIT,NOID,NOXREF  
SUBROUTINE GEOMRC(MN, NN, KSHIFT, U) 11570  
----- COMMON BLOCKS FOR THIS SUBROUTINE ----- 11580  
IMPLICIT REAL*8(A-H,O-Z),INTEGER(I-N)  
COMMON/B1/ R(2000),AK(480,240),NEG,IBAND,NUMBLK  
C----- 11600  
NNN = NEG + KSHIFT 11610  
N = NN + KSHIFT 11620  
DO 100 M=2,IBAND 11630  
K = N + M + 1 11640  
IF(K*LE.0) GO TO 50 11650  
J = K + KSHIFT 11660  
R(J) = R(J) - AK(K,M)*U 11670  
AK(K,M) = 0.0 11680  
50 K = N + M - 1 11690  
IF(K*GT.NNN) GO TO 100 11700  
J = K + KSHIFT 11710  
R(J) = R(J) - AK(N,M)*U 11720  
AK(N,M) = 0.0 11730  
100 CONTINUE 11740  
AK(N,1) = 1.0 11750  
N = N + KSHIFT 11760  
R(N) = U 11770  
RETURN 11780  
END 11790
```

• 111

22

C	MODIFY THE LOAD VECTOR	12320
C		12330
	90 NB = 0	12340
	00 NB = NB + 1	12350
	NH = NN * NR	12360
	NM = NH - NN / 2	12370
	NL = NM - NN / 2 + 1	12380
	KSHIFT = 2 * NL - 2	12390
	DO 101 I=1,NN	
101	READ (20) (AK(I,J), J = 1, IBAND)	
	DO 130 I = 1, NN	12410
	IF(DABS(AK(I,1)) .LE. 1.0D-15) GO TO 130	
	INDEX = I + (NR - 1) * IBAND	12430
	IF (INDEX .GE. NEQ) GO TO 120	12440
	CP = R(INDEX)	12450
	R(INDEX) = CP / AK(I, 1)	12460
	DO 110 J = 2, IBAND	12470
	JINDEX = INDEX + J - 1	12480
	IF (JINDEX .GT. NEQ) GO TO 110	12490
	R(JINDEX) = R(JINDEX) - AK(I,J) * CP	12500
110	CONTINUE	12510
	GO TO 130	12520
120	IF (INDEX .GT. NEQ) GO TO 130	12530
	R(NEQ) = R(NEQ) / AK(I,1)	12540
130	CONTINUE	12550
	IF (NB .LT. NUMBLK) GO TO 100	12560
	DO 135 KBUG = 1, NN	
	BACKSPACE 20	12570
135	CONTINUE	
C		12580
C	PERFORM THE BACK SUBSTITUTION	12590
C		12600
	140 DO 160 M = 1, NN	12610
	N = NN + 1 - M	12620
	INDEX = NB * IBAND - M + 1	12630
	IF (INDEX .GE. NEQ) GO TO 160	12640
	DO 150 K = 2, IBAND	12650
	JINDEX = INDEX + K - 1	12660
	IF (JINDEX .GT. NEQ) GO TO 150	12670
	R(INDEX) = R(INDEX) - AK(N, K) * R(JINDEX)	12680
150	CONTINUE	12690
160	CONTINUE	12700
	NB = NR - 1	12710
	IF (NB .EQ. 0) GO TO 170	12720
	DO 165 KBUG = 1, NN	
	BACKSPACE 20	12730
165	CONTINUE	
	DO 161 N=1,NN	
161	READ (20) (AK(N,M), M = 1, IBAND)	
	DO 167 KBUG = 1, NN	
	BACKSPACE 20	12750
167	CONTINUE	
	GO TO 140	12760
170	RETURN	12770
	END	12780

```

PILER OPTIONS = NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,
SOURCE,FBCDIC,NCLIST,NODECK,LOAD,MAP,NOEDIT,NOID,NOXREF
SUBROUTINE FPIST(N) 12790
IMPLICIT REAL*8(A-H,O-Z),INTEGER(I-N)
COMMON/B1/ R(2000),AK(480,240),NEG,IBAND,NUMBLK
COMMON/B2/ F(5),PR(5),RO(5),TH(5),ALPHA(5) 12820
1, X(1000),Y(1000),ULX(1000),VLY(1000)
2, IE(400,9),KODE(1000)
3, NNP,NEL,NMAT,NSLC,NOPT,NBODY,Mtyp 12850
COMMON /ONF/ QK(16, 17), B(3, 17), C(3, 3, 5), Z(8), RODYF(2) 12860
1, BT(9, 13), CF(3, 3, 5) 12870
COMMON/TSTRN/ TNEW(1000),TOLD(1000),CLST(9,9,5),EPIT(9),QPIT(24),
1 EPI(9),QPI(24),NSTP 12890
C----- 12900
C 12910
MNUM=IE(N,9) 12920
FAC=1.0 12930
IF(NOPT .EQ. 1) FAC=1.0 + PR(MNUM) 12940
C 12950
DO 5 I=1,5,2 12960
NP=IE(N,I) 12970
JJ= I/2 + 1 12980
IF(I .EQ. 5) JJ=3 12990
2 DT= TNEW(NP) - TOLD(NP) 13000
EPIT(JJ)= FAC*ALPHA(MNUM)*DT 13010
EPIT(JJ+3) = EPIT(JJ) 13020
5 EPIT(JJ+6) = 0.0 13030
RETURN 13040
END 13050

```

COMPILER OPTIONS = NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,

SOURCE,FBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,NOID,NOXREF

SUBROUTINE QPIT(N)

13060

----- COMMON BLOCKS FOR THIS SUBROUTINE ----- 13070

IMPLICIT REAL*8(A-H,O-Z),INTEGER(I-N)

COMMON/B1/ R(2000),AK(480,240),NEG,IBAND,NUMBLK

COMMON/B2/ F(5),PR(5),RO(5),TH(5),ALPHA(5)

13090

1, X(1000),Y(1000),ULX(1000),VLY(1000)

2, IE(400,9),KODE(1000)

3, NNP,NEL,NMAT,NSLC,NOPT,NBODY,MTYP

13120

COMMON /ONE/ QK(16, 17), B(3, 17), C(3, 3, 5), Z(8), RODYF(2)

13130

1, BT(9, 13), CF(3, 3, 5)

13140

COMMON/TSTRN/ TNEW(1000),TOLD(1000),CLST(9,9,5),EPIT(9),QPIT(24),

1 EPI(9),QPT(24),NSTP

13160

C

MNUM = IE(N,9)

13170

FAC=1.0

13180

IF(NOPT.EQ.1) FAC=1.0 + PR(MNUM)

13190

DO 3 I=1,8

13200

NP=IE(N,I)

13210

DT=TNEW(NP)-TOLD(NP)

13220

QPIT(I)=FAC*ALPHA(MNUM)*DT

13230

8 QPIT(I+8)=QPIT(I)

13240

DO 7 I=1,8

13250

7 QPIT(I+16)=0.0

13260

RETURN

13270

END

13280

13290

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PILER OPTIONS = NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,
SOURCE,FBCDIC,NOLIST,NODECK,LOAD,MAP,NOEDIT,NOID,NOXREF
SUBROUTINE QPIS(N)
IMPLICIT REAL*8(A-H,O-Z),INTEGER(I-N)
COMMON/B1/ R(2000),AK(480,240),NEG,IBAND,NUMBLK
COMMON/B2/ F(5),PR(5),RO(5),TH(5),ALPHA(5)
1,      X(1000),Y(1000),ULX(1000),VLY(1000)
2,      TE(400,9),KODE(1000)
3,      NNP,NEL,NMAT,NSLC,NOPT,NBODY,MTYP
COMMON /ONF/ QK(16, 17), B(3, 17), C(3, 3, 5), Z(8), BODYF(2)
1, BT(9, 13), CF(3, 3, 5)
COMMON/DELC/ DFIT,TM,JT,IPR,IVE
COMMON/SIGS/ SFIAS(1000,3)
COMMON/TSTRN/ TNEW(1000),TOLD(1000),CLST(9,9,5),EPIT(9),QPIT(24),
1 EPI(9),QPI(24),NSTP
DIMENSION ST(24)
C
TMM = TM
TMH=0.2*DELT*8760./((TM*8760.0D0)*0.6)
DO 3 I=1,8
NP = IE(N,I)
SM = (SELAS(NP,1)-SELAS(NP,2))/2.0
SP = (SELAS(NP,1)+SELAS(NP,2))/2.0
DS = DSQRT(SM*SM + SELAS(NP,3)*SELAS(NP,3))
PS1 = SP+DS
PS2=SP-DS
IF(NOPT.EQ.2) GO TO 1
SE = 0.8660254038*(PS1-PS2)
ST(I) = 1.5*(SFIAS(NP,1)-SELAS(NP,2))
ST(I+8) = -ST(I)
ST(I+16) = SELAS(NP,3)*3.
GO TO 2
1 SE = DSQRT(PS1*PS1 + PS2*PS2 - PS1*PS2)
ST(I) = 2.0*SEIAS(NP,1)-SELAS(NP,2)
ST(I+8)=2.0*SEIAS(NP,2)-SELAS(NP,1)
ST(I+16)=3.*SEIAS(NP,3)
2 CONTINUE
S3=4.50D-14*SE**3
QPI(I) = S3*TMH*ST(I)/SE
QPI(I+8)=S3*TMH*ST(I+8)/SE
QPI(I+16)=S3*TMH*ST(I+16)/SE
3 CONTINUE
DO 4 I=17,24
4 QPI(I)=QPI(I)*2.
RETURN
END

```

COMPILER OPTIONS - NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,		
SOURCE,BCDIC,NCLIST,NODECK,LOAD,MAP,NOEDIT,NOID,NOXREF		
	SUBROUTINE EPI(N)	13730
	IMPLICIT REAL*8(A-H,O-Z),INTEGER(I=N)	
	COMMON/B1/ R(2000),AK(480,240),NEG,IBAND,NUMBLK	
	COMMON/B2/ F(5),PR(5),RO(5),TH(5),ALPHA(5)	13750
1,	X(1000),Y(1000),ULX(1000),VLY(1000)	
2,	TE(400,9),KODE(1000)	
3,	NNP,NEL,NMAT,NSLC,NOPT,NBODY,MTYP	13780
	COMMON /ONE/ BK(16, 17), B(3, 17), C(3, 3, 5), Z(8), RODYF(2)	13790
1,	BT(9, 13), CF(3, 3, 5)	13800
	COMMON/DELC/ DEFT, TM, JT, IPR, IVE	13810
	COMMON/SIGS/ SFIAS(1000,3)	
	COMMON/TSTRN/ TNEW(1000),TOLD(1000),CLST(9,9,5),EPIT(9),QPIT(24),	
1	EPI(9),QPT(24),NSTP	13840
	DIMENSION ST(9)	13850
	MNUM = IE(N,9)	13860
	TMM = TM	13870
	TMH=0.2*DELT*8760./(((TM*8760.0D0)**0.6)	
C	COMPUTE PRINCIPAL STRESSES	13890
	DO 3 I=1,5,2	13900
	NP = IE(N,I)	13910
	JJ = I/2 + 1	13920
	IF(I.EQ.5) JJ=3	13930
	SP = (SELAS(NP,1) + SELAS(NP,2))/2.	13940
	SM = (SELAS(NP,1) - SELAS(NP,2))/2.	13950
	DS = DSQRT(SM*SM + SELAS(NP,3)*SELAS(NP,3))	
	PS1 = SP + DS	13970
	PS2 = SP - DS	13980
	IF(NOPT.EQ.2) GO TO 1	13990
	SE = 0.8660254038 * (PS1-PS2)	14000
	ST(JJ) = 1.5 * (SELAS(NP,1)-SELAS(NP,2))	14010
	ST(JJ+3) = -ST(JJ)	14020
	ST(JJ+6) = SELAS(NP,3)*3.	14030
	GO TO 2	14040
1	SE = DSQRT(PS1*PS1 + PS2*PS2 - PS1*PS2)	
	ST(JJ)=2.0*SELAS(NP,1)-SELAS(NP,2)	14060
	ST(JJ+3)=2.0*SFIAS(NP,2)-SELAS(NP,1)	14070
	ST(JJ+6)=3.0*SFIAS(NP,3)	14080
2	CONTINUE	14090
	S3=4.50D=14*SE**3	
	EPI(JJ) = S3 * TMH*ST(JJ)/SE	14110
	EPI(JJ+3)=S3 * TMH*ST(JJ+3)/SE	14120
	EPI(JJ+6)=S3 * TMH*ST(JJ+6)/SE	14130
3	CONTINUE	14140
	DO 4 I=7,9	14150
4	EPI(I) = EPT(I)*2.0	14160
	RETURN	14170
	END	14180

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      OPTIONS = NAME= MAIN,OPT=02,LINECNT=60,SIZE=0000K,
               SOURCE,BCDIC,NCLIST,NODECK,LOAD,MAP,NOEDIT,NOID,NOXREF
      SUBROUTINE TEMPS(IOP,NNP,T,IVE)
      IMPLICIT REAL*8(A-H,O-Z),INTEGER(I-N)
      COMMON/TSTRN/ TNEW(1000),TOLD(1000)
      COMMON/STAR/ TSTAR
      DIMENSION TTMP(1000)

C      IOP      =1  GENERATES TEMPERATURE FILE
C      IOP      =2  OBTAIN TEMPERATURE FIELD AT TIME T
C                  THROUGH LINEAR INTERPOLATION
C      NTF      NUMBER OF TEMPERATURE FIELDS
C      T        TIME OF DESIRED TEMPERATURE FIELD
C      TO       TIME OF LAST TEMPERATURE FIELD USED
C      TEMP     NODAL TEMPERATURE ARRAY AT TIME=T
C      TOLD     NODAL TEMPERATURE ARRAY AT TIME=TO
C
      IF(IOP .NE. 1) GO TO 30
      MT = 900
      IF(NNP.LE.900) MT=NNP
      IB=MT+1

C
      READ 490, NTF
      DO 10 I=1,NTF
      READ 501, TM
      READ 500, (TNEW(J),J=1,NNP)
      IF( IVE .EQ. 1) GO TO 50
      WRITE(4) TM,(TNEW(J),J=1,MT)
      IF(NNP.LE.MT) GO TO 10
      WRITE(4) (TNEW(J),J=IB,NNP)
10  CONTINUE
      REWIND 4
      TM=TSTAR
      TO=TSTAR
      GO TO 50

C
30  IF(T .LT. TM) GO TO 35
31  READ(4) TM,(TTMP(I),I=1,MT)
      IF(NNP.LE.MT) GO TO 32
      READ(4) (TTMP(I),I=IB,NNP)
32  IF(T.GT.TM) GO TO 31
35  FAC=(T-TO)/(TM-TO)

C
      DO 40 N=1,NNP
40  TNEW(N)=TOLD(N)+FAC*(TTMP(N)-TOLD(N))
      TO = T
50  CONTINUE
490  FORMAT(I5)
500  FORMAT(8(3X,F7.1))
501  FORMAT(F10.4)
      RETURN
      END

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