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土 木 研 究 所 資 料

非定常等方性熱伝導・温度応力解析プログラム

使用説明書および解説

昭和53年 3 月

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まえがき

ダムを築造する材料の1つであるコンクリートはセメントの水和による硬化をその基本としているが、その際発生する水和熱によってコンクリート内に温度応力が発生し、これがコンクリート内にクラックを発生させる大きな原因になっている。クラックはその発生位置によってはダム堤体の安全性を大きく左右させるため、クラック発生の主たる原因であるこの温度応力を抑えるために、施工上、ブロック工法・人工冷却法・リフト高や打設間隔の規正等の対策が行われている。

一方、解析面でのホローとしては Carlson の方法・岩盤拘束度による方法によって温度応力の大きさを捉えている。しかるに、これら解析法は原理的には1次元場における解析法であり、これをダムコンクリートの打設に適用させるに当ってはある程度の仮定を設けている（たとえば土研資料1318号コンクリートダムの温度応力解析について参照）。一般にこのような2次元問題の解析には有限要素法が便利であり、今度プログラムの開発を行うことになった。しかし、完全な形でダムコンクリートの打設に伴う温度応力履歴をプログラム中に入入れるには未だ技術的な問題が多いため、それに先立ち、一般的な（すなわち、解析系の大きさが時間的に一定な）熱伝導・温度応力解析プログラムを完成させた。本書はその使用説明書および解説書である。

本プログラムは超大型のコンピュータを使用するため、IBMシステム370モデル168-3型用に作成されている。従ってIBM社に計算作業を依頼することになるが、詳しくは土木研究所ダム構造研究室に問合わせられたい。

なお、プログラミングに際しては、日本IBM株式会社の高野夏樹・篠崎志朗両氏に御協力願った。ここに両者に深く感謝の意を表する次第である。

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1. 有限要素法基礎理論

1.1. 熱伝導問題

1.1.1. 熱伝導方程式

固体内の熱の流れ（熱伝導）は次の Laplace の方程式で表現できる。

$$\frac{\partial}{\partial x} \left(k_x \frac{\partial \phi}{\partial x} \right) + \frac{\partial}{\partial y} \left(k_y \frac{\partial \phi}{\partial y} \right) + \frac{\partial}{\partial z} \left(k_z \frac{\partial \phi}{\partial z} \right) + Q - \rho C \frac{\partial \phi}{\partial t} = 0 \quad (1)$$

ここに、

ϕ : 温度 (°C)

k_x, k_y, k_z : 主軸 x, y, z 方向の熱伝導係数 (kcal/m·day·deg)

ρ : 密度 (t/m³)

C : 比熱 (kcal/t·deg)

Q : 発熱量 (kcal/m³·day)

である。次に境界条件としては、次の3つが考えられる。

① 境界での温度が与えられている場合

$$\phi = \phi_1 \quad (2)$$

② 境界での熱流入量が与えられている場合

$$k_x \frac{\partial \phi}{\partial x} l + k_y \frac{\partial \phi}{\partial y} m + k_z \frac{\partial \phi}{\partial z} n = q_2 \quad (3)$$

③ 境界での熱放散が与えられている場合

$$k_x \frac{\partial \phi}{\partial x} l + k_y \frac{\partial \phi}{\partial y} m + k_z \frac{\partial \phi}{\partial z} n + \alpha (\phi - \phi_0) = 0 \quad (4)$$

ここに、

l, m, n : 境界面の外向法線ベクトルの方向余弦

q_2 : 境界面の熱流入量 (kcal/m²·day)

α : 外部熱伝導係数 (kcal/m²·day·deg)

ϕ_0 : 境界に接する流体の温度 (°C)

である。次に、有限要素法を適用するに当ってこれらの式を変分原理で表現すると、Euler の定理より、

$$\begin{aligned} \chi = \iiint_V \left[\frac{1}{2} \left\{ k_x \left(\frac{\partial \phi}{\partial x} \right)^2 + k_y \left(\frac{\partial \phi}{\partial y} \right)^2 + k_z \left(\frac{\partial \phi}{\partial z} \right)^2 \right\} - Q\phi + \rho C \frac{\partial \phi}{\partial t} \phi \right] dV \\ - \iint_A \left\{ q\phi - \frac{\alpha}{2} (\phi - \phi_0)^2 \right\} dA \end{aligned} \quad (5)$$

$$\frac{\partial \chi}{\partial \phi} = 0$$

となる。以下では2次元等方性体を扱うから上式は次のように改められる。

$$\chi = \iint_A \left[\frac{k}{2} \left\{ \left(\frac{\partial \phi}{\partial x} \right)^2 + \left(\frac{\partial \phi}{\partial y} \right)^2 \right\} - Q\phi + \rho C \frac{\partial \phi}{\partial t} \phi \right] dA - \int_s \left[q\phi - \frac{\alpha}{2} (\phi - \phi_0)^2 \right] ds \quad (6)$$

1. 1. 2. 有限要素法による熱伝導方程式の表現

有限要素法に用いる要素として、図1-1に示すような3角形要素を考えると、要素内の温度分布を3頂点の温度を用いて次のように表わすことができる。

$$\phi = \frac{1}{2\Delta} \begin{bmatrix} a_1 + b_1 x + c_1 y \\ a_2 + b_2 x + c_2 y \\ a_3 + b_3 x + c_3 y \end{bmatrix}^T \begin{bmatrix} \phi_1 \\ \phi_2 \\ \phi_3 \end{bmatrix} \quad (7)$$

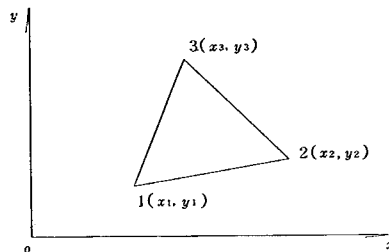


図1-1. 3角形要素

ここに、

$$\begin{aligned} a_1 &= x_2 y_3 - x_3 y_2 & b_1 &= y_2 - y_3 \\ c_1 &= x_3 - x_2 \\ a_2 &= x_3 y_1 - x_1 y_3 & b_2 &= y_3 - y_1 \\ c_2 &= x_1 - x_3 \\ a_3 &= x_1 y_2 - x_2 y_1 & b_3 &= y_1 - y_2 & c_3 &= x_2 - x_1 \\ 2\Delta &= x_1 y_2 + x_2 y_3 + x_3 y_1 - x_2 y_1 - x_3 y_2 \end{aligned} \quad (8)$$

である。従って、変分原理(6)式は次式と同値である。

$$\begin{bmatrix} \partial \chi / \partial \phi_1 \\ \partial \chi / \partial \phi_2 \\ \partial \chi / \partial \phi_3 \end{bmatrix} = 0 \quad (9)$$

これを実際に求めると次式が得られる。

$$[K][\phi] - [Q] - [q] + [A] \left\{ [\phi] - [\phi_0] \right\} + [P] \left[\frac{\partial}{\partial t} \phi \right] = 0 \quad (10)$$

ここに、

$$\begin{aligned} [K] &= \frac{k}{4\Delta} \begin{bmatrix} b_1 b_1 + c_1 c_1 & b_1 b_2 + c_1 c_2 & b_1 b_3 + c_1 c_3 \\ b_2 b_1 + c_2 c_1 & b_2 b_2 + c_2 c_2 & b_2 b_3 + c_2 c_3 \\ b_3 b_1 + c_3 c_1 & b_3 b_2 + c_3 c_2 & b_3 b_3 + c_3 c_3 \end{bmatrix} \\ [A] &= \frac{1}{6} \begin{bmatrix} 2(\alpha_{12} L_{12} + \alpha_{13} L_{13}) & \alpha_{12} L_{12} & \alpha_{13} L_{13} \\ \alpha_{12} L_{12} & 2(\alpha_{12} L_{12} + \alpha_{23} L_{23}) & \alpha_{23} L_{23} \\ \alpha_{13} L_{13} & \alpha_{23} L_{23} & 2(\alpha_{13} L_{13} + \alpha_{23} L_{23}) \end{bmatrix} \\ [P] &= \frac{\rho C \Delta}{12} \begin{bmatrix} 2 & 1 & 1 \\ 1 & 2 & 1 \\ 1 & 1 & 2 \end{bmatrix} \end{aligned} \quad (11)$$

$$L_{12} = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

また、要素内で Q 、各辺で q を一定とすれば、

$$[Q] = \frac{Q \Delta}{3} \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} \quad (12)$$

$$[q] = \frac{1}{2} \begin{bmatrix} q_{12} L_{12} + q_{13} L_{13} \\ q_{12} L_{12} + q_{23} L_{23} \\ q_{13} L_{13} + q_{23} L_{23} \end{bmatrix}$$

である。ここに、

$[K]$: 熱伝導マトリックス

$[\phi]$: 節点の温度ベクトル

$[Q]$: 等価節点発熱量ベクトル

$[q]$: 等価節点流入熱量ベクトル

$[A]$: 外部熱伝導マトリックス

$[\phi_0]$: 節点に接する流体の温度ベクトル

$[P]$: 熱拡散マトリックス

$[\frac{\partial}{\partial t} \phi]$: 節点の温度の時間微分ベクトル

$\alpha_{12}, \alpha_{23}, \alpha_{13}$: 辺 $1 \cdot 2$ $2 \cdot 3$ $1 \cdot 3$ の外部熱伝導係数

q_{12}, q_{23}, q_{13} : 辺 $1 \cdot 2$ $2 \cdot 3$ $1 \cdot 3$ の単位長さ当りの熱流入量である。次に、温度の時間微分を差分で表わすと、

$$[\frac{\partial}{\partial t} \phi]_t = \frac{1}{\delta t} ([\phi]_t - [\phi]_{t-\delta t}) \quad (13)$$

ないし、

$$[\frac{\partial}{\partial t} \phi]_t = - [\frac{\partial}{\partial t} \phi]_{t-\delta t} + \frac{2}{\delta t} ([\phi]_t - [\phi]_{t-\delta t}) \quad (14)$$

となる。この両差分式について説明を加えると、(13)式は十分小さな時間間隔を用いないと精度が悪くなる。(14)式は $[\frac{\partial}{\partial t} \phi]$ が時間と共に直線的に変化するものとした式であり、(13)式に比べ大きな時間間隔を用いることができる。しかし、漸化式の形をとっているため初期値が与えられていないと任意の時間での値を求めることができない欠点がある。

次に、3角形要素について求められた式を系全体に拡張しよう。今、系全体から見て i 節点に流入する熱量を q_i 、(10)式より求められる N 要素の i 節点の等価節点流入熱量を $(q_i)_N$ で表わせば次式が成立する。

$$q_i = \sum (q_i)_N \quad (15)$$

ここに、 $\sum$ は i 節点を共有する要素に対しての和を意味する。

(15)式を全節点について求めると、

$$[q] = [K][\phi] - [Q] + [A] \{ [\phi] - [\phi_0] \} + [P] [\frac{\partial}{\partial t} \phi] \quad (16)$$

が得られる。

また、各要素内の熱の流れは、

$$q_x = -k \frac{\partial \phi}{\partial x} \quad q_y = -k \frac{\partial \phi}{\partial y} \quad (17)$$

で求まるから、次式で表わされる。

$$\begin{bmatrix} q_x \\ q_y \end{bmatrix} = \frac{-k}{2\Delta} \begin{bmatrix} b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{bmatrix} \begin{bmatrix} \phi_1 \\ \phi_2 \\ \phi_3 \end{bmatrix} \quad (18)$$

1.2. 弾性問題

1.2.1. 弾性方程式

ここでは系が弾性体であると仮定する。弾性方程式は等方性体の場合、次式で表わされる。

$$\begin{aligned} \sigma_x &= \frac{E}{(1+\nu)(1-2\nu)} \{ (1-\nu)(\epsilon_x - \epsilon\phi) + \nu(\epsilon_y - \epsilon\phi) + \nu(\epsilon_z - \epsilon\phi) \} \\ \sigma_y &= \frac{E}{(1+\nu)(1-2\nu)} \{ \nu(\epsilon_x - \epsilon\phi) + (1-\nu)(\epsilon_y - \epsilon\phi) + \nu(\epsilon_z - \epsilon\phi) \} \\ \sigma_z &= \frac{E}{(1+\nu)(1-2\nu)} \{ \nu(\epsilon_x - \epsilon\phi) + \nu(\epsilon_y - \epsilon\phi) + (1-\nu)(\epsilon_z - \epsilon\phi) \} \\ \tau_{xy} &= \frac{E}{2(1+\nu)} \gamma_{xy} \\ \tau_{yx} &= \frac{E}{2(1+\nu)} \gamma_{yx} \\ \tau_{zx} &= \frac{E}{2(1+\nu)} \gamma_{zx} \\ \epsilon\phi &= \alpha \Delta \phi \end{aligned} \quad (19)$$

ここに、

- $\sigma_x, \sigma_y, \sigma_z$: 直応力 (t/m^2)
- $\tau_{xy}, \tau_{yz}, \tau_{zx}$: せん断応力 (t/m^2)
- $\epsilon_x, \epsilon_y, \epsilon_z$: 直ひずみ
- $\gamma_{xy}, \gamma_{yz}, \gamma_{zx}$: せん断ひずみ
- $\epsilon\phi$: 温度ひずみ
- E : 弾性係数 (t/m^2)
- ν : ポアソン比
- α : 線膨張率 (熱膨張率) ($1/\text{deg}$)
- $\Delta \phi$: 温度変化量 (deg)

である。また、境界条件式としては次の2つが考えられる。

① 境界での変位が与えられている場合

$$u = u_1 \quad v = v_1 \quad w = w_1 \quad (20)$$

② 境界での外力が与えられている場合

$$P_x = \sigma_x l + \tau_{xy} m + \tau_{zx} n$$

$$P_y = \tau_{xy} l + \sigma_y m + \tau_{yz} n$$

$$P_z = \tau_{zx} l + \tau_{yz} m + \sigma_z n$$

(20)

ここに,

u, v, w : 変位 (m)

P_x, P_y, P_z : 境界に作用する外力 (t/m^2)

l, m, n : 境界面の外向き法線ベクトルの方向余弦

である。

以下では, 2次元場を取扱うことにする。2次元場には平面応力状態と平面ひずみ状態があるが, 平面応力状態の場合(19)式は次式で改められる。

$$\sigma_x = \frac{E}{1-\nu^2} \left\{ (\epsilon_x - \epsilon_\phi) + \nu (\epsilon_y - \epsilon_\phi) \right\}$$

$$\sigma_y = \frac{E}{1-\nu^2} \left\{ \nu (\epsilon_x - \epsilon_\phi) + (\epsilon_y - \epsilon_\phi) \right\}$$

(21)

$$\tau_{xy} = \frac{E}{2(1+\nu)} \tau_{xy}$$

次に平面ひずみ状態の場合(19)式は次式で改められる。

$$\sigma_x = \frac{E}{(1+\nu)(1-2\nu)} \left[(1-\nu) \left\{ \epsilon_x - (1+\nu) \epsilon_\phi \right\} + \nu \left\{ \epsilon_y - (1+\nu) \epsilon_\phi \right\} \right]$$

$$\sigma_y = \frac{E}{(1+\nu)(1-2\nu)} \left[\nu \left\{ \epsilon_x - (1+\nu) \epsilon_\phi \right\} + (1-\nu) \left\{ \epsilon_y - (1+\nu) \epsilon_\phi \right\} \right]$$

(22)

$$\tau_{xy} = \frac{E}{2(1+\nu)} \tau_{xy}$$

ここで注意すべきことは, 平面ひずみの場合, 温度ひずみは $(1+\nu) \epsilon_\phi$ で表わされることである。これは平面ひずみの場合, $\epsilon_z - \epsilon_\phi = 0$ でなく $\epsilon_z = 0$ であることによる。

1. 2. 2. 有限要素法による弾性方程式の表現

有限要素法に用いる要素として, 図1-1に示すような3角要素を考えると, 要素内の変位分布を3頂点の変位を用いて次式のように表わすことができる。

$$\begin{bmatrix} u \\ v \end{bmatrix} = \frac{1}{2\Delta} \begin{bmatrix} a_1 + b_1 x + c_1 y, & 0 \\ 0, & a_1 + b_1 x + c_1 y \\ a_2 + b_2 x + c_2 y, & 0 \\ 0, & a_2 + b_2 x + c_2 y \\ a_3 + b_3 x + c_3 y, & 0 \\ 0, & a_3 + b_3 x + c_3 y \end{bmatrix}^T \begin{bmatrix} u_1 \\ v_1 \\ u_2 \\ v_2 \\ u_3 \\ v_3 \end{bmatrix}$$

(23)

従って要素内のひずみは一定で

$$\begin{bmatrix} \epsilon_x \\ \epsilon_y \\ \gamma_{xy} \end{bmatrix} = \frac{1}{2\Delta} \begin{bmatrix} b_1, 0, b_2, 0, b_3, 0 \\ 0, c_1, 0, c_2, 0, c_3 \\ c_1, b_1, c_2, b_2, c_3, b_3 \end{bmatrix} \begin{bmatrix} u_1 \\ v_1 \\ u_2 \\ v_2 \\ u_3 \\ v_3 \end{bmatrix} \quad (25)$$

または

$$[\epsilon] = [B][U] \quad (26)$$

で表わされる。次に、応力ひずみ関係は平面応力状態では

$$\begin{bmatrix} \sigma_x \\ \sigma_y \\ \tau_{xy} \end{bmatrix} = \frac{E}{1-\nu^2} \begin{bmatrix} 1, \nu, 0 \\ \nu, 1, 0 \\ 0, 0, \frac{1-\nu}{2} \end{bmatrix} \left\{ \begin{bmatrix} \epsilon_x \\ \epsilon_y \\ \gamma_{xy} \end{bmatrix} - \begin{bmatrix} \alpha \Delta \phi \\ \alpha \Delta \phi \\ 0 \end{bmatrix} \right\} \quad (27)$$

平面ひずみ状態では

$$\begin{bmatrix} \sigma_x \\ \sigma_y \\ \tau_{xy} \end{bmatrix} = \frac{E}{(1+\nu)(1-2\nu)} \begin{bmatrix} 1-\nu, \nu, 0 \\ \nu, 1-\nu, 0 \\ 0, 0, \frac{1-2\nu}{2} \end{bmatrix} \left\{ \begin{bmatrix} \epsilon_x \\ \epsilon_y \\ \gamma_{xy} \end{bmatrix} - \begin{bmatrix} \alpha(1+\nu)\Delta\phi \\ \alpha(1+\nu)\Delta\phi \\ 0 \end{bmatrix} \right\} \quad (28)$$

で表わされる。いずれにしろこれを簡単に、

$$[\sigma] = [D]\{[\epsilon] - [\epsilon\phi]\} \quad (29)$$

で表わす。今、変分原理として仮想仕事の原理を用いると、

$$\int_S [\tilde{u}]^T [P] ds + \iint_A [\tilde{u}]^T [w] dA = \iint_A [\tilde{\epsilon}]^T [D]\{[\epsilon] - [\epsilon\phi]\} dA \quad (30)$$

が成立する。ここに、

[P] : 表面力ベクトル

[w] : 物体力ベクトル

[\tilde{u}] : 仮想変位ベクトル

[\tilde{\epsilon}] : 仮想ひずみベクトル

である。いま、(29)式の関係を用い、要素内で物体力を一定、各辺で表面力を一定とすれば(30)式は次の式で表わされる。

$$[S_p] + [S_w] + [S_\phi] = [K][U] \quad (31)$$

ここに、

$$[S_p] = \frac{1}{2} \begin{bmatrix} (p_{12} \ell_{12} - q_{12} m_{12}) L_{12} + (p_{13} \ell_{13} - q_{13} m_{13}) L_{13} \\ (p_{12} m_{12} + q_{12} \ell_{12}) L_{12} + (p_{13} m_{13} + q_{13} \ell_{13}) L_{13} \\ (p_{12} \ell_{12} - q_{12} m_{12}) L_{12} + (p_{23} \ell_{23} - q_{23} m_{23}) L_{23} \\ (p_{12} m_{12} + q_{12} \ell_{12}) L_{12} + (p_{23} m_{23} + q_{23} \ell_{23}) L_{23} \\ (p_{13} \ell_{13} - q_{13} m_{13}) L_{13} + (p_{23} \ell_{23} - q_{23} m_{23}) L_{23} \\ (p_{13} m_{13} + q_{13} \ell_{13}) L_{13} + (p_{23} m_{23} + q_{23} \ell_{23}) L_{23} \end{bmatrix}$$

$$[S_w] = \frac{\Delta}{3} \begin{bmatrix} w_x \\ w_y \\ w_x \\ w_y \\ w_x \\ w_y \end{bmatrix}$$

(32)

$$[S_\phi] = \frac{E \alpha \Delta \phi}{2f(\nu)} \begin{bmatrix} b_1 \\ c_1 \\ b_2 \\ c_2 \\ b_3 \\ c_3 \end{bmatrix}$$

$$f(\nu) = \begin{cases} 1 - \nu & (\text{平面応力}) \\ 1 - 2\nu & (\text{平面ひずみ}) \end{cases}$$

$$L_{12} = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

である。ここに、

$[S_p]$: 表面力による等価節点力

$[S_w]$: 物体力による等価節点力

$[S_\phi]$: 熱膨張による等価節点力

p_{12}, p_{23}, p_{13} : 辺 $\overline{1 \cdot 2}$, $\overline{2 \cdot 3}$, $\overline{1 \cdot 3}$ の表面力の法線方向成分 (外向きを正)

q_{12}, q_{23}, q_{13} : 辺 $\overline{1 \cdot 2}$, $\overline{2 \cdot 3}$, $\overline{1 \cdot 3}$ の表面力の接線方向成分 (反時計回り向きを正)

$\ell_{12}, m_{12}, \ell_{23}, m_{23}, \ell_{13}, m_{13}$: 辺 $\overline{1 \cdot 2}$, $\overline{2 \cdot 3}$, $\overline{1 \cdot 3}$ の外向法線ベクトルの方向余弦

w_x, w_y : 物体力の x, y 成分

である。また、剛性マトリックス

$$[K] = \Delta [B]^T [D] [B]$$

(33)

は、平面応力の場合

$$\begin{aligned}
[K] = \frac{L}{4\Delta(1-\nu^2)} & \left[\begin{array}{l}
b_1 b_1 + \frac{1-\nu}{2} c_1 c_1, \quad \nu b_1 c_1 + \frac{1-\nu}{2} c_1 b_1, \quad b_1 b_2 + \frac{1-\nu}{2} c_1 c_2, \\
\nu c_1 b_1 + \frac{1-\nu}{2} b_1 c_1, \quad c_1 c_1 + \frac{1-\nu}{2} b_1 b_1, \quad \nu c_1 b_2 + \frac{1-\nu}{2} b_1 c_2, \\
b_2 b_1 + \frac{1-\nu}{2} c_2 c_1, \quad \nu b_2 c_1 + \frac{1-\nu}{2} c_2 b_1, \quad b_2 b_2 + \frac{1-\nu}{2} c_2 c_2, \\
\nu c_2 b_1 + \frac{1-\nu}{2} b_2 c_1, \quad c_2 c_1 + \frac{1-\nu}{2} b_2 b_1, \quad \nu c_2 b_2 + \frac{1-\nu}{2} b_2 c_2, \\
b_3 b_1 + \frac{1-\nu}{2} c_3 c_1, \quad \nu b_3 c_1 + \frac{1-\nu}{2} c_3 b_1, \quad b_3 b_2 + \frac{1-\nu}{2} c_3 c_2, \\
\nu c_3 b_1 + \frac{1-\nu}{2} b_3 c_1, \quad c_3 c_1 + \frac{1-\nu}{2} b_3 b_1, \quad \nu c_3 b_2 + \frac{1-\nu}{2} b_3 c_2, \\
\nu b_1 c_2 + \frac{1-\nu}{2} c_1 b_2, \quad b_1 b_3 + \frac{1-\nu}{2} c_1 c_3, \quad \nu b_1 c_3 + \frac{1-\nu}{2} c_1 b_3, \\
c_1 c_2 + \frac{1-\nu}{2} b_1 b_2, \quad \nu c_1 b_3 + \frac{1-\nu}{2} b_1 c_3, \quad c_1 c_3 + \frac{1-\nu}{2} b_1 b_3, \\
\nu b_2 c_2 + \frac{1-\nu}{2} c_2 b_2, \quad b_2 b_3 + \frac{1-\nu}{2} c_2 c_3, \quad \nu b_2 c_3 + \frac{1-\nu}{2} c_2 b_3, \\
c_2 c_2 + \frac{1-\nu}{2} b_2 b_2, \quad \nu c_2 b_3 + \frac{1-\nu}{2} b_2 c_3, \quad c_2 c_3 + \frac{1-\nu}{2} b_2 b_3, \\
\nu b_3 c_2 + \frac{1-\nu}{2} c_3 b_2, \quad b_3 b_3 + \frac{1-\nu}{2} c_3 c_3, \quad \nu b_3 c_3 + \frac{1-\nu}{2} c_3 b_3, \\
c_3 c_2 + \frac{1-\nu}{2} b_3 b_2, \quad \nu c_3 b_3 + \frac{1-\nu}{2} b_3 c_3, \quad c_3 c_3 + \frac{1-\nu}{2} b_3 b_3
\end{array} \right]
\end{aligned}$$

(34)

また、平面ひずみの場合は、

$$[K] = \frac{E}{4\Delta(1+\nu)(1-2\nu)}$$

$$\left[\begin{array}{l} (1-\nu)b_1b_1 + \frac{1-2\nu}{2} c_1c_1, \quad \nu b_1c_1 + \frac{1-2\nu}{2} c_1b_2, \quad (1-\nu)b_1b_2 + \frac{1-2\nu}{2} c_1c_2, \\ \nu c_1b_1 + \frac{1-2\nu}{2} b_1c_1, \quad (1-\nu)c_1c_1 + \frac{1-2\nu}{2} b_1b_1, \quad \nu c_1b_2 + \frac{1-2\nu}{2} b_1c_2, \\ (1-\nu)b_2b_1 + \frac{1-2\nu}{2} c_2c_1, \quad \nu b_2c_1 + \frac{1-2\nu}{2} c_2b_1, \quad (1-\nu)b_2b_2 + \frac{1-2\nu}{2} c_2c_2, \\ \nu c_2b_1 + \frac{1-2\nu}{2} b_2c_1, \quad (1-\nu)c_2c_1 + \frac{1-2\nu}{2} b_2b_1, \quad \nu c_2b_2 + \frac{1-2\nu}{2} b_2c_2, \\ (1-\nu)b_3b_1 + \frac{1-2\nu}{2} c_3c_1, \quad \nu b_3c_1 + \frac{1-2\nu}{2} c_3b_1, \quad (1-\nu)b_3b_2 + \frac{1-2\nu}{2} c_3c_2, \\ \nu c_3b_1 + \frac{1-2\nu}{2} b_3c_1, \quad (1-\nu)c_3c_1 + \frac{1-2\nu}{2} b_3b_1, \quad \nu c_3b_2 + \frac{1-2\nu}{2} b_3c_2, \\ \\ \nu b_1c_2 + \frac{1-2\nu}{2} c_1b_2, \quad (1-\nu)b_1b_3 + \frac{1-2\nu}{2} c_1c_3, \quad \nu b_1c_3 + \frac{1-2\nu}{2} c_1b_3 \\ (1-\nu)c_1c_2 + \frac{1-2\nu}{2} b_1b_2, \quad \nu c_2b_3 + \frac{1-2\nu}{2} b_1c_3, \quad (1-\nu)c_1c_3 + \frac{1-2\nu}{2} b_1b_3 \\ \nu b_2c_2 + \frac{1-2\nu}{2} c_2b_2, \quad (1-\nu)b_2b_3 + \frac{1-2\nu}{2} c_2c_3, \quad \nu b_2c_3 + \frac{1-2\nu}{2} c_2b_3 \\ (1-\nu)c_2c_2 + \frac{1-2\nu}{2} b_2b_2, \quad \nu c_2b_3 + \frac{1-2\nu}{2} b_2c_3, \quad (1-\nu)c_2c_3 + \frac{1-2\nu}{2} b_2b_3 \\ \nu b_3c_2 + \frac{1-2\nu}{2} c_3b_2, \quad (1-\nu)b_3b_3 + \frac{1-2\nu}{2} c_3c_3, \quad \nu b_3c_3 + \frac{1-2\nu}{2} c_3b_3 \\ (1-\nu)c_3c_2 + \frac{1-2\nu}{2} b_3c_2, \quad \nu c_3b_3 + \frac{1-2\nu}{2} b_3c_3, \quad (1-\nu)c_3c_3 + \frac{1-2\nu}{2} b_3b_3 \end{array} \right] \quad (3)$$

となる。

次に、3 三角形要素について求められた式を系全体に拡張しよう。今、系全体から見て、 i 節点に作用する表面力・反力を $[Sipx, Sipy][Rix, Riy]$ とし、(8)式より求めらる N 要素の i 節点の表面力を $[(Sipx)_N, (Sipy)_N]$ とすれば、

$$Sipx + Rix = \Sigma (Sipx)_N \quad (9)$$

$$Sipy + Riy = \Sigma (Sipy)_N$$

となる。ここに、 Σ は i 節点を共有する要素についての和を意味する。(9)式を全節点について求めると、

$$[R] + [S_p] + [S_w] + [S_\phi] = [K][U] \quad (10)$$

が得られる。なお、これを熱伝導問題と組合わせる場合、各時間間隔に対して弾性係数を一定とみて、各要素の温度変化量に対しては 3 三角形の重心の温度変化を用いればよい。

(10)式により変位が求まると、各要素の応力は次式で求められる。

$$[\sigma] = [D] \{ [B][U] - [\epsilon_\phi] \} \quad (11)$$

平面応力の場合、(8)式は

$$\begin{bmatrix} \sigma_x \\ \sigma_y \\ \tau_{xy} \end{bmatrix} = \frac{E}{2\Delta(1-\nu^2)} \begin{bmatrix} b_1 & \nu c_1 & b_2 & \nu c_2 & b_3 & \nu c_3 \\ \nu b_1 & c_1 & \nu b_2 & c_2 & \nu b_3 & c_3 \\ \frac{1-\nu}{2} c_1 & \frac{1-\nu}{2} b_1 & \frac{1-\nu}{2} c_2 & \frac{1-\nu}{2} b_2 & \frac{1-\nu}{2} c_3 & \frac{1-\nu}{2} b_3 \end{bmatrix} \begin{bmatrix} u_1 \\ v_1 \\ u_2 \\ v_2 \\ u_3 \\ v_3 \end{bmatrix} - \frac{E}{1-\nu^2} \begin{bmatrix} 1, \nu, 0 \\ \nu, 1, 0 \\ 0, 0, \frac{1-\nu}{2} \end{bmatrix} \begin{bmatrix} \alpha \Delta \phi \\ \alpha \Delta \phi \\ 0 \end{bmatrix} \quad (12)$$

平面ひずみの場合は

$$\begin{bmatrix} \sigma_x \\ \sigma_y \\ \tau_{xy} \end{bmatrix} = \frac{E}{2\Delta(1+\nu)(1-2\nu)} \begin{bmatrix} (1-\nu)b_1 & \nu c_1 & (1-\nu)b_2 & \nu c_2 & (1-\nu)b_3 & \nu c_3 \\ \nu b_1 & (1-\nu)c_1 & \nu b_2 & (1-\nu)c_2 & \nu b_3 & (1-\nu)c_3 \\ \frac{1-2\nu}{2} c_1 & \frac{1-2\nu}{2} b_1 & \frac{1-2\nu}{2} c_2 & \frac{1-2\nu}{2} b_2 & \frac{1-2\nu}{2} c_3 & \frac{1-2\nu}{2} b_3 \end{bmatrix} \begin{bmatrix} u_1 \\ v_1 \\ u_2 \\ v_2 \\ u_3 \\ v_3 \end{bmatrix} - \frac{E}{(1+\nu)(1-2\nu)} \begin{bmatrix} 1-\nu & \nu & 0 \\ \nu & 1-\nu & 0 \\ 0 & 0 & \frac{1-2\nu}{2} \end{bmatrix} \begin{bmatrix} \alpha(1+\nu)\Delta\phi \\ \alpha(1+\nu)\Delta\phi \\ 0 \end{bmatrix} \quad (13)$$

となる。

2. 有限要素法による熱伝導・温度応力解析プログラム作成上の技術的事項について

2.1. 熱伝導方程式

2.1.1. 熱伝導・外部熱伝導・熱拡散マトリックス

熱伝導・外部熱伝導・熱拡散マトリックスは、系の節点数を N とした場合、 $N \times N$ マトリックスとなる。しかし、これらのマトリックスの元は大部分 0 である。従って、要素の結び付きについて、図 2-1 のように、1 つの節点と要素を通じて直接に結び付く節点を最大 8 ままで規定することにより、これらのマトリックスを $N \times 9$ に圧縮することにする。この時圧縮されたマトリックスと元のマトリックスの対応を表わす記憶マトリックス $[M]$ を用意する。いま、これを数学的に表現すれば、

$$k_{ij} = \tilde{k}_{i\ell} \quad a_{ij} = \tilde{a}_{i\ell} \quad p_{ij} = p_{i\ell} \quad j = m_{i\ell} \quad (1)$$

となる。ここに、

k_{ij}, a_{ij}, p_{ij} : 圧縮される前の $[K][A][P]$ の (i, j) 元

$\tilde{k}_{i\ell}, \tilde{a}_{i\ell}, \tilde{p}_{i\ell}$: 圧縮された後の $[K][A][P]$ の (i, ℓ) 元
 $m_{i\ell}$: $[M]$ の (i, ℓ) 元

である。これによって、計算機内の記憶容量を大幅に節約できる。

2.1.2. $\frac{\partial}{\partial t} \phi$ の算出法

熱伝導方程式 (第 1 章 04 式) 中、 ϕ と $\frac{\partial}{\partial t} \phi$ の関係を与える式として、第 1 章 03 04 式を示したが前進差分式である 04 式は精度的に優れるけれども初期値を与えなければ適用できない。そこであらかじめ 03 式によって初期値を求めておくことが必要となる。この場合 03 式は 04 式に比べ精度が落ちるため、04 式の $1/20$ の時間間隔を用いて計算する。すなわち、 $[\frac{\partial}{\partial t} \phi]$ の算出式として次式を用いる。

$$\left[\frac{\partial}{\partial t} \phi \right]_0 = \frac{20}{\delta t} \left\{ [\phi]_{\delta t/20} - [\phi]_0 \right\} \quad (2)$$

$$\left[\frac{\partial}{\partial t} \phi \right]_t = - \left[\frac{\partial}{\partial t} \phi \right]_{t-\delta t} + \frac{2}{\delta t} \{ [\phi]_t - [\phi]_{t-\delta t} \}$$

従って、計算の時間間隔を δt とした場合、時刻 $\delta t, 2\delta t, \dots$ の計算に先立ち、時刻 $\delta t/20$ の計算をすることになる。

2.1.3. 熱伝導方程式の解法

(2) 式を用いると、熱伝導方程式は次式で改められる。

$$[Q]_{\delta t/20} = \left\{ [K] + [A] + \frac{20}{\delta t} [P] \right\} [\phi]_{\delta t/20}$$

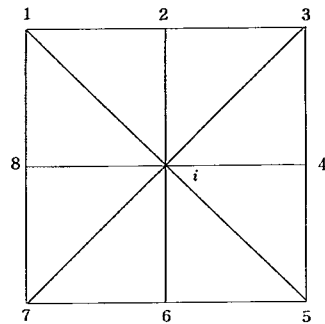


図 2-1. 節点の結び付き

$$\begin{aligned}
& - \left\{ [Q] \delta t/2_0 + [A] [\phi]_0 \delta t/2_0 + \frac{20}{\delta t} [P] [\phi]_0 \right\} \\
[Q]_t &= \left\{ [K] + [A] + \frac{2}{\delta t} [P] \right\} [\phi]_t \\
& - \left\{ [Q]_t + [A] [\phi]_t + [P] \left(\frac{2}{\delta t} [\phi]_{t-\delta t} + \left[\frac{\partial}{\partial t} \phi \right]_{t-\delta t} \right) \right\}
\end{aligned} \tag{3}$$

いま、両式を簡単に、

$$[Q] = [B] [\phi] - [C] \tag{4}$$

で表わす。ここで未知数は $[\phi]$ $[Q]$ であり、任意の節点に対し ϕ または q のいずれか一方が未知である。

方程式の解法はCG法（共役傾斜法）を用いる。ここで、未知数が1つのベクトル内だけでなく、2つのベクトル内に含まれるため、その取扱いは多少複雑になる。その計算手順を示すと次のようになる。

① 初期値の設定

$$\begin{aligned}
(\phi_i)_0 &= \begin{cases} \phi_i \cdots \cdots i \text{ 節点の温度が既知数 } \phi_i \text{ の時} \\ 0 \cdots \cdots i \text{ 節点の温度が未知の時} \end{cases} \\
(P_i)_0 = (r_i)_0 &= \begin{cases} 0 \cdots \cdots i \text{ 節点の温度が既知の時} \\ (q_i)_0 + (C_i)_0 - \sum_j (B_{ij})(\phi_j)_0 \\ \cdots \cdots i \text{ 節点の温度が未知の時} \end{cases}
\end{aligned} \tag{5}$$

$$k=0$$

ここに、

$$\begin{aligned}
(\phi_i)_0, (P_i)_0, (r_i)_0 &: [\phi]_0, [P]_0, [r]_0 \text{ の } i \text{ 元} \\
(B_{ij}) &: [B] \text{ の } (i, j) \text{ 元}
\end{aligned}$$

② 解の近似値の算出

$$\alpha^k = \frac{[P]_k^T [r]_k}{[P]_k^T [B] [P]_k} \tag{6}$$

$$[\phi]_{k+1} = [\phi]_k + \alpha_k [P]_k$$

③ 残差ベクトルの算出

$$[r]_{k+1} = [r]_k - \alpha_k [B] [P]_k \tag{7}$$

④ 解への近似方向の算出

$$\beta_k = - \frac{[r]_{k+1}^T [B] [P]_k}{[P]_k^T [B] [P]_k} \tag{8}$$

$$[P]_{k+1} = [r]_{k+1} + \beta_k [P]_k$$

⑤ 繰返し計算

$$k \rightarrow k+1 \text{ として②へ戻る。}$$

これを未知数の数だけ繰返せば真の解が得られる。また、 $[\phi]$ が求まると(4)式より $[Q]$ が求められる。

2.2. 弾性方程式

2.2.1. 剛性マトリックス

剛性マトリックスは、系の節点数を N とした場合、 $2N \times 2N$ マトリックスとなるが、熱伝導マトリックスと同様に $2N \times 18$ マトリックスに圧縮する。また、弾性係数が変化するため、弾性係数の変化のパターン毎に剛性マトリックスを作成し、各回毎の剛性マトリックスの作成を容易にする。すなわち、系全体の剛性マトリックスは次式で表わされる。

$$[K(t)] = [K_0] + \sum E_i(t) [K']_i \quad (9)$$

ここに、

$[K(t)]$: 系全体の剛性マトリックス

$[K_0]$: 弾性係数一定部分の剛性マトリックス

$[K']_i$: 各弾性係数パターン毎の剛性マトリックス (但し $E_i(t) = 1$ とした場合の値)

$E_i(t)$: 各弾性係数パターン

2.2.2. 熱膨張による等価節点力

熱伝導解析では各節点毎の温度が与えるのに対し、応力解析では要素毎の温度が必要となる。そこで、要素の温度を 3 角形要素の重心の温度で定義する。

$$\phi = \frac{1}{3}(\phi_i + \phi_j + \phi_k) \quad (10)$$

この時、各節点に作用する等価節点力は第 1 章 2.1 式で与えられる。

2.2.3 弾性方程式の解法

系全体の弾性方程式は、温度変化による応力を考えるから、

$$[R] + [S_\phi] = [K][U] \quad (11)$$

で与えられる。ここに、未知数は $[R][U]$ であり、任意の節点において U または R のいずれか一方が未知である。これは (4) 式と全く同形であり、熱伝導の場合と全く同様に解くことができる。

3. プログラムの入力方法と出力の見方

3.1. プログラムの概要

① 本プログラムは有限要素法による「非定常等方性熱伝導・温度応力解析プログラム」であり、主として、コンクリートの硬化時の発熱による温度変化・温度応力、外気温の日変化・年変化によるダム等の温度変化・温度応力等の解析を対象にしている。

② 応力解析については、弾性係数の経常変化を考慮することができるが、弾塑性・粘弾性問題は取扱えない。

③ 使用する要素は3角形要素のみであり、計算可能な最大節点数は500、最大要素数は1000である。

④ 異なる物性をもつ要素の組合せは最大5種類までであり、特に、弾性係数の変化するものは最大2種類までである。

⑤ 境界条件中、節点温度、節点外部温度、熱流入量はそれぞれ5種類の組合せまで可能である。

⑥ 要素分割において、1つの節点に要素を通じて直接結びつく節点数は最大8までとする。

(図2-1参照p11)

⑦ 発熱量、弾性係数、節点温度、節点外部温度、熱流入量は全て与えられた関数形で入力するものとする。

⑧ 計算時間については、節点数100、要素数200程度で1回の計算当りCPU=3.5秒である。

3.2. 入力データシートの作成方法

入力データシートは図3-1に従って記入する。記入すべき文字・数字は全て指定されたカラムに書かなければならない。実数は指定された枠内のカラムに納っていれば小数点の位置はどこでもよい。整数は指定された枠内の右に寄せて記入しなければならない。またE変換・D変換の指数部分(たとえば1.0E-5における-5)も右に寄せて記入する必要がある。0、0.0の記入は無記入(ブランク)でもよい。

① CONTカード

記号	型	説明
A	I	応力計算を (する 1 しない 0)
B	I	平面ひずみ状態 1 平面応力状態 2
T1	R	最初の計算の時間間隔(day)
C1	I	T1による計算回数
P1	I	出力をプリントする間隔
T2	R	次の計算の時間間隔(day)
C2	I	T2による計算回数
P2	I	出力をプリントする間隔
RRH	R	熱伝導方程式における残差ベクトルの2乗
RPS	R	弾性方程式における残差ベクトルの2乗

ここで、たとえば

$$T1=1.0 \quad C1=3 \quad P1=2 \quad T2=2.0 \quad C2=4 \quad P2=2 \quad (1)$$

とした場合、計算は次のように行い、プリントは○の場合に行う。

1 ② ③ 5 ⑦ 9 ⑪ (day)

なお、各時間間隔の計算の最終回は必ずプリントする。

また、RRH, RRS については、 1.0×10^{-12} にすれば 1.0×10^{-6} 程度の計算誤差に納まることを示す。通常 1.0×10^{-12} 程度でよい。

また、表中の型 (I or R) はそれぞれ (整数 or 実数) を意味する。

② タイトルカード

タイトルを記入する。

③ P A T 1 カード

記 号	型	説	明
N	I	パターン総数 (≤ 5)	
I	I	パターン番号 (≤ 5)	
k	R	熱伝導係数 ($\text{kcal}/\text{m} \cdot \text{day} \cdot \text{deg}$)	
ρ	R	単位体積重量 (t/m^3)	
C	R	比熱 ($\text{kcal}/\text{t} \cdot \text{deg}$)	
α_L	R	線膨張率 ($1/\text{deg}$)	
Q_1, Q_2	R	発熱量の係数 ($\text{kcal}/\text{m}^3 \cdot \text{day}$)	
m_Q	R	発熱量の指数 ($1/\text{day}$)	
ν	R	ボアソン比	
E_1, E_2	R	弾性係数の係数 (t/m^2)	
m_E	R	弾性係数の指数 ($1/\text{day}$)	

発熱量、弾性係数は次式で表わされる。

$$\begin{aligned} Q(t) &= Q_1 + Q_2 \exp(-m_Q t) \\ E(t) &= E_1 + E_2 \exp(-m_E t) \end{aligned} \quad (2)$$

パターン数は 5 まで可能であるが、弾性係数が変化するものは 2 以下に限る。従って $E_2 = 0$ のパターン数は 3 を越えてはならない。

④ P A T 2 カード

記 号	型	説	明
N	I	パターン総数 (≤ 5)	
I	I	パターン番号 (≤ 5)	
α	R	外部熱伝導係数 ($\text{kcal}/\text{m}^2 \cdot \text{day} \cdot \text{deg}$)	

外部熱伝導係数を入力しない時も $N=0$ として P A T 2 カードだけは入力する必要がある。

⑤ NODEカード

記 号	型	説 明
N	I	節点総数 (≤ 500)
I	I	節点番号 (≤ 1000)
x	R	節点の x 座標 (m)
y	R	節点の y 座標 (m)
ϕ	R	節点の初期温度 ($^{\circ}\text{C}$)
I_1	I	節点温度のパターン番号 (TEMP参照)
I_2	I	節点で接する流体の温度のパターン番号 (TMPO参照)
IX	I	節点の x 方向支持条件 { 固定 1 自由 b
IY	I	節点の y 方向支持条件 { 固定 1 自由 b

節点番号は空番があったり、順序がバラバラでもよいが、1000より小さい値とする。節点の初期温度は節点温度パターンが与えられている場合は無記入でもよい。

⑥ LMNTカード

記 号	型	説 明
N	I	要素総数 (≤ 1000)
I	I	要素番号 (≤ 1500)
i, j, k	I	要素の節点番号
$\sigma_{x0}, \sigma_{y0}, \sigma_{z0}, \tau_{xy0}$	R	要素の初期応力 (t/m^2)
$I1$	I	要素の物性値のパターン (PAT1参照)
$\alpha_1, \alpha_2, \alpha_3$	I	辺 $\overline{ij}$, $\overline{jk}$, $\overline{ki}$ の外部熱伝導係数のパターン番号 (PAT2参照)
q_1, q_2, q_3	I	辺 $\overline{ij}$, $\overline{jk}$, $\overline{ki}$ の熱流入量のパターン番号 (FLXQ参照)

要素番号は空番があってもよく、順序がバラバラでもよいが、1500より小さい番号とする。要素の節点番号は反時計回りに読み込む。

⑦ TEMPカード

記 号	型	説 明
N	I	パターン総数(≤5)
I	I	パターン番号(≤5)
ϕ_1, ϕ_2	R	節点温度の係数(°C)
T	R	節点温度の周期(day)
θ	R	節点温度の位相(rad)

節点温度は次式で表わされる。

$$\phi(t) = \phi_1 + \phi_2 \cos\left(\frac{2\pi t}{T} + \theta\right) \quad (3)$$

また $\phi_2 = 0.0$ の時は, T, θ は 0.0 または無記入とする。節点温度パターンを入力しない時も, $N = 0$ としてTEMPカードだけは入力する必要がある。

⑧ TMPOカード

記 号	型	説 明
N	I	パターン総数(≤5)
I	I	パターン番号(≤5)
ϕ_{01}, ϕ_{02}	R	節点で接する流体の温度の係数(°C)
T	R	節点で接する流体の温度の周期(day)
θ	R	節点で接する流体の温度の位相(rad)

節点で接する流体の温度(節点外部温度)は次式で表わされる。

$$\phi_0(t) = \phi_{01} + \phi_{02} \cos\left(\frac{2\pi t}{T} + \theta\right) \quad (4)$$

また $\phi_{02} = 0.0$ の時は, T, θ は 0.0 または無記入とする。節点外部温度のパターンを入力しない時も, $N = 0$ としてTMPOカードだけは入力する必要がある。

⑨ FLXQカード

記 号	型	説 明
N	I	パターン総数(≤5)
I	I	パターン番号(≤5)
q_1, q_2	R	熱流入量の係数(kcal/m·day)
T	R	熱流入量の周期(day)
θ	R	熱流入量の位相(rad)
m_q	R	熱流入量の指数(1/day)

節点流入量は次式で表わされる。

$$q(t) = q_1 \cos\left(\frac{2\pi t}{T} + \theta\right) + q_2 \exp(-m_q t) \quad (5)$$

熱流入量のパターンを入力しない時も、 $N = 0$ としてFLXQカードだけは入力する必要がある。

⑩ GOカード

これは計算実行指定カードで、このカードを入力すれば計算を実行し、入力しなければデータチェックのみを行う。

3.3. 出力データの見方

出力データ例を図3-2に示す。

- ① 入力データのベタリスト
- ② 計算を行う時刻(TIME)と回数(CALC. COUNT)の出力
- ③ 熱伝導解析結果の出力

NODE NO.	節点番号
TEMP	節点温度(°C)
FLOW	等価節点流入熱量(kcal/day)
RADQ	等価節点放散熱量(kcal/day)
GENQ	等価節点発熱量(kcal/day)
FLUX(X) FLUX(Y)	節点での熱の流れのx, y成分(kcal/m ² ·day)
LMNT NO.	要素番号
X, Y	要素内の熱の流れのx, y成分(kcal/m ² ·day)

④ 応力解析結果の出力

NODE NO.	節点番号
LMNT NO.	要素番号
DX, DY	節点変位のx, y成分(m)
R-X, R-Y	節点反力のx, y成分(t)
S(X), S(Y) S(Z), T(XY)	節点要素} 応力 $\sigma_x, \sigma_y, \sigma_z, \tau_{xy}$ (t/m ²)
E(X), E(Y) E(Z), E(XY)	節点要素} ひずみ $\epsilon_x, \epsilon_y, \epsilon_z, \gamma_{xy}$

⑤ 系の面積(TOTAL AREA)の出力

3.4. エラーメッセージ

入力ミスがある場合、次のエラーメッセージが伝えられる。

エラー 番 号	エ ラ ー メ ッ セ ー ジ	説 明
1	*ERROR... INPUT DATA NOTHING	入力データがない
2	*ERROR... INPUT DATA INCOMPLETE	入力データが不完全
3	*ERROR... NO. OF PAT1 DATA INVALID	PAT1 のパターン数が1～5以外
4	*ERROR... INVALID PAT1 PATTERN NO.	PAT1 のパターン番号が1～5以外
5	*ERROR... DUPLICATE PAT1 PATTERN NO.	PAT1 のパターン番号に重複あり
6	*ERROR... NO. OF PAT2 DATA INVALID	PAT2 のパターン数が0～5以外
7	*ERROR... NO. OF TIME-DEPENDENT YOUNG CONST. GE. 3	時間依存の弾性係数が3つ以上
8	*ERROR... INVALID PAT2 PATTERN NO.	PAT2 のパターン番号が1～5以外
9	*ERROR... DUPLICATE PAT2 PATTERN NO.	PAT2 のパターン番号に重複あり
10	*ERROR... NO. OF NODE INVALID	節点数が3～500以外
11	*ERROR... INVALID NODE NO.	節点番号が1～1000以外
12	*ERROR... DUPLICATE NODE NO.	節点番号に重複あり
13	*ERROR... NO. OF ELEMENT INVALID	要素数が1～1000以外
14	*ERROR... INVALID ELEMENT NO.	要素番号が1～1500以外
15	*ERROR... DUPLICATE ELEMENT NO.	要素番号に重複あり
16	*ERROR... INVALID NODE NO. IN ELEMENT CARD	要素を構成する節点番号が1～1000以外
17	*ERROR... INVALID PAT1 NO. IN ELEMENT CARD	要素のPAT1 のパターン番号に誤りあり
18	*ERROR... INVALID PAT2 NO. IN ELEMENT CARD	要素のPAT2 のパターン番号に誤りあり
19	*ERROR... INVALID HEAT-FLUX PAT NO. IN ELEMENT CARD	要素のFLXQ のパターン番号に誤りあり
20	*ERROR... NO. OF NODE-TEMP DATA INVALID	TEMP のパターン数が0～5以外
21	*ERROR... INVALID NODE-TEMP PAT. NO.	TEMP のパターン番号が1～5以外

エラー 番号	エ ラ ー メ ッ セ ー ジ	説 明
22	*ERROR... DUPLICATE NODE-TEMP PAT. NO.	TEMP のパターン番号に重複あり
23	*ERROR... SECOND TERM OF GIVEN FUNCTION INVALID	$\phi_1 + \phi_2 \cos(\frac{2\pi t}{T} + \theta)$ において $\phi_2 = 0$ の時 $T \neq 0$
24	*ERROR... NO. OF BOUNDARY-TEMP DATA INVALID	TMPO のパターン数が0～5以外
25	*ERROR... INVALID BOUNDARY-TEMP PAT. NO.	TMPO のパターン番号が1～5以外
26	*ERROR... DUPLICATE BOUNDARY-TEMP PAT. NO.	TMPO のパターン番号に重複あり
27	*ERROR... SECOND TERM OF GIVEN FUNCTION INVALID	$\phi_{01} + \phi_{02} \cos(\frac{2\pi t}{T} + \theta)$ において $\phi_{02} = 0$ の時 $T \neq 0$
28	*ERROR... NO. OF HEAT-FLUX DATA INVALID	FLXQ のパターン数が0～5以外
29	*ERROR... INVALID HEAT-FLUX PAT. NO.	FLXQ のパターン番号が1～5以外
30	*ERROR... DUPLICATE HEAT-FLUX PAT. NO.	FLXQ のパターン番号に重複あり
31	*ERROR... SECOND TERM OF GIVEN FUNCTION INVALID	$q_1 \cos(\frac{2\pi t}{T} + \theta) + q_2 e^{-mt}$ において $q_1 = 0$ の時 $T \neq 0$
32	*ERROR... INVALID GO CARD	GOカードが正しく指定されていない
33	*ERROR... NODE IN ELEMENT DATA NOT COUNTER- CLOCKWISE. ELEMENT NO. = ××××	要素を構成する節点の読込が反時計回りでない。 要素番号××××をチェック
34	*ERROR... INVALID TEMP. PAT. NO. IN NODE DATA. NODE NO. = ××××	節点データ中で指定されているTEMP パターンデータが入力されていない。 節点番号××××をチェック
35	*ERROR... INVALID BOUNDARY-TEMP. PAT. NO. IN NODE DATA. NODE NO. = ×××××	節点データ中で指定されているTMPO パターンデータが入力されていない。 節点番号×××××をチェック
36	*ERROR... INVALID SUSTAIN CONDITION IN NODE DATA. NODE NO. = ××××	節点データ中で境界支持条件が正しく指定されていない。節点番号×××× をチェック
37	*ERROR... INVALID NODE NO. IN ELEMENT DATA. ELEMENT NO. = ××××	要素を構成する節点に定義されていない番号がある。 要素番号×××××をチェック
38	*ERROR... INVALID HEAT FLUX PAT. NO. IN ELEMENT DATA. ELEMENT NO. = ××××	要素辺上で指定されているFLXQ パターンが定義されていない。要素番号 ×××××をチェック

エラー 番 号	エ ラ ー メ ッ セ ー ジ	説 明
39	*ERROR... NO. OF CONNECTED ELEMENT MORE THAN 8. NODE NO. = ××××	節点番号××××を共有する要素が8を超える
40	*ERROR... ISOLATED NODE. NODE NO. = ××××	節点番号××××は孤独節点である
41	*ERROR... BOUNDARY TEMP. PAT. NO. IS GIVEN. ELEMENT NO. = ×××× NODE NO. = ××××	要素辺上でPAT 2パターンが指定されているのにその両端の節点でTMPO パターンが与えられていない。要素番号××××と節点番号××××をチェ ック
42	*ERROR... NOT CONVERGED IN SUBROUTINE CGHOH	熱伝導計算でCG法が収束しない。
43	*ERROR... (P, A*P) IS ZERO IN SUBROUTINE CGHOH	熱伝導計算で修正係数(P, A*P) = 0
44	*ERROR... NOT CONVERGED IN SUBROUTINE CGHOD	温度応力計算でCG法が収束しない。
45	*ERROR... (P, A*P) IS ZERO IN SUBROUTINE CGHOD	温度応力計算で修正係数(P, A*P) = 0
46	*ERROR... INITIAL DERIVATIVE(TEMP.) IS NOT SOLVED	熱伝導計算で温度の初期微係数が求まらない。

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PROBLEM

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PAGE 1 OF 2

[illegible]

図 3-1. 入力データ

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PROBLEM_

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PAGE 2 OF 2

[illegible]

图 3-2. 出力例

***** INPUT DATA LIST *****

	1	2	3	4	5	6	7	8
0	0	0	0	0	0	0	0	0

CGNT	1	0.5	6	1	0.5	14	2	1.0E-12
PROGRAM CHECK TEST DATA NO.3								
PAT1	1	100.0	1.0	1000.0	1.0E-5	0.0	0.0	0.0000100
	1	0.0	0.2	100000.0	0.0	0.0	0.0	0.0000200
PAT2	1	0.000	0.000	10.0	1	1	1	0.0000300
NODE	99	0.500	0.000	10.0	1	1	1	0.0000400
	1	0.0	0.0	10.0	1	1	1	0.0000500
	2	0.483	0.129	10.0	1	1	1	0.0000600
	3							0.0000700
	97	2.000	3.464		1			0.0000800
	98	1.035	3.864		1			0.0000900
	99	0.000	4.000		1	1		0.0001000
LMNT	174	1	2	3		1		0.0010400
	1	1	3	4		1		0.0010500
	2	1	3	4		1		0.0010600
	172	85	98	92		1		0.0010700
	173	98	99	92		1		0.0010800
	174	99	86	92		1		0.0010900
TEMP	1	0.0	0.0					0.0027900
	1							0.0028000
TMPC	1							0.0028100
FLXC	1							0.0028200
GO	1							0.0028300
	1							0.0028400
	1							0.0028500
	1							0.0028600

0	0	0	0	0	0	0	0	0

***** PROGRAM CHECK TEST DATA NO.3

***** PAGE 1

TIME 0.5 (DAY)
CALC. COUNT 1

HEAT CONDUCTION

1 NODE

TEMP TEMPERATURE (DEGREE CENTIGRADE)
FLCW HEAT FLOW (KCAL/DAY)
RADQ HEAT RADIATION (KCAL/DAY)
GENG HEAT GENERATION (KCAL/DAY)
FLUX HEAT FLUX AVERAGED ON ELEMENT (KCAL/M**2/DAY)

NODE NO.	TEMP	FLCW	RADQ	GENG	FLUX(X)	FLUX(Y)
(1)	1.0000E+01	0.0	0.0	0.0	1.5788D-06	1.5788E-06
(2)	1.0000E+01	0.0	0.0	0.0	-2.8168D-06	4.8147D-06
(3)	1.0000E+01	0.0	0.0	0.0	-2.2014D-06	-8.7317E-08

(98) 0.0	-1.5733D+C3	0.0	0.0	4.2850D+02	1.5986D+C3
(99) 0.0	-7.8675D+C2	0.0	0.0	2.3827D+02	1.6554D+C3

2 ELEMENT HEAT FLUX (KCAL/M**2/DAY)

LMNT NO.	X	Y	LMNT NO.	X	Y	LMNT NO.	X	Y	LMNT NO.	X	Y
(1) 2.6896D-C6	-1.07C2C-06		(2) 1.4416D-06	3.6024D-06		(3) 4.4947D-06	-1.6854D-06		(4) -1.6854D-06	4.4947D-C6	
(5) 3.6024D-C6	1.4416D-06		(6) -1.0702D-06	2.6896D-06		(7) -1.7877D-06	-1.66C2D-06		(8) -9.3524D-06	1.7174D-05	
(9) -1.4756D-C5	3.0524D-C6		(10) -3.1321D-06	-1.2979D-05		(11) -3.1275D-06	1.7143D-C6		(12) -6.2921D-06	9.9078D-C6	
(13) -1.1865D-C5	-1.5174D-C5		(14) 7.3170D-C7	-2.54C4D-C5		(15) 7.7779D-C7	-4.5088D-06		(16) -2.1316D-05	1.2782D-05	

***** PROGRAM CHECK TEST DATA NO.3

***** PAGE 5

TIME 0.5 (DAY)
CALC. CCLNT 1

THERMAL STRESS

CX,CY..... DISPLACEMENT (M)
S(X)..... NORMAL STRESS (TON/M**2)
S(Y)..... NORMAL STRESS (TON/M**2)
S(Z)..... NORMAL STRESS (TON/M**2)
T(XY)..... SHEARING STRESS (TON/M**2)
E(X)..... NORMAL STRAIN (NONE)
E(Y)..... NORMAL STRAIN (NONE)
E(Z)..... NORMAL STRAIN (NONE)
E(XY)..... SHEARING STRAIN (NONE)
R-X..... X-DIRECTIONAL REACTION (TON)
R-Y..... Y-DIRECTIONAL REACTION (TON)

1 NODE

NODE NO.	DX	DY	R-X	R-Y	NODE NO.	DX	DY	R-X	R-Y
(1) 0.0	0.0		-1.1650D-01	-1.1650D-01	(2) -1.6776D-C6	0.0	0.0	0.0	-2.3300D-01
(3) -1.62C5D-C6	-4.3282D-C7	0.0	0.0	0.0	(4) -1.4528D-06	-8.3379D-C7	0.0	0.0	0.0
(5) -1.1877D-C6	-1.1877D-C6	0.0	0.0	0.0	(6) -8.3879D-07	-1.4528D-06	0.0	0.0	0.0

NODE NO.	S(X)	S(Y)	S(Z)	T(XY)	E(X)	E(Y)	E(Z)	E(XY)
(1) -4.6599D-C1	-4.6599D-C1	-1.8640D-01	-1.12C3D-C6	-3.3552D-C6	-3.3552D-C6	0.0	-2.6881D-11	
(2) -4.6599D-C1	-4.6600D-01	-1.8640D-01	-1.3321D-06	-3.3551D-06	-3.3552D-C6	0.0	-3.1954D-11	
(3) -4.6599D-C1	-4.6600D-01	-1.8640D-01	-2.4390D-C6	-3.3551D-06	-3.3552D-C6	0.0	-5.8536D-11	

2 ELEMENT

LMNT NO.	S(X)	S(Y)	S(Z)	T(XY)	E(X)	E(Y)	E(Z)	E(XY)
(1) -4.6599D-01	-4.6600D-01	-1.8640D-01	-3.1093D-07	-3.3551D-06	-3.3552D-C6	0.0	-7.4623D-12	
(2) -4.6599D-01	-4.6599D-01	-1.8640D-01	-1.2164D-06	-3.3551D-06	-3.3552D-06	0.0	-2.9193D-11	
(3) -4.6599D-01	-4.6599D-01	-1.8640D-01	-1.8328D-C6	-3.3551D-06	-3.3551D-C6	0.0	-4.3988D-11	
(4) -4.6599D-01	-4.6599D-01	-1.8640D-01	-1.8328D-06	-3.3551D-06	-3.3551D-C6	0.0	-4.3988D-11	
(5) -4.6599D-01	-4.6599D-01	-1.8640D-01	-1.2164D-06	-3.3552D-06	-3.3551D-C6	0.0	-2.9193D-11	
(6) -4.6600D-01	-4.6599D-01	-1.8640D-01	-3.1093D-07	-3.3552D-06	-3.3551D-C6	0.0	-7.4623D-12	

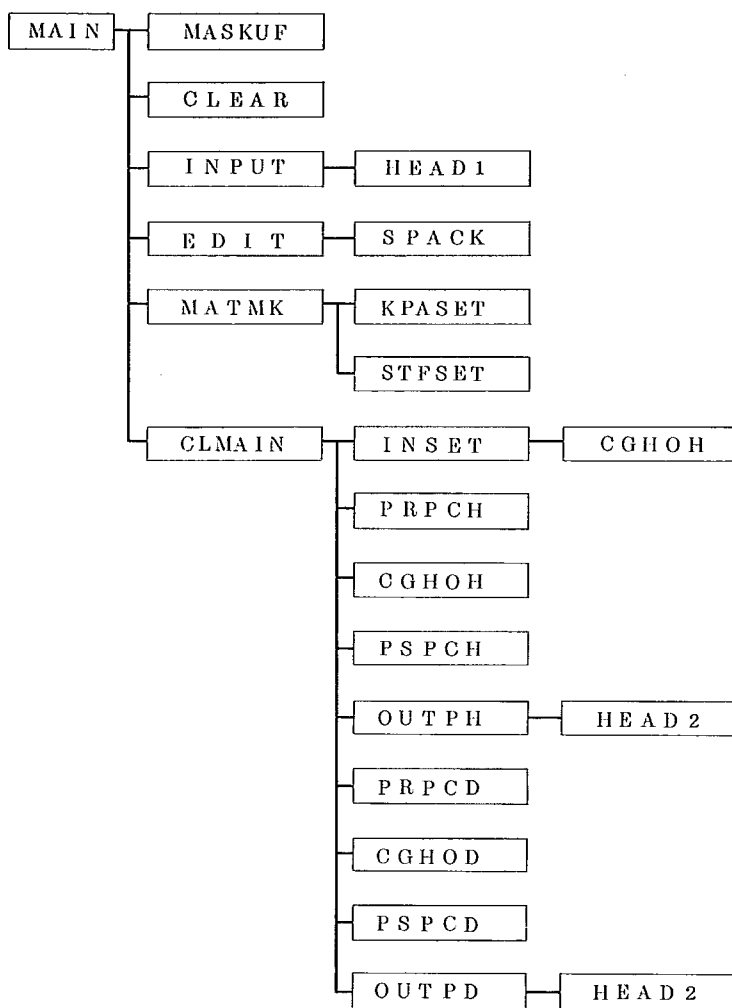
4. プログラムの構成

4.1. 概 説

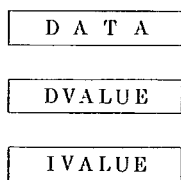
プログラムリストは紙面の都合で省略する。必要であればダム構造研究室に問合わせられたい。
本章ではプログラムの構成とプログラム内の変数について説明する。

4.2. プログラムの構成

プログラムのフローチャートを図 4 - 1 に、各サブルーチンの内容を表 4 - 1 に示す。また、プログラム内の変数の説明を表 4 - 2 に示す。



(*) ユーティリティサブルーチン



(*) チェックプリントサブルーチン

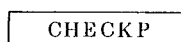


図 4 - 1. フローチャート

表 4-1. サブルーチンの説明

サブルーチン名	パラメータ	説 明
MASKUF	無	浮動小数点演算中に起こるアンダーフローインタラプションを生じさせないようにする。
CLEAR	無	コモン変数を全てゼロクリアする。
INPUT	無	入力データの読込とプリント，対応する変数の値をセット。
EDIT	無	節点・要素がもつ情報のチェックと編集。要素の剛性マトリックスのセット。
MATMK	無	要素の各マトリックスから系全体のマトリックスを作成。
CLMAIN	無	熱伝導計算および応力計算をコントロール。
INSET	無	各種係数とベクトルの初期値設定。熱放散量・熱流入量・反力を計算する節点テーブル作成。
PRPCH	無	熱伝導計算に必要な各種係数・ベクトル等を δt 進めた時点で計算する。
PRPCD	無	応力計算に必要な剛性マトリックス・熱膨張による等価節点力を計算する。
CGHOH	有	未知数である温度をCG法により求める。
CGHOD	有	未知数である変位をCG法により求める。
PSPCH	無	熱伝導計算において求められた新時刻の温度を用いて温度の時間微分・要素上の平均温度を求める。
PSPCD	無	応力計算において求められた変位を用いて要素毎に歪・応力を計算し節点毎にも平均歪応力を計算する。
OUTPH	無	熱伝導計算に関する出力プリント。
OUTPD	無	応力計算に関する出力プリント。
HEAD 1	無	入力データリストの見出をプリント。
HEAD 2	有	熱伝導・応力計算に関する出力時において見出しをプリント。
SPACK	有	ある節点に結合する節点を番号順に並べ同一数字は1つだけにする。
KPASET	有	要素毎の熱伝導・熱放散・熱拡散マトリックスを圧縮させた形で系のマトリックスに加える。
STFSET	有	要素毎の剛性マトリックスを圧縮させた形で系の行列に加える。
DATA	有	ある配列を他の配列に移す。
DVALUE	有	実変数の配列の全要素に実定数をセットする。
IVALUE	有	整数変数の配列の全要素に整数定数をセットする。
CHECKP	無	変数の内容を出力するチェックルーチン。

表 4 - 2. 変数の説明

変 数 名	スカラー or アレイ	用 途
NSSC	スカラー	応力計算コントロール (1:する 0:しない)
NPSS	"	応力ひずみ状態 (1:平面ひずみ 2:平面応力)
NCLS	"	計算コントロール (1:する 0:しない)
DLT1	"	計算時間刻み $\delta t 1$
DLT2	"	" $\delta t 2$
N1CL	"	$\delta t 1$ の刻みで計算する回数
N2CL	"	$\delta t 2$ "
N1PR	"	N1CL回の計算中にN1PR回毎に計算結果出力
N2PR	"	N2CL回の計算中にN2PR回毎に計算結果出力
CGHC	"	熱伝導計算時の収束判定係数
CGSC	"	熱応力 " "
TIME	"	計算開始からの時間
NITT	"	" 計算回数
NIT1	"	$\delta t 1$ の刻みでの計算回数
NIT2	"	$\delta t 2$ "
DLTN	"	計算時点の δt
TITL	10	タイトル
IERR	スカラー	エラーを示す (0:なし 1:あり)
LCNT	"	出力ラインのカウンタ
IPGE	"	出力ページカウンタ
NNDU	"	節点数
NDNO	500	i 番目に入力した節点のもつ節点番号
NDNS	1000	節点番号 j は何番目に入力した節点か

変 数 名	スカラー or アレイ	用 途
XCDN	500	i 番目の節点の x 座標
YCDN	"	" y 座標
TINT	"	" 初期温度
QINT	"	" 初期熱流入量
NPTS	"	" 温度変化パターン番号
NPTP	"	" 境界外部の温度変化パターン番号
NBDC	1000	i 番目の節点の支持条件 $\begin{pmatrix} 0: \text{自由} \\ 1: \text{固定} \end{pmatrix}$ x 方向 $\sim 2i-1$ y 方向 $\sim 2i$
NDOF	スカラー	$2 \times \text{NNDU}$
NPEN	500	i 番目の節点を持つ要素数
NPEL	8×500	" 要素の順番号
NPNN	500	" につながる節点数
NPND	9×500	" につながる節点の順番号 (自身もふくむ)
NELU	スカラー	要素数
NELO	1000	i 番目に入力した要素のもつ要素番号
NELS	1500	要素番号 j は何番目に入力した要素か
NNME	3×1000	i 番目の要素は何番目の節点で構成されるか
SINT	4×1000	i 番目の要素の初期応力 $\sigma_{x0}, \sigma_{y0}, \sigma_{z0}, \tau_{xy0}$
NPTE	1000	" 物性値パターン番号
NPEM	3×1000	i 番目の要素の ij, jk, ki 辺のもつ外部熱伝導係数パターン番号
NPEI	"	" " 熱流入量パターン番号
NPT1	スカラー	物性値の入力パターン数
NP1C	5	パターン番号 i は $\begin{pmatrix} \text{与えられている: } 1 \\ \text{与えられていない: } 0 \end{pmatrix}$
NP1E	"	パターン番号 i の弾性係数は $\begin{pmatrix} \text{時間変化する: } 1 \text{ or } 2 \\ \text{時間変化しない: } 0 \end{pmatrix}$
DCFT	"	パターン番号 i の熱伝導係数

変 数 名	スカラー or アレイ	用 途
DENC	5	パターン番号 i の密度
SPHT	"	" 比熱
CLEP	"	" 線膨張率
CPSN	"	" ボアン比
QEX1	"	$\left. \begin{array}{l} \text{パターン番号 } i \text{ の発熱量} \\ QEX1_i + QEX2_i * \\ \exp(-CEXP_i * TIME) \end{array} \right\}$
QEX2	"	
CEXP	"	
ENG1	"	$\left. \begin{array}{l} \text{パターン番号 } i \text{ の弾性係数} \\ ENG1_i + ENG2_i * \\ \exp(-CENG_i * TIME) \end{array} \right\}$
ENG2	"	
CENG	"	
NPT2	スカラー	外部熱伝導係数の入力パターン数
NP2C	5	パターン番号 i は $\left(\begin{array}{l} \text{与えられている: 1} \\ \text{与えられていない: 0} \end{array} \right)$
CEMT	6	" の外部熱伝導係数
NPT5	スカラー	熱流入量の入力パターン数
NP5C	5	パターン番号 i は $\left(\begin{array}{l} \text{与えられている: 1} \\ \text{与えられていない: 0} \end{array} \right)$
EIN1	"	$\left. \begin{array}{l} \text{パターン番号 } i \text{ の熱流入量} \\ EIN1_i * \cos\left(2\pi \frac{TIME}{EPRQ_i} + EPHS_i\right) \\ + EIN2_i * \\ \exp(-CEIN_i * TIME) \end{array} \right\}$
EIN2	"	
EPRQ	"	
EPHS	"	
CEIM	"	
NPT3	スカラー	節点温度の入力パターン数
NP3C	5	パターン番号 i は $\left(\begin{array}{l} \text{与えられている: 1} \\ \text{与えられていない: 0} \end{array} \right)$

変数名	スカラー or アレイ	用 途
TES1	5	$\left. \begin{array}{l} \text{パターン番号 } i \text{ の節点温度} \\ \text{TES1}_i + \text{TES2}_i * \\ \cos \left(2\pi \frac{\text{TIME}}{\text{TPRS}_i} + \text{TPHS}_i \right) \end{array} \right\}$
TES2	"	
TPRS	"	
TPHS	"	
NPT4	スカラー	節点の境界外部の温度の人力パターン数
NP4C	5	パターン番号 i は (与えられている: 1 与えられていない: 0)
TE1P	"	$\left. \begin{array}{l} \text{パターン番号 } i \text{ の節点の境界外部の温度} \\ \text{TE1P}_i + \text{TE2P}_i * \\ \cos \left(2\pi \frac{\text{TIME}}{\text{TPRP}_i} + \text{TPHP}_i \right) \end{array} \right\}$
TE2P	"	
TPRP	"	
TPHP	"	
DMAT	9×500	熱伝導マトリックス [K]
PMAT	"	熱拡散 " [P]

変 数 名	スカラー or アレイ	用 途
AMAT	9×500	外部熱伝導マトリックス〔A〕
QEXL	5×500	パターン番号 i の正規化等価節点発熱量〔Q〕
QINL	〃	パターン番号 i の正規化等価節点流入量〔q〕
HMAT	9×500	〔A〕〔X〕=〔b〕のA
BVEC	500	〔A〕〔X〕=〔b〕のb
TNNW	〃	節点温度〔 ϕ 〕 $_t$
TNLD	〃	〃 〔 ϕ 〕 $_t - \delta t$
GRTM	〃	$\frac{2}{\delta t} [\phi] + [\frac{\partial \phi}{\partial t}]$
TPTR	〃	節点の境界外部の温度〔 ϕ_0 〕 $_t$
QTFX	〃	温度固定点での熱流入量
NQIN	スカラー	熱流入量を計算する節点数
NQIP	500	〃 節点順番号
QIVL	〃	節点での熱流入量
NDFN	スカラー	熱放散量を計算する節点数
NDFP	500	〃 節点順番号
QDFV	〃	節点での熱放散量
FLND	2×500	節点での平均的熱の流れ
FLFL	2×1000	要素での熱の流れ
QEXN	5	パターン別の時刻 t での発熱量
ENMN	〃	〃 弾性係数
TEMN	〃	〃 節点温度
TEON	〃	〃 節点の境界外部の温度
FLXQ	〃	〃 熱流入量
ENMP	〃	パターン別時刻 $t - \delta t$ での弾性係数

変 数 名	スカラー or アレイ	用 途
DNRM	3×3×5	要素の剛性マトリックス/E
ELMC	7×1000	ひずみ変位行列
STFE	18×1000×2	正規化剛性マトリックス(時間変化部分)
STFX	18×1000	時間的変化しない剛性マトリックス
STFM	"	剛性マトリックス
FVEC	1000	[A][X]=[b]のb
DPLC	"	節点の変位
TENW	"	要素の平均温度(新)
TELD	"	" (旧)
STRS	4×1000	要素の応力 σ_x σ_y σ_z τ_{xy} (累積)
STRN	"	" ひずみ ϵ_x ϵ_y ϵ_z γ_{xy} (累積)
NRFN	スカラー	反力計算をする節点数
NRFP	500	" 節点順番号
RFCV	2×500	節点での反力 R_x , R_y (累積)
SSND	4×500	" 平均応力(累積)
SRND	"	節点での平均ひずみ(累積)
SSWK	"	" 応力計算の為のワーク
SRWK	"	" ひずみ計算の為のワーク
DXDY	1000	節点での累積変化

5. 有限要素法の合理的使用法—主として熱伝導に関して—

5.1. 解析上の仮定と要素分割法

有限要素法による解析は、次の2つの大きな仮定を設けている。

- ① 要素内の温度分布を1次式で仮定している。

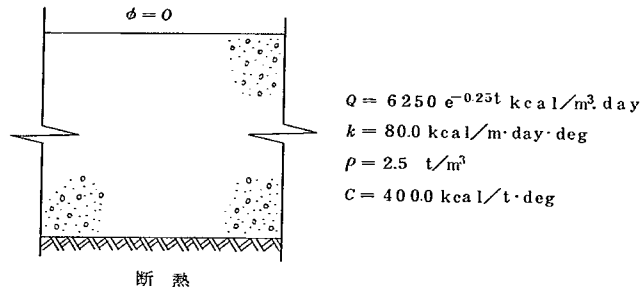


図 5 - 1. 解析モデル

- ② 要素間の熱の伝導は節点を通じてのみ行

われる。

まず①について、要素分割を行う場合には、予想される温度分布を推定して、温度分布の場所的变化の著しい部分は細かく分割を行う必要がある（これは要素内の温度分布が1次式で仮定されるためである。）。従って、要素分割を細かくすればするほど精度は向上することになるが、要素数が多くなれば必然的に計算費用は増大するから、精度・費用のかねあいから適切な要素分割が存在することになる。たとえば、図5-1に示すようなモデルに対して、図5-2（左）のような要素分割を行った場合の結果を図5-3から5および表5-1に示す。比較のため、理論値とカールソンの方法による結果を併記するが、実用上十分な精度が得られている。

次に②について。これは一般に見落されがちなので注意を要する。いま、図5-6（a）のモデルを考える。この場合節点1・4および節点2、3の関係は同等でない。すなわち、節点2、3間はその間の温度勾配に比例して熱が流れるのに対

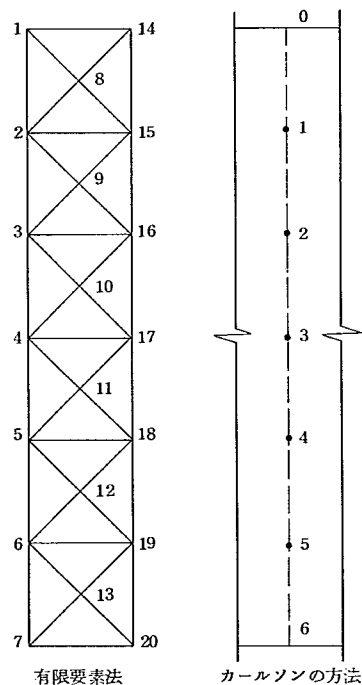


図 5 - 2. 解析モデル

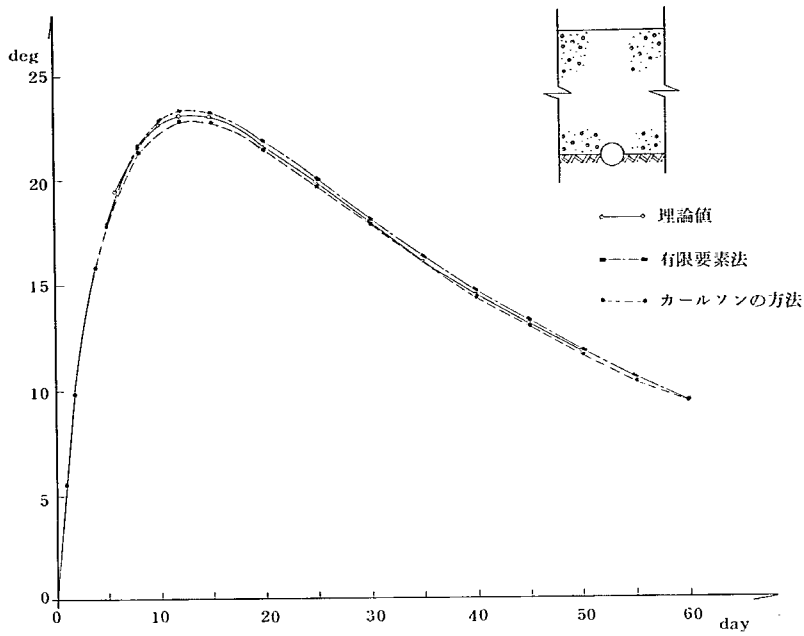


図 5 - 3. 有限要素法の精度の検討

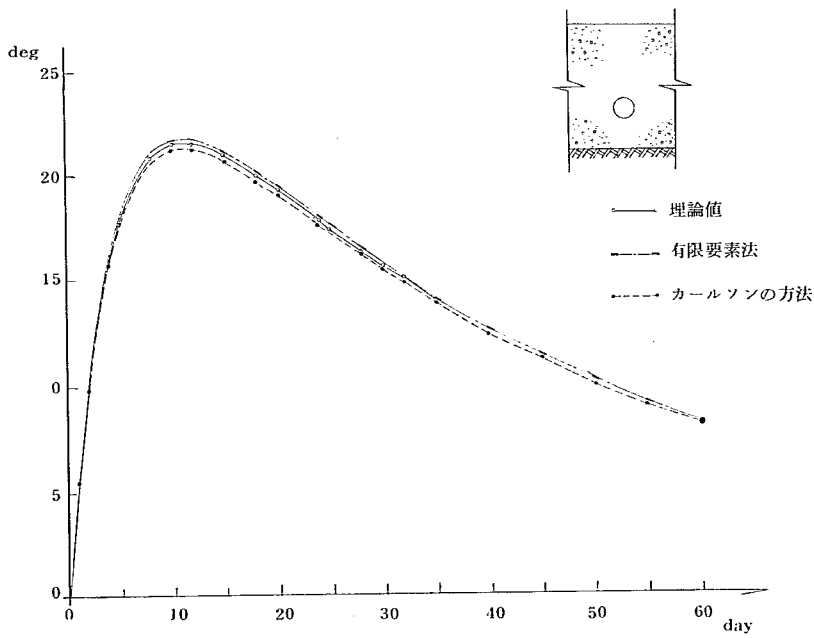


図 5 - 4. 有限要素法の精度の検討

表 5 - 1. 解析結果の比較

理論解

m \ 日	5	10	15	20	25	30	35	40	45	50	55	60
0	17.83	22.63	22.97	21.66	19.84	17.95	16.15	14.49	13.00	11.65	10.44	9.36
1.5	17.14	19.48	18.08	16.16	14.39	12.84	11.48	10.27	9.20	8.24	7.39	6.62

カールソンの方法による解

m \ 日	5	10	15	20	25	30	35	40	45	50	55	60
0	17.75	22.47	22.67	21.36	19.64	17.76	16.00	14.36	12.89	11.55	10.37	9.30
1.5	16.94	19.28	17.91	16.00	14.25	12.71	11.37	10.19	9.12	8.18	7.34	6.57

有限要素法による解

m \ 日	5	10	15	20	25	30	35	40	45	50	55	60
0	17.89	22.78	23.15	21.83	20.01	18.09	16.26	14.59	13.07	11.71	10.49	9.39
1.5	17.32	19.63	18.19	16.25	14.47	12.91	11.54	10.33	9.25	8.28	7.42	6.64

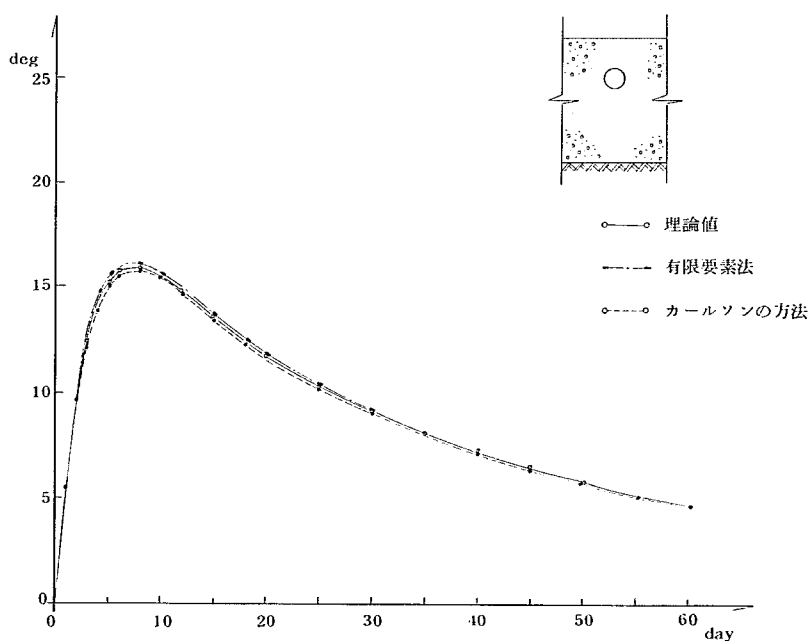


図 5 - 5. 有限要素法の精度の比較

し、節点1, 4間は節点2, 3を通して熱が流れる。そこで図5-1のモデルに対して、図5-6(b)のモデルを考えるのは誤りである。すなわち、たとえば節点5, 6を比較した場合、節点5は節点7から熱を受け節点3, 4に熱を与えるのに対し、節点6は節点7, 8から熱を受け節点4に熱を与えることになる。従って、節点5, 6の温度は等しくならない。正しくは図5-6(c)のモデルが必要である。しかし、図5-6(d)のように何層にもすれば、端部を除いて十分な精度(対称性)が得られる。

次に、節点における熱の流れを考えよう。この場合、図5-6(c)のモデルでも、節点1~10は正しい熱の流れを示さない。これは図5-6(c)を取出した場合、熱の流れは同図(c)に示すようになり、従って要素の平均で表わされる節点での熱の流れは中央の節点でしか正しい方向を示さない。しかし、図5-6(f)のように何層にもすれば端部を除いて十分な精度(対称性)が得られる。

以上のことを考えると、要素の基本単位としては図5-6(g)を考えた方が間違いが少なく、熱の流れは同図中央の節点の値を用いるのがよい。

5.2. 計算の時間間隔について

非定常計算を行う場合、計算の時間間隔 δt は短かければ短かいほど精度はよくなる。しかし、経済性から考えると時間間隔は長い方が望ましい。従って、実用上の最適な時間間隔の目安を知っておく必要があるが、十分な精度を得るためには次の条件が必要である。

$$\delta t \ll \min \left\{ \frac{\rho C L^2}{k}, \frac{\rho C L}{\alpha}, \frac{1}{m_E}, \frac{1}{m_F}, \frac{1}{m_Q}, \frac{1}{m_q}, \frac{T}{2\pi} \right\} \quad (1)$$

ここに、

L : 3角形要素の代表的長さ

ρ : 密度

C : 比熱

k : 熱伝導係数

α : 外部熱伝導係数

m_E, m_Q, m_q, T : 弾性係数・発熱量・流入熱量・節点温度・節点外部温度の指数・周期(第3章参照)

である。《としては1/10 ~ 1/5 程度を考えておけば十分である。

5.3. 計算費用の見積り

熱伝導・温度応力の解析を行う場合、IBM社に計算作業を依頼することになるが、次式によっておおよその費用を見積ることができる。

① CPU使用時間(sec)

$$T_{CPU} \doteq N_C \{ 6.98 \times 10^{-5} N_N^2 + 1.02 \times 10^{-2} N_N \} + 1.75 \quad (2)$$

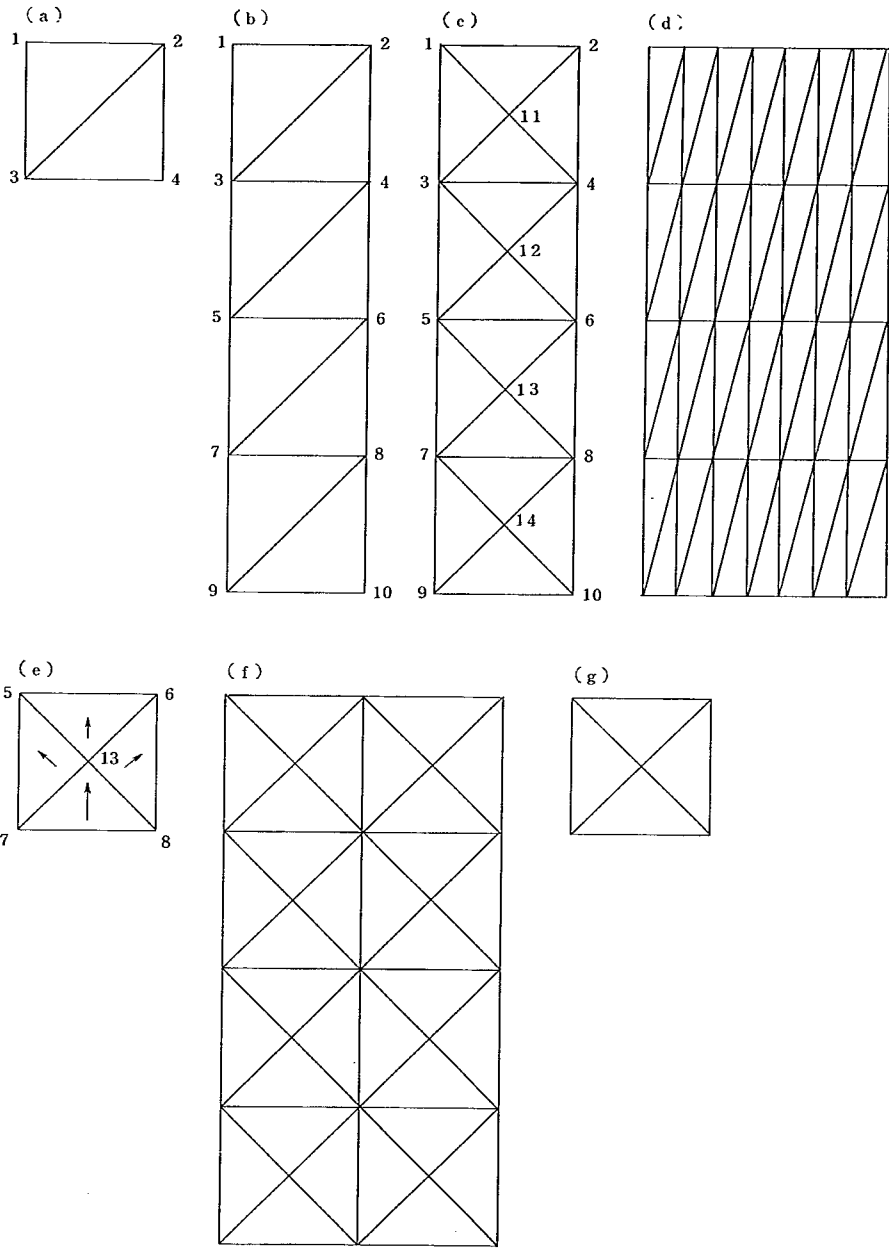


图 5 - 6. 要素分割

② 出力ライン数 (sec)

$$L \div N_P \left\{ \frac{5}{2} N_N + \frac{5}{4} N_E + 35 \right\} \quad (3)$$

③ CHANNEL 使用時間 (sec)

$$T_{CHA} \div \frac{1}{100} T_{CPU} \quad (4)$$

ここに,

N_C : 計算回数

N_P : プリント回数

N_N : 節点数

N_E : 要素数

である。従って, 計算機使用料は次式で与えられる。

$$C = (a + b) T_{CPU} + C T_{CHA} + (d + e) L \quad (5)$$

ここに,

a : CPU使用料の単価

b : 記憶装置使用料の単価

c : CHANNEL使用料の単価

d : 印刷料の単価

e : フォーム料の単価

である。

000000		1	MASKUF	START
	00000	2	USING	*,15
000000 54E0 F008	00008	3	N	14,FD
000004 04E0		4	SPM	14
000006 07FE		5	BR	14
000008		6	FD	DS 0E
000008 F0FFFFFF		7	DC	X'F0FFFFFF'
		8	END	

00000100
00000200
00000300
00000400
00000500
00000600
00000700
00000800

	C.....	NON-STEADY ISOTROPIC HEAT CONDUCTION	00000100
	C.....		00000200
	C.....	AND ITS THERMAL STRESS ANALYSIS PROGRAM.	00000300
	C.....		00000400
ISN 0002		IMPLICIT REAL*8(A-H,O-Z) , INTEGER*4(I-N)	00000500
ISN 0003		COMMON /CONT1/NSSC,NPSS,N1CL,N2CL,N1PR,N2PR,IERR,NCLS,LCNT,	00000600
	1	NITT,NIT1,NIT2,IPGE	00000700
	2	/CONT1/DLT1,DLT2,CGHC,CGSC,TITL(10),AREA,DLTN,TIME	00000800
ISN 0004		COMMON /BUSSEI/NPT1,NPT2,NP1C(5),NP2C(5),NP1E(5)	00000900
	1	/BUSSEI/DCET(5),DENC(5),SPHT(5),CLEP(5),QEX1(5),QEX2(5),	00001000
	2	CEXP(5),CPSN(5),ENG1(5),ENG2(5),CENG(5),CEMT(6)	00001100
ISN 0005		COMMON /MODEI /NNDU,NDDF,NDND(500),NDNS(1000),NP1S(500),NP1P(500),	00001200
	1	NBDC(1000),NPEN(500),NP1L(8,500),NP1N(500),	00001300
	2	NP1D(9,500)	00001400
	3	/NODER /XCDN(500),YCDN(500),TINT(500),QINT(500)	00001500
ISN 0006		COMMON /ELMNTI/NELU,NELO(1000),NELS(1500),NNME(3,1000),	00001600
	1	NPTE(1000),NP1M(3,1000),NP1E(3,1000)	00001700
	2	/ELMNTI/SINT(4,1000)	00001800
ISN 0007		COMMON /NDTMTI/NPT3,NP3C(5)	00001900
	1	/NDTMTI/TE1(5),TE2(5),TPRS(5),TPHS(5)	00002000
ISN 0008		COMMON /BDTMTI/NPT4,NP4C(5)	00002100
	1	/BDTMTI/TE1P(5),TE2P(5),TPRP(5),TPHP(5)	00002200
ISN 0009		COMMON /HTFLXI/NP1S,NP5C(5)	00002300
	1	/HTFLXI/EIN1(5),EIN2(5),EPRQ(5),EPHS(5),CEIN(5)	00002400
ISN 0010		COMMON /STRESR/DNRN(3,3,5),ELMC(7,1000),STFE(18,1000,2),	00002500
	1	STFX(18,1000),STFM(18,1000),FVEC(1000),DPLC(1000),	00002600
	2	TENW(1000),TELD(1000),STRS(4,1000),STRN(4,1000)	00002700
ISN 0011		COMMON /HEATR /DMAT(9,500),PMAT(9,500),AMAT(9,500),QEXL(5,500),	00002800
	1	QINL(5,500),HMAT(9,500),BVEC(500),TNNW(500),	00002900
	2	TNLD(500),GRTM(500),TPTR(500),QTFX(500)	00003000
ISN 0012		COMMON /WORKR /PVEC(1000),RVEC(1000),APVC(1000),SSWK(4,500),	00003100
	1	SRWK(4,500),QEXN(5),ENMN(5),FNMP(5),TEMN(5),	00003200
	2	TEON(5),FLXQ(5)	00003300
ISN 0013		COMMON /OUTPTI/NQIN,NQIP(500),NDFN,NDFP(500),NRFN,NRFP(500),	00003400
	1	/OUTPTR/QIVL(500),QDFV(500),RFCV(2,500),FLND(2,500),	00003500
	2	FL1L(2,1000),SSND(4,500),SRND(4,500)	00003600
ISN 0014		COMMON /ADDVAR/DXDY(1000)	00003700
	C.....		00003800
ISN 0015		C..... MASKING UNDERFLOW	00003900
		CALL MASKUF	00004000
	C		00004100
ISN 0016		C..... ZERO SET & CLEAR ALL VARIABLES	00004200
		CALL CLEAR	00004300
	C		00004400
ISN 0017		C..... READ INPUT DATA	00004500
ISN 0018		CALL INPUT	00004600
		IF (IERR.NE.0) GO TO 9000	00004700
	C		00004800
ISN 0020		C..... NODE & ELEMENT CHECK. STRESS-STRAIN MATRIX GENERATION	00004900
		CALL EDIT	00005000
ISN 0021		IF (IERR.NE.0) GO TO 9000	00005100
		CALL CHECKP(1)	00005200
	C		00005300
			00005400

	C.....	TIME-INDEPENDANT PART OF MATRIX	00005200
ISN 0023		CALL MATMK	00005300
ISN 0024		IF (IERR.NE.0) GO TO 9000	00005400
	C	CALL CHECKP(2)	00005410
	C		00005500
	C.....	HEAT & STRESS CALCULATION CONTROL	00005600
ISN 0026		CALL CLMAIN	00005700
	C		00005800
ISN 0027		NW = 6	00005810
ISN 0028		WRITE(NW,6000) AREA	00005820
ISN 0029	6000	FORMAT(*1 *** TOTAL AREA (M**2) = *,1PD11.5)	00005830
	C		00005840
	C		00005850
ISN 0030	9000	STOP	00005900
ISN 0031		END	00006000

ISN 0002	SUBROUTINE CLEAR		00006100
	C.....		00006200
	C.....	CLEAR ALL VARIABLES	00006300
	C.....		00006400
ISN 0003	IMPLICIT REAL*8(A-H,O-Z), INTEGER*4(I-N)		00006500
ISN 0004	COMMON	/CONTI/11(13)	00006600
	1	/CONTR/R1(17)	00006700
	2	/BUSSEI/12(17)	00006800
	3	/BUSSEI/R2(61)	00006900
	4	/NODEI /13(13002)	00007000
	5	/NODEI /R3(2000)	00007100
	6	/ELMNTI/14(12501)	00007200
	7	/ELMNTI/R4(4000)	00007300
	8	/NOTMPI/15(6)	00007400
	9	/NOTMPI/R5(20)	00007500
	A	/BDTMP/16(6)	00007600
	B	/BDTMP/R6(20)	00007700
	C	/HTFLX/17(6)	00007800
	D	/HTFLX/R7(25)	00007900
	E	/STRESS/R8(91045)	00008000
	F	/HEATR /R9(26000)	00008100
	G	/WORKS /R4(7030)	00008200
	H	/OUTPTI/18(1503)	00008300
	I	/OUTPTR/R8(9000)	00008400
	J	/ADDDVAR/RC(1000)	00008410
	C		00008500
	C		00008600
ISN 0005	CALL	IVALUE(I1, 13, 0)	00008700
ISN 0006	CALL	IVALUE(I2, 17, 0)	00008800
ISN 0007	CALL	IVALUE(I3, 13002, 0)	00008900
ISN 0008	CALL	IVALUE(I4, 12501, 0)	00009000
ISN 0009	CALL	IVALUE(I5, 6, 0)	00009100
ISN 0010	CALL	IVALUE(I6, 6, 0)	00009200
ISN 0011	CALL	IVALUE(I7, 6, 0)	00009300
ISN 0012	CALL	IVALUE(I8, 1503, 0)	00009400
	C		00009500
ISN 0013	CALL	DVALUE(R1, 17, 0.00)	00009600
ISN 0014	CALL	DVALUE(R2, 61, 0.00)	00009700
ISN 0015	CALL	DVALUE(R3, 2000, 0.00)	00009800
ISN 0016	CALL	DVALUE(R4, 4000, 0.00)	00009900
ISN 0017	CALL	DVALUE(R5, 20, 0.00)	00010000
ISN 0018	CALL	DVALUE(R6, 20, 0.00)	00010100
ISN 0019	CALL	DVALUE(R7, 25, 0.00)	00010200
ISN 0020	CALL	DVALUE(R8, 91045, 0.00)	00010300
ISN 0021	CALL	DVALUE(R9, 26000, 0.00)	00010400
ISN 0022	CALL	DVALUE(RA, 7030, 0.00)	00010500
ISN 0023	CALL	DVALUE(RB, 9000, 0.00)	00010600
ISN 0024	CALL	DVALUE(RC, 1000, 0.00)	00010610
	C		00010700
ISN 0025	RETURN		00010800
ISN 0026	END		00010900

ISN 0002	SUBROUTINE DATA(A,B,N)	00011000
	C.....	00011100
	C..... MOVE B(I) INTO A(I) FOR I=1....N	00011200
	C.....	00011300
ISN 0003	REAL*8 A(N),B(N)	00011400
	C	00011500
ISN 0004	DO 100 I = 1 , N	00011600
ISN 0005	A(I) = B(I)	00011700
ISN 0006	100 CONTINUE	00011800
	C	00011900
ISN 0007	RETURN	00012000
ISN 0008	END	00012100

ISN 0002	SUBROUTINE DVALUE(A,N,B)	00012200
	C.....	00012300
	C..... ASSIGN VALUE B INTO A(1)....A(N) (REAL TYPE)	00012400
	C.....	00012500
ISN 0003	REAL*8 A(N),B	00012600
	C	00012700
ISN 0004	DO 100 I = 1 , N	00012800
ISN 0005	A(I) = B	00012900
ISN 0006	100 CONTINUE	00013000
	C	00013100
ISN 0007	RETURN	00013200
ISN 0008	END	00013300

ISN 0002	SUBROUTINE IVALUE(IARY,N,IV)	00013400
	C.....	00013500
	C..... ASSIGN VALUE IV INTO IARY(1).....IARY(N)	00013600
	C.....	00013700
ISN 0003	INTEGER*4 IARY(N),IV	00013800
	C	00013900
ISN 0004	DO 100 I = 1 , N	00014000
ISN 0005	IARY(I) = IV	00014100
ISN 0006	100 CONTINUE	00014200
	C	00014300
ISN 0007	RETURN	00014400
ISN 0008	END	00014500

ISN 0002	SUBROUTINE INPUT	00000100
C.....		00000200
C.....	INPUT DATA READ & PRINT	00000300
C.....		00000400
ISN 0003	IMPLICIT REAL*8(A-H,O-Z) , INTEGER*4(I-N)	00000500
ISN 0004	COMMON /CONTL/NSSC,NPSS,NICL,N2CL,N1PR,N2PR,TERR,NCLC,LCNT,	00000600
1	NITT,NIT1,NIT2,TPGE	00000700
2	/CONTLR/DLT1,DLT2,CGHC,CGSC,TITL(10),AREA,DLTN,TIME	00000800
ISN 0005	COMMON /BUSSET/NPT1,NPT2,NPIC(5),NP2C(5),NP1E(5)	00000900
1	/BUSSET/DCET(5),DENC(5),SPHT(5),CLEP(5),QEX1(5),QEX2(5),	00001000
2	CEXP(5),CPSN(5),ENG1(5),ENG2(5),CENG(5),CEMT(6)	00001100
ISN 0006	COMMON /NODEI /NNOU,NDOE,NDOO(500),NDNS(1000),NPTS(500),NPTP(500),	00001200
1	NADC(1000),NPEN(500),NPEL(8,500),NPNH(500),	00001300
2	NPNQ(9,500)	00001400
3	/NODER /XCDN(500),YCDN(500),TINT(500),QINT(500)	00001500
ISN 0007	COMMON /ELMNTJ/NELU,NELO(1000),NELS(1500),NNME(3,1000),	00001600
1	NPTE(1000),NPEM(3,1000),NPEI(3,1000)	00001700
2	/ELMNTJ/SINT(4,1000)	00001800
ISN 0008	COMMON /NDTMPI/NPT3,NP3C(5)	00001900
1	/NDTMPI/TES1(5),TES2(5),TPRS(5),TPHS(5)	00002000
ISN 0009	COMMON /BDTMPI/NPT4,NP4C(5)	00002100
1	/BDTMPI/TE1P(5),TE2P(5),TPRP(5),TPHP(5)	00002200
ISN 0010	COMMON /HTFLXI/NPTS,NP5C(5)	00002300
1	/HTFLXI/EIN1(5),EIN2(5),EPRQ(5),EPHS(5),CEIN(5)	00002400
ISN 0011	COMMON /STRESR/DNRM(3,3,5),ELMC(7,1000),STFE(18,1000,2),	00002500
1	STFX(18,1000),STFM(18,1000),FVEC(1000),DPLC(1000),	00002600
2	TENW(1000),TELO(1000),STRS(4,1000),STRN(4,1000)	00002700
ISN 0012	COMMON /HEATR /HMAT(9,500),PMAT(9,500),AMAT(9,500),QEXL(5,500),	00002800
1	QINL(5,500),HMAT(9,500),BVEC(500),TNNW(500),	00002900
2	TNLO(500),GRTH(500),TPTR(500),QTFX(500)	00003000
ISN 0013	COMMON /WORKR /PVEC(1000),RVEC(1000),APVC(1000),SSWK(4,500),	00003100
1	SRWK(4,500),QFXN(5),ENMN(5),ENMP(5),TEMN(5),	00003200
2	TEON(5),FLXQ(5)	00003300
ISN 0014	COMMON /OUTPTI/NGIN,NQIP(500),NDEN,NDEP(500),NREN,NREP(500)	00003400
1	/OUTPTR/QIVL(500),QDFV(500),RFCV(2,500),FLND(2,500),	00003500
2	FLEL(2,1000),SSND(4,500),SRND(4,500)	00003600
ISN 0015	DIMENSION CARD(10),WK(6),IA(3),IQ(3),II(3)	00003700
ISN 0016	REAL*4 XGO,GOGO	00003800
ISN 0017	DATA GOGO/*GO */	00003900
C		00004000
ISN 0018	NR = 5	00004100
ISN 0019	NW = 6	00004200
ISN 0020	WRITE(NW,6010)	00004300
ISN 0021	WRITE(NW,6020) (I, I = 1, 8)	00004400
ISN 0022	J = 0	00004410
ISN 0023	WRITE(NW,6020) (J, J = 1, 8)	00004420
ISN 0024	WRITE(NW,6030)	00004430
C		00004500
C.....	CONT & TITLE CARD	00004600
C		00004700
ISN 0025	READ(NR,5010,END=9010) NSSC , NPSS , DLT1 , NICL , N1PR , DLT2 ,	00004800
1	N2CL , N2PR , CGHC , CGSC , CARD	00004900
ISN 0026	CALL HEAD1	00004910

ISN 0027	WRITE(NW,6040) CARD	00005000
ISN 0028	READ(NR,5020,END=9020) (TITL(I),I = 1 ,9) , CARD	00005100
ISN 0029	WRITE(NW,6040) CARD	00005200
C		00005300
C.....	PATTERN-1 CARD	00005400
C		00005500
ISN 0030	READ(NR,5030,END=9020) NPT1 , CARD	00005600
ISN 0031	CALL HEAD1	00005610
ISN 0032	WRITE(NW,6040) CARD	00005700
ISN 0033	IF (NPT1.GE.1.AND.NPT1.LE.5) GO TO 100	00005800
ISN 0035	WRITE(NW,6070)	00005900
ISN 0036	IERR = 1	00006000
ISN 0037	GO TO 8000	00006100
ISN 0038	100 CONTINUE	00006200
ISN 0039	K = 0	00006300
ISN 0040	DO 200 I = 1 , NPT1	00006400
ISN 0041	READ(NR,5040,END=9020) IPI , WK , CARD	00006500
ISN 0042	CALL HEAD1	00006510
ISN 0043	WRITE(NW,6040) CARD	00006600
ISN 0044	IF (IPI.GE.1.AND.IPI.LE.5) GO TO 110	00006700
ISN 0046	WRITE(NW,6080)	00006800
ISN 0047	IERR = 1	00006900
ISN 0048	GO TO 8000	00007000
ISN 0049	110 CONTINUE	00007100
ISN 0050	IF (NPIC(IPI).EQ.0) GO TO 120	00007200
ISN 0052	WRITE(NW,6090)	00007300
ISN 0053	IERR = 1	00007400
ISN 0054	GO TO 8000	00007500
ISN 0055	120 CONTINUE	00007600
ISN 0056	NPIC(IPI) = 1	00007700
ISN 0057	DCFT(IPI) = WK(1)	00007800
ISN 0058	DENC(IPI) = WK(2)	00007900
ISN 0059	SPHT(IPI) = WK(3)	00008000
ISN 0060	CLEP(IPI) = WK(4)	00008100
ISN 0061	QEX1(IPI) = WK(5)	00008200
ISN 0062	QEX2(IPI) = WK(6)	00008300
ISN 0063	READ(NR,5050,END=9020) (WK(J) , J = 1 , 5) , CARD	00008400
ISN 0064	CALL HEAD1	00008410
ISN 0065	WRITE(NW,6040) CARD	00008500
ISN 0066	CEXP(IPI) = WK(1)	00008600
ISN 0067	CPSN(IPI) = WK(2)	00008700
ISN 0068	ENG1(IPI) = WK(3)	00008800
ISN 0069	ENG2(IPI) = WK(4)	00008900
ISN 0070	CENG(IPI) = WK(5)	00009000
ISN 0071	IF (ENG2(IPI).EQ.0) GO TO 200	00009100
ISN 0073	K = K + 1	00009200
ISN 0074	NPIC(IPI) = K	00009300
ISN 0075	IF (NPIC(IPI).LE.2) GO TO 200	00009400
ISN 0077	WRITE(NW,6110)	00009500
ISN 0078	IERR = 1	00009600
ISN 0079	GO TO 8000	00009700
ISN 0080	200 CONTINUE	00009800
C		00009900
C.....	PATTERN-2 CARD	00010000
C		00010100
ISN 0081	READ(NR,5060,END=9020) NPT2 , CARD	00010200
ISN 0082	CALL HEAD1	00010210
ISN 0083	WRITE(NW,6040) CARD	00010300

ISM 0084		IF (NPT2.EQ.0)	GO TO 450	00010310
ISM 0086		IF (NPT2.GE.1.AND.NPT2.LE.5)	GO TO 300	00010400
ISM 0088		WRITE(NW,6100)		00010500
ISM 0089		IERR = 1		00010600
ISM 0090		GO TO 8000		00010700
ISM 0091	300	CONTINUE		00010800
ISM 0092		DO 400 I = 1, NPT2		00010900
ISM 0093		READ(NR,5070,END=9020) IPI, WK(1), CARD		00011000
ISM 0094		CALL HEAD1		00011010
ISM 0095		WRITE(NW,6040) CARD		00011100
ISM 0096		IF (IPI.GE.1.AND.IPI.LE.5)	GO TO 310	00011200
ISM 0098		WRITE(NW,6120)		00011300
ISM 0099		IERR = 1		00011400
ISM 0100		GO TO 8000		00011500
ISM 0101	310	CONTINUE		00011600
ISM 0102		IF (NP2C(IPI).EQ.0)	GO TO 320	00011700
ISM 0104		WRITE(NW,6130)		00011800
ISM 0105		IERR = 1		00011900
ISM 0106		GO TO 8000		00012000
ISM 0107	320	CONTINUE		00012100
ISM 0108		NP2C(IPI) = 1		00012200
ISM 0109		CEMT(IPI) = WK(1)		00012300
ISM 0110		400 CONTINUE		00012400
	C			00012500
	C.....	NODE CARD		00012600
	C			00012700
ISM 0111	450	CONTINUE		00012710
ISM 0112		READ(NR,5030,END=9020) NNDU, CARD		00012800
ISM 0113		CALL HEAD1		00012810
ISM 0114		WRITE(NW,6040) CARD		00012900
ISM 0115		IF (NNDU.GE.3.AND.NNDU.LE.500)	GO TO 500	00013000
ISM 0117		WRITE(NW,6140)		00013100
ISM 0118		IERR = 1		00013200
ISM 0119		GO TO 8000		00013300
ISM 0120	500	CONTINUE		00013400
ISM 0121		NDOF = NNDU*2		00013500
ISM 0122		DO 600 I = 1, NNDU		00013600
ISM 0123		READ(NR,5080,END=9020) INI, (WK(J), J=1, 4),		00013700
	1	IT, ITO, IX, IY, CARD		00013800
ISM 0124		CALL HEAD1		00013900
ISM 0125		WRITE(NW,6040) CARD		00014000
ISM 0126		IF (INI.GE.1.AND.INI.LE.1000)	GO TO 510	00014100
ISM 0128		WRITE(NW,6150)		00014200
ISM 0129		IERR = 1		00014300
ISM 0130		GO TO 8000		00014400
ISM 0131	510	CONTINUE		00014500
ISM 0132		NDNO(IJ) = INI		00014600
ISM 0133		IF (NDNS(INI).NE.0)	GO TO 520	00014700
ISM 0135		NDNS(INI) = 1		00014800
ISM 0136		GO TO 530		00014900
ISM 0137	520	CONTINUE		00015000
ISM 0138		WRITE(NW,6160)		00015100
ISM 0139		IERR = 1		00015200
ISM 0140		GO TO 8000		00015300
ISM 0141	530	CONTINUE		00015400
ISM 0142		XCON(I) = WK(1)		00015500
ISM 0143		YCON(I) = WK(2)		00015600
ISM 0144		TINT(I) = WK(3)		00015700

ISN 0145	QINT(I) = WK(4)	00015800
ISN 0146	NPTS(I) = IT	00015900
ISN 0147	NPTP(I) = ITO	00016000
ISN 0148	K = 2*I - 1	00016100
ISN 0149	L = 2*I	00016200
ISN 0150	NBDC(K) = IX	00016300
ISN 0151	NBDC(L) = IY	00016400
ISN 0152	600 CONTINUE	00016500
	C	00016600
	C..... ELEMENT CARD	00016700
	C	00016800
ISN 0153	READ(INR,5030,END=9020) NELU , CARD	00016900
ISN 0154	CALL HEAD1	00017000
ISN 0155	WRITE(NW,6040) CARD	00017100
ISN 0156	IF (NELU.GE.1.AND.NELU.LE.1000) GO TO 700	00017200
ISN 0158	WRITE(NW,6170)	00017300
ISN 0159	IERR = 1	00017400
ISN 0160	GO TO 8000	00017500
ISN 0161	700 CONTINUE	00017600
ISN 0162	DO 800 I = 1 , NELU	00017700
ISN 0163	READ(INR,5090) ILI , (II(J) , J = 1 , 3) , (WK(K) , K = 1 , 4) ,	00017800
	1 IPI , IA , IQ , CARD	00017900
		00018000
ISN 0164	CALL HEAD1	00018100
ISN 0165	WRITE(NW,6040) CARD	00018200
ISN 0166	IF (ILI.GE.1.AND.ILI.LE.1500) GO TO 710	00018300
ISN 0168	WRITE(NW,6180)	00018400
ISN 0169	IERR = 1	00018500
ISN 0170	GO TO 8000	00018600
ISN 0171	710 CONTINUE	00018700
ISN 0172	IF (NELS(ILI).EQ.0) GO TO 715	00018800
ISN 0174	WRITE(NW,6240)	00018900
ISN 0175	IERR = 1	00019000
ISN 0176	GO TO 8000	00019100
ISN 0177	715 CONTINUE	00019200
ISN 0178	NEL0(I) = ILI	00019300
ISN 0179	NELS(ILI) = I	00019400
ISN 0180	DO 720 J = 1 , 3	00019500
ISN 0181	IF (II(J).GE.1.AND.II(J).LE.1000) GO TO 717	00019600
ISN 0183	WRITE(NW,6190)	00019700
ISN 0184	IERR = 1	00019800
ISN 0185	GO TO 8000	00019900
ISN 0186	717 CONTINUE	00020000
ISN 0187	NWME(I,I) = II(J)	00020100
ISN 0188	CONTINUE	00020200
ISN 0189	IF (NPIC(IPI).NE.0) GO TO 725	00020300
ISN 0191	WRITE(NW,6200)	00020400
ISN 0192	IERR = 1	00020500
ISN 0193	GO TO 8000	00020600
ISN 0194	725 CONTINUE	00020700
ISN 0195	NPTE(I) = IPI	00020800
ISN 0196	730 CONTINUE	00020900
ISN 0197	DO 740 J = 1 , 3	00021000
ISN 0198	K = IA(J)	00021100
ISN 0199	IF (K.EQ.0) GO TO 740	00021200
ISN 0201	IF (K.GE.1.AND.K.LE.5) GO TO 733	00021300
ISN 0203	WRITE(NW,6210)	00021400
ISN 0204	IERR = 1	00021500
ISN 0205	GO TO 8000	

ISN 0206	733	CONTINUE		00021600
ISN 0207		IF (NP2C(K).NE.0)	GO TO 735	00021700
ISN 0209		WRITE(NW,6210)		00021800
ISN 0210		IERR = 1		00021900
ISN 0211		GO TO 8000		00022000
ISN 0212	735	CONTINUE		00022100
ISN 0213		NP2M(J,I) = K		00022200
ISN 0214	740	CONTINUE		00022300
ISN 0215		DO 750 J = 1, 3		00022400
ISN 0216		K = IQ(J)		00022500
ISN 0217		IF (K.EQ.0)	GO TO 750	00022600
ISN 0219		IF (K.GE.1.AND.K.LE.5)	GO TO 745	00022700
ISN 0221		WRITE(NW,6220)		00022800
ISN 0222		IERR = 1		00022900
ISN 0223		GO TO 8000		00023000
ISN 0224	745	CONTINUE		00023100
ISN 0225		NP2I(J,I) = K		00023200
ISN 0226	750	CONTINUE		00023300
ISN 0227		DO 760 J = 1, 4		00023400
ISN 0228		SINT(J,I) = WK(J)		00023500
ISN 0229	760	CONTINUE		00023600
ISN 0230	800	CONTINUE		00023700
	C			00023800
	C.....	NODE TEMPERATURE CARD		00023900
	C			00024000
ISN 0231		READ(NR,5030,END=9020) NPT3, CARD		00024100
ISN 0232		CALL HEAD1		00024200
ISN 0233		WRITE(NW,6040) CARD		00024300
ISN 0234		IF (NPT3.EQ.0)	GO TO 905	00024310
ISN 0236		IF (NPT3.GE.1.AND.NPT3.LE.5)	GO TO 810	00024400
ISN 0238		WRITE(NW,6230)		00024500
ISN 0239		IERR = 1		00024600
ISN 0240		GO TO 8000		00024700
ISN 0241	810	CONTINUE		00024800
ISN 0242		DO 900 I = 1, NPT3		00024900
ISN 0243		READ(NR,5100,END=9020) IPI, (WK(J), J = 1, 4), CARD		00025000
ISN 0244		CALL HEAD1		00025100
ISN 0245		WRITE(NW,6040) CARD		00025200
ISN 0246		IF (IPI.GE.1.AND.IPI.LE.5)	GO TO 820	00025300
ISN 0248		WRITE(NW,6250)		00025400
ISN 0249		IERR = 1		00025500
ISN 0250		GO TO 8000		00025600
ISN 0251	820	CONTINUE		00025700
ISN 0252		IF (NP3C(IPI).EQ.0)	GO TO 830	00025800
ISN 0254		WRITE(NW,6260)		00025900
ISN 0255		IERR = 1		00026000
ISN 0256		GO TO 8000		00026100
ISN 0257	830	NP3C(IPI) = 1		00026200
ISN 0258		TES1(IPI) = WK(1)		00026300
ISN 0259		TES2(IPI) = WK(2)		00026400
ISN 0260		TPRS(IPI) = WK(3)		00026500
ISN 0261		TPHS(IPI) = WK(4)		00026600
ISN 0262		IF (TES2(IPI).NE.0.00)	GO TO 900	00026602
ISN 0264		IF (TPRS(IPI).EQ.0.00)	GO TO 840	00026604
ISN 0266		WRITE(NW,6265)		00026606
ISN 0267	840	CONTINUE		00026612
ISN 0268		TPRS(IPI) = 1.00		00026614
ISN 0269	900	CONTINUE		00026700

	C		00026800
	C.....	BOUNDARY TEMPERATURE CARD	00026900
	C		00027000
ISN 0270	905	CONTINUE	00027010
ISN 0271		READ(NR,5030,END=9020) NPT4 , CARD	00027100
ISN 0272		CALL HEAD1	00027200
ISN 0273		WRITE(NW,6040) CARD	00027300
ISN 0274		IF (NPT4.EQ.0) GO TO 1005	00027310
ISN 0276		IF (NPT4.GE.1.AND.NPT4.LE.5) GO TO 910	00027400
ISN 0278		WRITE(NW,6270)	00027500
ISN 0279		IERR = 1	00027600
ISN 0280		GO TO 8000	00027700
ISN 0281	910	CONTINUE	00027800
ISN 0282		DO 1000 I = 1 , NPT4	00027900
ISN 0283		READ(NR,5100,END=9020) IPI , (WK(J) , J = 1 , 4) , CARD	00028000
ISN 0284		WRITE(NW,6040) CARD	00028100
ISN 0285		CALL HEAD1	00028200
ISN 0286		IF (IPI.GE.1.AND.IPI.LE.5) GO TO 920	00028300
ISN 0288		WRITE(NW,6280)	00028400
ISN 0289		IERR = 1	00028500
ISN 0290		GO TO 8000	00028600
ISN 0291	920	CONTINUE	00028700
ISN 0292		IF (NP4C(IPI).EQ.0) GO TO 930	00028800
ISN 0294		WRITE(NW,6290)	00028900
ISN 0295		IERR = 1	00029000
ISN 0296		GO TO 8000	00029100
ISN 0297	930	CONTINUE	00029200
ISN 0298		NP4C(IPI) = 1	00029300
ISN 0299		TE1P(IPI) = WK(1)	00029400
ISN 0300		TE2P(IPI) = WK(2)	00029500
ISN 0301		TPRP(IPI) = WK(3)	00029600
ISN 0302		TPHP(IPI) = WK(4)	00029700
ISN 0303		IF (TE2P(IPI).NE.0.00) GO TO 1000	00029702
ISN 0305		IF (TPRP(IPI).EQ.0.00) GO TO 940	00029704
ISN 0307		WRITE(NW,6295)	00029706
ISN 0308	940	CONTINUE	00029712
ISN 0309		TPRP(IPI) = 1.00	00029714
ISN 0310	1000	CONTINUE	00029800
	C		00029900
	C.....	HEAT-FLUX CARD	00030000
	C		00030100
ISN 0311	1005	CONTINUE	00030110
ISN 0312		READ(NR,5030,END=9020) NPT5 , CARD	00030200
ISN 0313		CALL HEAD1	00030300
ISN 0314		WRITE(NW,6040) CARD	00030400
ISN 0315		IF (NPT5.EQ.0) GO TO 1150	00030410
ISN 0317		IF (NPT5.GE.1.AND.NPT5.LE.5) GO TO 1010	00030500
ISN 0319		WRITE(NW,6300)	00030600
ISN 0320		IERR = 1	00030700
ISN 0321		GO TO 8000	00030800
ISN 0322	1010	CONTINUE	00030900
ISN 0323		DO 1100 I = 1 , NPT5	00031000
ISN 0324		READ(NR,5110,END=9020) IPI , (WK(J) , J = 1 , 5) , CARD	00031100
ISN 0325		CALL HEAD1	00031200
ISN 0326		WRITE(NW,6040) CARD	00031300
ISN 0327		IF (IPI.GE.1.AND.IPI.LE.5) GO TO 1020	00031400
ISN 0329		WRITE(NW,6310)	00031500
ISN 0330		IERR = 1	00031600

ISN 0331		GO TO 8000	00031700
ISN 0332	1020	CONTINUE	00031800
ISN 0333		IF (NPSC(IPI).EQ.0) GO TO 1030	00031900
ISN 0335		WRITE(NW,6320)	00032000
ISN 0336		IERR = 1	00032100
ISN 0337		GO TO 8000	00032200
ISN 0338	1030	CONTINUE	00032300
ISN 0339		NPSC(IPI) = 1	00032400
ISN 0340		EIN1(IPI) = WK(1)	00032500
ISN 0341		EIN2(IPI) = WK(2)	00032600
ISN 0342		EPRQ(IPI) = WK(3)	00032700
ISN 0343		EPHS(IPI) = WK(4)	00032800
ISN 0344		CEIN(IPI) = WK(5)	00032900
ISN 0345		IF (EIN1(IPI).NE.0.00) GO TO 1100	00032902
ISN 0347		IF (EPRQ(IPI).EQ.0.00) GO TO 1040	00032904
ISN 0349		WRITE(NW,6325)	00032906
ISN 0350	1040	CONTINUE	00032912
ISN 0351		EPRQ(IPI) = 1.00	00032914
ISN 0352	1100	CONTINUE	00033000
C			00033100
C.....		GO DATA	00033200
C			00033300
ISN 0353	1150	CONTINUE	00033310
ISN 0354		READ(INR,5120,END=1300) XGO , CARD	00033400
ISN 0355		CALL HEAD1	00033500
ISN 0356		WRITE(NW,6040) CARD	00033600
ISN 0357		IF (XGO.EQ.0060) GO TO 1200	00033700
ISN 0359		WRITE(NW,6330)	00033800
ISN 0360		IERR = 1	00033900
ISN 0361		GO TO 8000	00034000
ISN 0362	1200	CONTINUE	00034100
ISN 0363		NCLS = 1	00034200
ISN 0364	1300	CONTINUE	00034300
ISN 0365		WRITE(NW,6030)	00034400
ISN 0366		WRITE(NW,6020) (I, I = 1, 8)	00034600
ISN 0367		I = 0	00034610
ISN 0368		WRITE(NW,6020) (I, J = 1, 8)	00034700
ISN 0369		GO TO 9900	00034800
ISN 0370	8000	CONTINUE	00034900
ISN 0371		READ(INR,5130,END=1300) CARD	00035000
ISN 0372		CALL HEAD1	00035100
ISN 0373		WRITE(NW,6040) CARD	00035200
ISN 0374		GO TO 8000	00035300
ISN 0375	9010	CONTINUE	00035400
ISN 0376		WRITE(NW,6050)	00035500
ISN 0377		IERR = 1	00035600
ISN 0378		GO TO 9900	00035700
ISN 0379	9020	CONTINUE	00035800
ISN 0380		WRITE(NW,6060)	00035900
ISN 0381		IERR = 1	00036000
ISN 0382		GO TO 9900	00036100
C			00036200
C.....		FORMAT	00036300
C			00036400
ISN 0383	5010	FORMAT(5X,2I5,2(F5.0,2I5),5X,2D10.0,T1,10A8)	00036500
ISN 0384	5020	FORMAT(9A8,T1,10A8)	00036600
ISN 0385	5030	FORMAT(5X,I4,T1,10A8)	00036700
ISN 0386	5040	FORMAT(5X,I4,1X,6D10.0,T1,10A8)	00036800

ISN 0387	5050	FORMAT(10X,5D10.0,T1,10A8)	00036900
ISN 0388	5060	FORMAT(5X,I4,T1,10A8)	00037000
ISN 0389	5070	FORMAT(5X,I4,1X,D10.0,T1,10A8)	00037100
ISN 0390	5080	FORMAT(5X,I4,1X,4D10.0,4I2,T1,10A8)	00037200
ISN 0391	5090	FORMAT(5X,I4,1X,3I5,4D8.0,TI2,T1,10A8)	00037300
ISN 0392	5100	FORMAT(5X,I4,1X,4D10.0,T1,10A8)	00037400
ISN 0393	5110	FORMAT(5X,I4,1X,5D10.0,T1,10A8)	00037500
ISN 0394	5120	FORMAT(A4,T1,10A8)	00037600
ISN 0395	5130	FORMAT(10A8)	00037700
ISN 0396	6010	FORMAT('1',25X,' ***** INPUT DATA LIST *****'//)	00037800
ISN 0397	6020	FORMAT(26X,8(9X,I1))	00037900
ISN 0398	6030	FORMAT(24X,'+',16('.....+'))	00038000
ISN 0399	6040	FORMAT(' ',24X,10A8)	00038100
ISN 0400	6050	FORMAT(' *ERROR INPUT DATA NOTHING *')	00038200
ISN 0401	6060	FORMAT(' *ERROR INPUT DATA INCOMPLETE *')	00038300
ISN 0402	6070	FORMAT(' *ERROR NO.OF PAT1 DATA INVALID *')	00038400
ISN 0403	6080	FORMAT(' *ERROR INVALID PAT1 PATTERN NO.*')	00038500
ISN 0404	6090	FORMAT(' *ERROR DUPLICATE PAT1 PATTERN NO.*')	00038600
ISN 0405	6100	FORMAT(' *ERROR NO.OF PAT2 DATA INVALID *')	00038700
ISN 0406	6110	FORMAT(' *ERROR NO.OF TIME-DEPENDENT YOUNG CONST..GT.3*')	00038800
ISN 0407	6120	FORMAT(' *ERROR INVALID PAT2 PATTERN NO.*')	00038900
ISN 0408	6130	FORMAT(' *ERROR DUPLICATE PAT2 PATTERN NO.*')	00039000
ISN 0409	6140	FORMAT(' *ERROR NO.OF NODE INVALID*')	00039100
ISN 0410	6150	FORMAT(' *ERROR INVALID NODE NO. *')	00039200
ISN 0411	6160	FORMAT(' *ERROR DUPLICATE NODE NO. *')	00039300
ISN 0412	6170	FORMAT(' *ERROR NO.OF ELEMENT INVALID*')	00039400
ISN 0413	6180	FORMAT(' *ERROR INVALID ELEMENT NO.*')	00039500
ISN 0414	6190	FORMAT(' *ERROR INVALID NODE NO. IN ELEMENT CARD*')	00039600
ISN 0415	6200	FORMAT(' *ERROR INVALID PAT1 NO. IN ELEMENT CARD*')	00039700
ISN 0416	6210	FORMAT(' *ERROR INVALID PAT2 NO. IN ELEMENT CARD*')	00039800
ISN 0417	6220	FORMAT(' *ERROR INVALID HEAT-FLUX PAT NO. IN ELEMENT CARD*')	00039900
ISN 0418	6230	FORMAT(' *ERROR NO.OF NODE-TEMP DATA INVALID*')	00040000
ISN 0419	6240	FORMAT(' *ERROR DUPLICATE ELEMENT NO.*')	00040100
ISN 0420	6250	FORMAT(' *ERROR INVALID NODE-TEMP PAT. NO.*')	00040200
ISN 0421	6260	FORMAT(' *ERROR DUPLICATE NODE-TEMP PAT. NO.*')	00040300
ISN 0422	6265	FORMAT(' *WARNING SECOND TERM OF GIVEN FUNCTION INVALID*')	00040310
ISN 0423	6270	FORMAT(' *ERROR NO.OF BOUNDARY-TEMP DATA INVALID*')	00040400
ISN 0424	6280	FORMAT(' *ERROR INVALID BOUNDARY-TEMP PAT. NO.*')	00040500
ISN 0425	6290	FORMAT(' *ERROR DUPLICATE BOUNDARY-TEMP PAT. NO.*')	00040600
ISN 0426	6295	FORMAT(' *WARNING SECOND TERM OF GIVEN FUNCTION INVALID*')	00040610
ISN 0427	6300	FORMAT(' *ERROR NO.OF HEAT-FLUX DATA INVALID*')	00040700
ISN 0428	6310	FORMAT(' *ERROR INVALID HEAT-FLUX PAT. NO.*')	00040800
ISN 0429	6320	FORMAT(' *ERROR DUPLICATE HEAT-FLUX PAT. NO.*')	00040900
ISN 0430	6325	FORMAT(' *WARNING SECOND TERM OF GIVEN FUNCTION INVALID*')	00040910
ISN 0431	6330	FORMAT(' *ERROR INVALID GO CARD *')	00041000
	C		00041100
	C		00041200
ISN 0432	9900	CONTINUE	00041300
ISN 0433		RETURN	00041400
ISN 0434		END	00041500

ISN 0002	SUBROUTINE HEAD1		00041600
	C		00041700
	C	 INPUT CARD LIST HEADING	00041800
	C		00041900
ISN 0003		IMPLICIT REAL*8(A-H,O-Z) , INTEGER*4(I-N)	00042000
ISN 0004		COMMON /CONTLI/NSSC,NESS,N1CL,N2CL,N1PR,N2PR,TERR,NCLS,LCNT,	00042100
	1	NITT,NIT1,NIT2,IPGE	00042200
	2	/CONTLR/DLT1,DLT2,CGHC,CGSC,TITL(10),AREA,DLTN,TIME	00042300
	C		00042310
	C		00042320
ISN 0005		NW = 6	00042330
ISN 0006		LCNT = LCNT + 1	00042400
ISN 0007		IF (LCNT.LE.50) GO TO 100	00042500
ISN 0009		WRITE(NW,6030)	00042510
ISN 0010		WRITE(NW,6020) (I , I = 1 , 8)	00042520
ISN 0011		J = 0	00042530
ISN 0012		WRITE(NW,6020) (J , I = 1 , 8)	00042540
ISN 0013		WRITE(NW,6010)	00042600
ISN 0014		WRITE(NW,6020) (I , I = 1 , 8)	00042700
ISN 0015		J = 0	00042800
ISN 0016		WRITE(NW,6020) (J , I = 1 , 8)	00042900
ISN 0017		WRITE(NW,6030)	00043000
ISN 0018		LCNT = 0	00043100
	C		00043200
ISN 0019	6010	FORMAT('1',25X,' ***** INPUT DATA LIST *****//')	00043300
ISN 0020	6020	FORMAT(26X,8(9X,I1))	00043400
ISN 0021	6030	FORMAT(24X,' +',16('.....+'))	00043500
ISN 0022	100	CONTINUE	00043600
ISN 0023		RETURN	00043700
ISN 0024		END	00043800

ISN 0002	SUBROUTINE EDIT		00000100
C.....			00000200
C.....	(1) NODE & ELEMENT INFORMATION CHECK		00000300
C.....	(2) STRESS-STRAIN MATRIX GENERATION		00000400
C.....			00000500
ISN 0003	IMPLICIT REAL*8(A-H,O-Z), INTEGER*4(I-N)		00000600
ISN 0004	COMMON	/CONTL/NSSC,NPSS,NICL,NZCL,NIPR,NZPR,IERR,NCLS,LCNT, NITI,NITI,NIT2,IPGE	00000700
	1		00000800
	2	/CONTLR/OLTI,OLT2,CGHC,CGSC,TITL(10),AREA,OLTN,TIME	00000900
ISN 0005	COMMON	/BUSSEI/NPT1,NPT2,NP1C(5),NP2C(5),NP1E(5)	00001000
	1	/BUSSEI/DCFT(5),DENC(5),SPHT(5),CLEP(5),QEX1(5),QEX2(5),	00001100
	2	CEXP(5),CPSS(5),ENG1(5),ENG2(5),CENG(5),CENT(6)	00001200
ISN 0006	COMMON	/NODEI /NNDU,NDOF,NDNO(500),NDNS(1000),NPTS(500),NPTP(500),	00001300
	1	NBDC(1000),NPEM(500),NPFL(8,500),NPNM(500),	00001400
	2	NPND(9,500)	00001500
	3	/NODER /XCON(500),YCON(500),TINT(500),QINT(500)	00001600
ISN 0007	COMMON	/ELMNTI/NELU,NELD(1000),NELS(1500),NNME(3,1000),	00001700
	1	NPTE(1000),NPEM(3,1000),NPEI(3,1000)	00001800
	2	/ELMNTI/SINT(4,1000)	00001900
ISN 0008	COMMON	/NDTMT/NPT3,NP3C(5)	00002000
	1	/NDTMT/TE1(5),TE2(5),TPRS(5),TPHS(5)	00002100
ISN 0009	COMMON	/BDTMT/NPT4,NP4C(5)	00002200
	1	/BDTMT/TE1P(5),TE2P(5),TPRP(5),TPHP(5)	00002300
ISN 0010	COMMON	/HTFLX/NPTS,NP5C(5)	00002400
	1	/HTFLX/EIN1(5),EIN2(5),EPRQ(5),EPHS(5),CEIN(5)	00002500
ISN 0011	COMMON	/STRESR/DNRM(3,3,5),ELMC(7,1000),STFE(18,1000,2),	00002600
	1	STFX(18,1000),STFM(18,1000),FVEC(1000),DPLC(1000),	00002700
	2	TENW(1000),TELD(1000),STRS(4,1000),STRN(4,1000)	00002800
ISN 0012	COMMON	/HEATR /DMAT(9,500),PMAT(9,500),AMAT(9,500),QEXL(5,500),	00002900
	1	QINL(5,500),HMAT(9,500),BVEC(500),TNNW(500),	00003000
	2	TNLD(500),GRTM(500),TPTR(500),QTFX(500)	00003100
ISN 0013	COMMON	/WORKR /PVEC(1000),RVEC(1000),APVC(1000),SSWK(4,500),	00003200
	1	SRWK(4,500),QEXN(5),ENMN(5),ENMP(5),TEMN(5),	00003300
	2	TEON(5),FLXQ(5)	00003400
ISN 0014	COMMON	/OUTPTI/NQIN,NQIP(500),NDFN,NDFP(500),NRFN,NRFP(500)	00003500
	1	/OUTPIR/QIVL(500),QDEX(500),RECV(2,500),ELND(2,500),	00003600
	2	FLFL(2,1000),SSND(4,500),SRND(4,500)	00003700
ISN 0015	DIMENSION IW(24)		00003800
C			00003810
C			00003820
ISN 0016	NW = 6		00003830
C			00003840
C.....	NODE INFOR. CHECK		00003900
C			00004000
C			00004100
ISN 0017	WRITE(NW,6010)		00004200
ISN 0018	WRITE(NW,6005)		00004210
ISN 0019	DO 100 I = 1, NNDU		00004300
ISN 0020	J = NPTS(I)		00004400
ISN 0021	K = NDNO(I)		00004500
ISN 0022	IF (J.EQ.0)	GO TO 10	00004600
ISN 0023	IF (NP3C(J).NE.0)	GO TO 10	00004700
ISN 0025	WRITE(NW,6020) K		00004800
ISN 0026	IERR = 1		00004900

ISN 0027	10	CONTINUE	00005000
ISN 0028		J = NPTP(I)	00005100
ISN 0029		IF (J.EQ.0) GO TO 20	00005200
ISN 0031		IF (NP4C(J).NE.0) GO TO 20	00005300
ISN 0033		WRITE(NW,6030) K	00005400
ISN 0034		IERR = 1	00005500
ISN 0035	20	CONTINUE	00005600
ISN 0036		IF (NSSC.EQ.0) GO TO 100	00005700
ISN 0038		L = 2*I - 1	00005800
ISN 0039		M = 2*I	00005900
ISN 0040		IF (NBDC(L).EQ.0.OR.NBDC(L).EQ.1) GO TO 30	00006000
ISN 0042		WRITE(NW,6040) K	00006100
ISN 0043		IERR = 1	00006200
ISN 0044	30	CONTINUE	00006300
ISN 0045		IF (NBDC(M).EQ.0.OR.NBDC(M).EQ.1) GO TO 100	00006400
ISN 0047		WRITE(NW,6040) K	00006500
ISN 0048		IERR = 1	00006600
ISN 0049	100	CONTINUE	00006700
ISN 0050		IF (IERR.EQ.1) GO TO 9900	00006800
	C		00006900
	C.....	ELEMENT INEOR CHECK	00007000
	C		00007100
ISN 0052		DO 200 I = 1, NELU	00007200
ISN 0053		K = NELO(I)	00007300
ISN 0054		DO 190 J = 1, 3	00007400
ISN 0055		L = NNME(J,I)	00007500
ISN 0056		M = NDNS(L)	00007600
ISN 0057		IF (M.NE.0) GO TO 110	00007700
ISN 0059		WRITE(NW,6050) K	00007800
ISN 0060		IERR = 1	00007900
ISN 0061		GO TO 120	00008000
ISN 0062	110	CONTINUE	00008100
ISN 0063		NNME(J,I) = M	00008200
ISN 0064	120	CONTINUE	00008300
ISN 0065		L = NPET(J,I)	00008400
ISN 0066		IF (L.EQ.0) GO TO 190	00008410
ISN 0068		IF (NP5C(L).NE.0) GO TO 190	00008500
ISN 0070		WRITE(NW,6060) K	00008600
ISN 0071		IERR = 1	00008700
ISN 0072	190	CONTINUE	00008800
ISN 0073	200	CONTINUE	00008900
ISN 0074		IF (IERR.EQ.1) GO TO 9900	00009000
	C		00009100
	C...	RINSETSU YOSO-KAN NO CHECK	00009200
ISN 0076		DO 300 J = 1, NELU	00009300
ISN 0077		DO 250 I = 1, 3	00009400
ISN 0078		L = NNME(I,J)	00009500
ISN 0079		M = NPEN(L) + 1	00009600
ISN 0080		IF (M.LE.8) GO TO 210	00009700
ISN 0082		WRITE(NW,6070) L	00009800
ISN 0083		IERR = 1	00009900
ISN 0084		GO TO 250	00010000
ISN 0085	210	CONTINUE	00010100
ISN 0086		NPEN(L) = M	00010200
ISN 0087		NPEN(M,I) = J	00010300
ISN 0088	250	CONTINUE	00010400
ISN 0089	300	CONTINUE	00010500
ISN 0090		IF (IERR.EQ.1) GO TO 9900	00010600

ISN 0092	DO 400 I = 1, NNDU	00010700
ISN 0093	IF (NPEN(I).NE.0)	00010800
ISN 0095	J = NDNO(I)	00010900
ISN 0096	WRITE(NW,6080) J	00011000
ISN 0097	IERR = 1	00011100
ISN 0098	400 CONTINUE	00011200
ISN 0099	IF (IERR.EQ.1)	00011300
	GO TO 9900	
	C	00011400
	C... RINSETSU NODE-KAN NO CHECK	00011500
ISN 0101	DO 700 J = 1, NNDU	00011600
ISN 0102	NN = NPEN(J)	00011700
ISN 0103	NE = 0	00011800
ISN 0104	DO 600 I = 1, NN	00011900
ISN 0105	IE = NPEL(I,J)	00012000
ISN 0106	DO 500 K = 1, 3	00012100
ISN 0107	IN = NNME(K,IE)	00012200
ISN 0108	NE = NE + 1	00012300
ISN 0109	IW(NE) = IN	00012400
ISN 0110	500 CONTINUE	00012500
ISN 0111	600 CONTINUE	00012600
ISN 0112	CALL SPACK(IW,NE,NEND(1,J),N)	00012700
ISN 0113	NPNN(J) = N	00012800
ISN 0114	700 CONTINUE	00012900
	C	00013000
	C..... BOUNDARY TEMP.)---- RADIATIVE COEFFICIENT CHECK	00013100
	C	00013200
ISN 0115	IF (NPT4.EQ.0)	00013210
	GO TO 760	
ISN 0117	DO 750 J = 1, NELU	00013300
ISN 0118	DO 740 I = 1, 3	00013400
ISN 0119	IF (NPEM(I,J).EQ.0)	00013500
	GO TO 740	
ISN 0121	K1 = I	00013600
ISN 0122	K2 = I + 1	00013700
ISN 0123	IF (K2.GT.3)	00013800
	K2 = 1	
ISN 0125	N1 = NNME(K1,J)	00013900
ISN 0126	N2 = NNME(K2,J)	00014000
	C	00014100
ISN 0127	NP = NPTP(N1)	00014200
ISN 0128	IF (NP.NE.0)	00014300
	GO TO 710	
ISN 0130	WRITE(NW,6090) NELO(J), NDNO(N1)	00014400
ISN 0131	IERR = 1	00014500
ISN 0132	710 CONTINUE	00014600
ISN 0133	NP = NPTP(N2)	00014700
ISN 0134	IF (NP.NE.0)	00014800
	GO TO 740	
ISN 0136	WRITE(NW,6090) NELO(J), NDNO(N2)	00014900
ISN 0137	IERR = 1	00015000
ISN 0138	740 CONTINUE	00015100
ISN 0139	750 CONTINUE	00015200
ISN 0140	IF (IERR.NE.0)	00015300
	GO TO 9900	
ISN 0142	760 CONTINUE	00015310
	C	00015400
	C..... STRESS-STRAIN MATRIX	00015500
	C	00015600
ISN 0143	IF (INSSC.EQ.0)	00015700
	GO TO 9900	
ISN 0145	IF (NPSS.EQ.1)	00015800
	GO TO 850	
	C	00015900
	C... PLANE-STRESS	00016000
ISN 0147	DO 800 I = 1, 5	00016100
ISN 0148	IF (NPIC(I).EQ.0)	00016200
	GO TO 800	

ISN 0150	CM = CPSN(I)	00016300
ISN 0151	W1 = 1.00/(1.00 - CM*CM)	00016400
ISN 0152	W2 = W1*CM	00016500
ISN 0153	W3 = 0.500/(1.00 + CM)	00016600
ISN 0154	DNRM(1,1,I) = W1	00016700
ISN 0155	DNRM(1,2,I) = W2	00016800
ISN 0156	DNRM(2,1,I) = W2	00016900
ISN 0157	DNRM(2,2,I) = W1	00017000
ISN 0158	DNRM(3,3,I) = W3	00017100
ISN 0159	800 CONTINUE	00017200
ISN 0160	GO TO 9900	00017300
	C	00017400
	C... PLANE-STRAIN	00017500
ISN 0161	850 CONTINUE	00017600
ISN 0162	DO 900 I = 1, 5	00017700
ISN 0163	IF (NPIC(I).EQ.0) GO TO 900	00017800
ISN 0165	CM = CPSN(I)	00017900
ISN 0166	WW1 = 1.00 + CM	00018000
ISN 0167	WW2 = 1.00 - CM	00018100
ISN 0168	WW3 = WW2 - CM	00018200
ISN 0169	W1 = WW2/(WW1*WW3)	00018300
ISN 0170	W2 = CM/(WW1*WW3)	00018400
ISN 0171	W3 = 0.500/WW1	00018500
ISN 0172	DNRM(1,1,I) = W1	00018600
ISN 0173	DNRM(1,2,I) = W2	00018700
ISN 0174	DNRM(2,1,I) = W2	00018800
ISN 0175	DNRM(2,2,I) = W1	00018900
ISN 0176	DNRM(3,3,I) = W3	00019000
ISN 0177	900 CONTINUE	00019100
	C	00019200
	C..... HEAT-RADIATION PAT. NO. = 0 ---- 6	00019300
	C	00019400
ISN 0178	DO 950 J = 1, NELU	00019500
ISN 0179	DO 930 I = 1, 3	00019600
ISN 0180	K = NPEM(I,J)	00019700
ISN 0181	IF (K.EQ.0) NPEM(I,J) = 6	00019800
ISN 0183	930 CONTINUE	00019900
ISN 0184	950 CONTINUE	00020000
	C	00020100
	C..... FORMAT	00020200
	C	00020300
ISN 0185	6005 FORMAT('1')	00020310
ISN 0186	6010 FORMAT('1', '***** ERROR MESSAGE LIST *****//')	00020400
ISN 0187	6020 FORMAT(' *ERROR INVALID TEMP. PAT. NO IN NODE DATA.',	00020500
	1, ' NODE NO.=',I4)	00020600
ISN 0188	6030 FORMAT(' *ERROR INVALID BOUNDARY-TEMP. PAT. NO. IN NODE',	00020700
	1, ' DATA. NODE NO.=',I4)	00020800
ISN 0189	6040 FORMAT(' *ERROR INVALID SUSTAIN CONDITION IN NODE DATA.',	00020900
	1, ' NODE NO.=',I4)	00021000
ISN 0190	6050 FORMAT(' *ERROR INVALID NODE NO. IN ELEMENT DATA.',	00021100
	1, ' ELEMENT NO.=',I4)	00021200
ISN 0191	6060 FORMAT(' *ERROR INVALID HEAT-FLUX PAT. NO. IN ELEMENT DATA.',	00021300
	1, ' ELEMENT NO.=',I4)	00021400
ISN 0192	6070 FORMAT(' *ERROR NO.OF CONNECTED ELEMENT MORE THAN 8.',	00021500
	1, ' NODE NO.=',I4)	00021600
ISN 0193	6080 FORMAT(' *ERROR ISOLATED NODE. NODE NO.=',I4)	00021700
ISN 0194	6090 FORMAT(' *ERROR BOUNDARY TEMP. PAT. NO IS NOT GIVEN	00021800
	1, ' ELEMENT NO.=',I4, ' NODE NO.=',I4)	00021900

	C	
ISN 0195	9900 CONTINUE	00022000
ISN 0196	RETURN	00022100
ISN 0197	END	00022200
		00022300

ISN 0002	SUBROUTINE SPACK(NAA,NA,NBB,NB)	00022400
	C.....	00022500
	C..... SORT & DUPLICATE NO. ARE DELETED	00022600
	C.....	00022700
ISN 0003	DIMENSION NAA(NA),NBB(1)	00022800
	C	00022900
	C	00023000
ISN 0004	IF (NA.EQ.1) GO TO 300	00023100
ISN 0006	NAM = NA - 1	00023200
ISN 0007	DO 200 I = 1, NAM	00023300
ISN 0008	IM = I	00023400
ISN 0009	NM = NAA(I)	00023500
ISN 0010	JS = I + 1	00023600
ISN 0011	DO 100 J = JS, NA	00023700
ISN 0012	IF (NM.LE.NAA(J)) GO TO 100	00023800
ISN 0014	IM = J	00023900
ISN 0015	NM = NAA(J)	00024000
ISN 0016	100 CONTINUE	00024100
ISN 0017	NAA(IM) = NAA(I)	00024200
ISN 0018	NAA(I) = NM	00024300
ISN 0019	200 CONTINUE	00024400
ISN 0020	300 CONTINUE	00024500
ISN 0021	NB = 1	00024600
ISN 0022	NBB(1) = NAA(1)	00024700
ISN 0023	IF (NA.EQ.1) GO TO 1000	00024800
ISN 0025	NM = NAA(1)	00024900
ISN 0026	DO 400 I = 2, NA	00025000
ISN 0027	NM = NAA(I)	00025100
ISN 0028	IF (NM.EQ.NW) GO TO 400	00025200
ISN 0030	NM = NW	00025300
ISN 0031	NB = NB + 1	00025400
ISN 0032	NBB(NB) = NM	00025500
ISN 0033	400 CONTINUE	00025600
	C	00025700
ISN 0034	1000 CONTINUE	00025800
ISN 0035	RETURN	00025900
ISN 0036	END	00026000

ISN 0002	SUBROUTINE MATMK	00000100
C.....		00000200
C.....	SET TIME-INDEPENDENT PARTS OF MATICES & VECTORS	00000300
C.....		00000400
ISN 0003	IMPLICIT REAL*8(A-H,O-Z) , INTEGER*4(I-N)	00000500
ISN 0004	COMMON /CONTLI/NSSC,NPSS,N1CL,N2CL,N1PR,N2PR,IERR,NCLS,LCNT,	00000600
1	NITT,NIT1,NIT2,TPGE	00000700
2	/CONTLR/DLT1,DLT2,CGHC,CGSC,TITL(10),AREA,DLTN,TIME	00000800
ISN 0005	COMMON /BUSSEI/NPT1,NPT2,NPIC(5),NP2C(5),NP1E(5)	00000900
1	/BUSSEI/DCET(5),DENC(5),SPHT(5),CLEP(5),QEX1(5),QEX2(5),	00001000
2	CEXP(5),CPSN(5),ENGI(5),ENG2(5),CENG(5),CEMT(6)	00001100
ISN 0006	COMMON /NDOEY /NDOU,NDOF,NDOQ(500),NDNS(1000),NPYS(500),NPYP(500),	00001200
1	NBOC(1000),NPEM(500),NPEL(8,500),NPPN(500),	00001300
2	NPNQ(9,500)	00001400
3	/NODER /XCON(500),YCON(500),TINT(500),QINT(500)	00001500
ISN 0007	COMMON /ELMNTI/NELU,NELQ(1000),NELS(1500),NNME(3,1000),	00001600
1	NPTE(1000),NPEM(3,1000),NPEI(3,1000)	00001700
2	/ELMNTI/SINT(4,1000)	00001800
ISN 0008	COMMON /NDTMP1/NPT3,NP3C(5)	00001900
1	/NDTMPR/YES1(5),TES2(5),TPRS(5),TPHS(5)	00002000
ISN 0009	COMMON /BDTMP1/NPT4,NP4C(5)	00002100
1	/BDTMPR/TEP1(5),TE2P(5),TPRP(5),TPHP(5)	00002200
ISN 0010	COMMON /HTFLXI/NPTS,NP5C(5)	00002300
1	/HTFLXR/EIN1(5),EIN2(5),EPRQ(5),EPHS(5),CEIN(5)	00002400
ISN 0011	COMMON /STRESR/DNRM(3,3,5),ELMC(7,1000),STFE(18,1000,2),	00002500
1	STFX(18,1000),STEM(18,1000),FVEC(1000),DPLC(1000),	00002600
2	TENW(1000),TELD(1000),STRS(4,1000),STRN(4,1000)	00002700
ISN 0012	COMMON /HEATR /DMAT(9,500),PMAT(9,500),AMAT(9,500),QEXL(5,500),	00002800
1	QINL(5,500),HMAT(9,500),BVEC(500),TNNW(500),	00002900
2	TNLD(500),GRIM(500),TPTR(500),QTEX(500)	00003000
ISN 0013	COMMON /WORKR /PVEC(1000),RVEC(1000),APVC(1000),SSWK(4,500),	00003100
1	SRWK(4,500),QEXN(5),ENMN(5),ENMP(5),TEMN(5),	00003200
2	TEON(5),FLXQ(5)	00003300
ISN 0014	COMMON /OUTPTI/NQIN,NQIP(500),NDEN,NDEP(500),NREN,NREP(500)	00003400
1	/OUTPTR/QIVL(500),QDFV(500),RFCV(2,500),FLND(2,500),	00003500
2	ELEL(2,1000),SSND(4,500),SRND(4,500)	00003600
C		00003700
ISN 0015	DIMENSION DMT(3,3),PMT(3,3),AMT(3,3),BMT(3,6),OBM(3,6),BOB(6,6)	00003800
C		00003900
C.....	MATRIX ELMC , DMAT(K) , PMAT(P) , AMAT(A)	00004000
C		00004100
C.....	VECTOR QEXL(LARGE Q) , QINL(SMALL Q)	00004200
C		00004300
ISN 0016	NW = 6	00004400
ISN 0017	NEN = 0	00004500
ISN 0018	100 CONTINUE	00004600
ISN 0019	NEN = NEN + 1	00004700
ISN 0020	IF (NEN.GT.NELU) GO TO 1000	00004800
ISN 0022	CALL DVALUE(AMT,9,0.D0)	00004900
ISN 0023	TP = NNME(1,NEN)	00005000
ISN 0024	JP = NNME(2,NEN)	00005100
ISN 0025	KP = NNME(3,NEN)	00005200
ISN 0026	NEP = NPTE(NEN)	00005300

ISN 0027	ND1 = NPEM(1,NEN)	00005300
ISN 0028	ND2 = NPEM(2,NEN)	00005400
ISN 0029	ND3 = NPEM(3,NEN)	00005500
ISN 0030	NI1 = NPEI(1,NEN)	00005600
ISN 0031	NI2 = NPEI(2,NEN)	00005700
ISN 0032	NI3 = NPEI(3,NEN)	00005800
	C	00005900
ISN 0033	X1 = XCDN(IP)	00006000
ISN 0034	X2 = XCDN(JP)	00006100
ISN 0035	X3 = XCDN(KP)	00006200
ISN 0036	Y1 = YCDN(IP)	00006300
ISN 0037	Y2 = YCDN(JP)	00006400
ISN 0038	Y3 = YCDN(KP)	00006500
	C	00006600
ISN 0039	B1 = Y2 - Y3	00006700
ISN 0040	B2 = Y3 - Y1	00006800
ISN 0041	B3 = Y1 - Y2	00006900
ISN 0042	C1 = X3 - X2	00007000
ISN 0043	C2 = X1 - X3	00007100
ISN 0044	C3 = X2 - X1	00007200
ISN 0045	DL2 = X1*Y2 - X2*Y1 + X2*Y3 - X3*Y2 + X3*Y1 - X1*Y3	00007300
ISN 0046	DL = 0.500*DL2	00007400
ISN 0047	IF (DL-LE,0.00) GO TO 3000	00007500
ISN 0049	ELMC(1,NEN) = B1/DL2	00007600
ISN 0050	ELMC(2,NEN) = B2/DL2	00007700
ISN 0051	ELMC(3,NEN) = B3/DL2	00007800
ISN 0052	ELMC(4,NEN) = C1/DL2	00007900
ISN 0053	ELMC(5,NEN) = C2/DL2	00008000
ISN 0054	ELMC(6,NEN) = C3/DL2	00008100
ISN 0055	ELMC(7,NEN) = DL	00008200
	C	00008300
ISN 0056	AREA = AREA + DL	00008400
	C	00008500
ISN 0057	DFC = DCFT(NEP)/(4.00*DL)	00008600
ISN 0058	DMT(1,1) = DFC*(B1*B1 + C1*C1)	00008700
ISN 0059	DMT(1,2) = DFC*(B1*B2 + C1*C2)	00008800
ISN 0060	DMT(1,3) = DFC*(B1*B3 + C1*C3)	00008900
ISN 0061	DMT(2,2) = DFC*(B2*B2 + C2*C2)	00009000
ISN 0062	DMT(2,3) = DFC*(B2*B3 + C2*C3)	00009100
ISN 0063	DMT(3,3) = DFC*(B3*B3 + C3*C3)	00009200
	C	00009300
ISN 0064	W12 = DSORT(C3*C3 + B3*B3)	00009400
ISN 0065	W23 = DSORT(C1*C1 + B1*B1)	00009500
ISN 0066	W31 = DSORT(C2*C2 + B2*B2)	00009600
	C	00009700
ISN 0067	ISW = ND1 + ND2 + ND3	00009800
ISN 0068	IF (ISW-EO,18) GO TO 200	00009900
ISN 0070	A1 = CEMT(ND1)	00010000
ISN 0071	A2 = CEMT(ND2)	00010100
ISN 0072	A3 = CEMT(ND3)	00010200
	C	00010300
ISN 0073	W16 = 1.00/6.00	00010400
ISN 0074	W26 = W16*2.00	00010500
	C	00010600
ISN 0075	W1 = A1*W12	00010700
ISN 0076	W2 = A2*W23	00010800
ISN 0077	W3 = A3*W31	00010900
	C	00011000

ISN 0078	AMT(1,1) = W26*(W1 + W3)	00011100
ISN 0079	AMT(1,2) = W16* W1	00011200
ISN 0080	AMT(1,3) = W16* W3	00011300
ISN 0081	AMT(2,2) = W26*(W1 + W2)	00011400
ISN 0082	AMT(2,3) = W16* W2	00011500
ISN 0083	AMT(3,3) = W26*(W2 + W3)	00011600
	C	00011700
ISN 0084	200 CONTINUE	00011800
	C	00011900
ISN 0085	RW = DENC(NEP)	00012000
ISN 0086	CW = SPHT(NEP)	00012100
ISN 0087	W1 = RW*CW*DL/12.00	00012200
ISN 0088	W2 = W1*2.00	00012300
	C	00012400
ISN 0089	PMT(1,1) = W2	00012500
ISN 0090	PMT(1,2) = W1	00012600
ISN 0091	PMT(1,3) = W1	00012700
ISN 0092	PMT(2,2) = W2	00012800
ISN 0093	PMT(2,3) = W1	00012900
ISN 0094	PMT(3,3) = W2	00013000
	C	00013100
ISN 0095	CALL KPASET(DMT,PMT,AMT,IP,JP,KP)	00013200
	C	00013300
ISN 0096	W1 = DL/3.00	00013400
ISN 0097	QEXL(NEP,IP) = QEXL(NEP,IP) + W1	00013500
ISN 0098	QEXL(NEP,JP) = QEXL(NEP,JP) + W1	00013600
ISN 0099	QEXL(NEP,KP) = QEXL(NEP,KP) + W1	00013700
	C	00013800
ISN 0100	IF (NIL.EQ.0) GO TO 300	00013900
ISN 0102	QINL(NI1,IP) = QINL(NI1,IP) + 0.500*W12	00014000
ISN 0103	QINL(NI1,JP) = QINL(NI1,JP) + 0.500*W12	00014100
	C	00014200
ISN 0104	300 CONTINUE	00014300
ISN 0105	IF (NI2.EQ.0) GO TO 400	00014400
ISN 0107	QINL(NI2,JP) = QINL(NI2,JP) + 0.500*W23	00014500
ISN 0108	QINL(NI2,KP) = QINL(NI2,KP) + 0.500*W23	00014600
ISN 0109	400 CONTINUE	00014700
ISN 0110	IF (NI3.EQ.0) GO TO 500	00014800
ISN 0112	QINL(NI3,KP) = QINL(NI3,KP) + 0.500*W31	00014900
ISN 0113	QINL(NI3,IP) = QINL(NI3,IP) + 0.500*W31	00015000
	C	00015100
ISN 0114	500 CONTINUE	00015200
ISN 0115	GO TO 100	00015300
	C	00015400
	C.... SET STIFFNESS MATRIX	00015500
	C	00015600
ISN 0116	1000 CONTINUE	00015700
ISN 0117	IF (NSSC.EQ.0) GO TO 9900	00015800
ISN 0119	CALL DVALUE(BMT,18,0.00)	00015900
	C	00016000
ISN 0120	IPL = 0	00016100
ISN 0121	1500 CONTINUE	00016200
ISN 0122	IPL = IPL + 1	00016300
ISN 0123	IF (IPL.GT.5) GO TO 9900	00016400
ISN 0125	IS = NP1C(IPL)	00016500
ISN 0126	IF (IS.EQ.0) GO TO 1500	00016600
ISN 0128	IES = NP1E(IPL)	00016700
ISN 0129	ENG = 1.00	00016800

ISN 0130		IF (IES.EQ.0)	ENG = ENGI(IPL)	00016900
	C			00017000
ISN 0132		CALL DATA(DMT,DNRM(1,1,IPL),9)		00017100
	C			00017200
ISN 0133		NEN = 0		00017300
ISN 0134	2000	CONTINUE		00017400
ISN 0135		NEN = NEN + 1		00017500
ISN 0136		IF (NEN.GT.NELU)	GO TO 1500	00017600
ISN 0138		IS = NPTE(NEN)		00017700
ISN 0139		IF (IS.NE.IPL)	GO TO 2000	00017800
	C			00017900
ISN 0141		IP = NNME(1,NEN)		00017910
ISN 0142		JP = NNME(2,NEN)		00017920
ISN 0143		KP = NNME(3,NEN)		00017930
	C			00017940
ISN 0144		B1 = ELMC(1,NEN)		00018000
ISN 0145		B2 = ELMC(2,NEN)		00018100
ISN 0146		B3 = ELMC(3,NEN)		00018200
ISN 0147		C1 = ELMC(4,NEN)		00018300
ISN 0148		C2 = ELMC(5,NEN)		00018400
ISN 0149		C3 = ELMC(6,NEN)		00018500
ISN 0150		DL = ELMC(7,NEN)		00018600
	C			00018700
ISN 0151		BMT(1,1) = B1		00018800
ISN 0152		BMT(1,3) = B2		00018900
ISN 0153		BMT(1,5) = B3		00019000
ISN 0154		BMT(2,2) = C1		00019100
ISN 0155		BMT(2,4) = C2		00019200
ISN 0156		BMT(2,6) = C3		00019300
ISN 0157		BMT(3,1) = C1		00019400
ISN 0158		BMT(3,2) = B1		00019500
ISN 0159		BMT(3,3) = C2		00019600
ISN 0160		BMT(3,4) = B2		00019700
ISN 0161		BMT(3,5) = C3		00019800
ISN 0162		BMT(3,6) = B3		00019900
ISN 0163		DO 2300 J = 1, 6		00020000
ISN 0164		DO 2200 I = 1, 3		00020100
ISN 0165		WW = 0.00		00020200
ISN 0166		DO 2100 K = 1, 3		00020300
ISN 0167		WW = WW + DMT(I,K)*BMT(K,J)		00020400
ISN 0168	2100	CONTINUE		00020500
ISN 0169		DBM(I,J) = WW		00020600
ISN 0170	2200	CONTINUE		00020700
ISN 0171	2300	CONTINUE		00020800
	C			00020900
	C			00021000
ISN 0172		DO 2800 I = 1, 6		00021100
ISN 0173		DO 2700 J = 1, 6		00021200
ISN 0174		WW = 0.00		00021300
ISN 0175		DO 2600 K = 1, 3		00021400
ISN 0176		WW = WW + BMT(K,I)*DBM(K,J)		00021500
ISN 0177	2600	CONTINUE		00021600
ISN 0178		BDB(I,J) = WW*DL		00021700
ISN 0179		BDB(J,I) = WW*DL		00021800
ISN 0180	2700	CONTINUE		00021900
ISN 0181	2800	CONTINUE		00022000
	C			00022100
	C			00022200

ISN 0182	IF (IES.EQ.0)	CALL STFSET(BDB,STFX,	ENG,IP,JP,KP)	00022300
ISN 0184	IF (IES.NE.0)	CALL STFSET(BDB,STFE(1,1,IES),	ENG,IP,JP,KP)	00022400
	C			00022500
	C			00022600
ISN 0186	GO TO 2000			00022700
	C			00022800
	C			00022900
ISN 0187	3000 CONTINUE			00023000
ISN 0188	IERR = 1			00023010
ISN 0189	WRITE(NH,6000) NELO(NEN)			00023100
ISN 0190	6000 FORMAT(' *ERROR ---- NODE IN ELEMENT DATA NOT COUNTER-CLOCKWISE',			00023200
	1	' ELEMENT NO.=',I4)		00023300
	C			00023400
	C			00023500
ISN 0191	9900 CONTINUE			00023600
ISN 0192	RETURN			00023700
ISN 0193	END			00023800

ISN 0002	SUBROUTINE KPASET(DMT,PMT,AMT,TP,JP,KP)	00023900
C		00024000
C.....	TOTAL D-,P-,A-MATRIX GENERATION	00024100
C.....	BY SUB D-,P-,A-MATRIX OF ELEMENT	00024200
ISN 0003	IMPLICIT REAL*8(A-H,O-Z), INTEGER*4(I-N)	00024300
ISN 0004	COMMON /NDDEI /NDNU,NDDE,NDNO(500),NDNS(1000),NPTS(500),NPTP(500),	00024400
	NBDC(1000),NPEN(500),NPEL(8,500),NPNN(500),	00024500
	NPND(9,500)	00024600
ISN 0005	COMMON /HEATR /DMAT(9,500),PHAT(9,500),AMAT(9,500),QEXL(5,500),	00024700
	QINL(5,500),HMAT(9,500),BVEC(500),TNNH(500),	00024800
	TNLD(500),GRTH(500),TPTR(500),QTFX(500)	00024900
C		00025000
ISN 0006	DIMENSION DMT(3,3),PMT(3,3),AMT(3,3),NMT(3,3),NPT(3)	00025100
C		00025200
C		00025300
C.....	SYMMETRIC PARTS GENERATION	00025400
C		00025500
ISN 0007	DMT(2,1) = DMT(1,2)	00025600
ISN 0008	DMT(3,1) = DMT(1,3)	00025700
ISN 0009	DMT(3,2) = DMT(2,3)	00025800
ISN 0010	PMT(2,1) = PMT(1,2)	00025900
ISN 0011	PMT(3,1) = PMT(1,3)	00026000
ISN 0012	PMT(3,2) = PMT(2,3)	00026100
ISN 0013	AMT(2,1) = AMT(1,2)	00026200
ISN 0014	AMT(3,1) = AMT(1,3)	00026300
ISN 0015	AMT(3,2) = AMT(2,3)	00026400
C		00026500
ISN 0016	NPT(1) = JP	00026600
ISN 0017	NPT(2) = JP	00026700
ISN 0018	NPT(3) = KP	00026800
C		00026900
ISN 0019	DO 200 J = 1, 3	00027000
ISN 0020	IS = NPT(J)	00027100
ISN 0021	N = NPNN(IS)	00027200
ISN 0022	DO 100 I = 1, N	00027300
ISN 0023	NP = NPND(I,IS)	00027400
ISN 0024	IF (IP.EQ.NP) NMT(J,1) = I	00027500
ISN 0025	IF (JP.EQ.NP) NMT(J,2) = I	00027600
ISN 0026	IF (KP.EQ.NP) NMT(J,3) = I	00027700
ISN 0028		00027800
ISN 0030	100 CONTINUE	00027900
ISN 0031	200 CONTINUE	00028000
C		00028100
ISN 0032	DO 400 J = 1, 3	00028200
ISN 0033	IS = NPT(J)	00028300
ISN 0034	DO 300 I = 1, 3	00028400
ISN 0035	N = NMT(J,I)	00028500
ISN 0036	DMAT(N,IS) = DMAT(N,IS) + DMT(J,I)	00028600
ISN 0037	PHAT(N,IS) = PHAT(N,IS) + PMT(J,I)	00028700
ISN 0038	AMAT(N,IS) = AMAT(N,IS) + AMT(J,I)	00028800
ISN 0039	300 CONTINUE	00028900
ISN 0040	400 CONTINUE	00029000
C		00029100

	C		00029200
ISN 0041		RETURN	00029300
ISN 0042		END	00029400

ISN 0002	SUBROUTINE STFSET(BDB,STF,ENG,IP,JP,KP)	00029500
	C	00029600
	C..... TOTAL STIFFNESS MATRIX GENERATION	00029700
	C..... BY SUB STIFFNESS MATRIX OF ELEMENT	00029800
ISN 0003	IMPLICIT REAL*8(A-H,O-Z), INTEGER*4(I-N)	00029900
ISN 0004	COMMON /NODEI /NDU,NDOE,NDNQ(500),NDNS(1000),NPTS(500),NPTP(500),	00030000
	1 NBOC(1000),NPEN(500),NPOL(8,500),NPNM(500),	00030100
	2 NPND(9,500)	00030200
	C	00030300
ISN 0005	DIMENSION BDB(6,6),STF(18,1000),NMT(3),NPT(3)	00030400
	C	00030500
	C	00030600
ISN 0006	NPT(1) = IP	00030700
ISN 0007	NPT(2) = JP	00030800
ISN 0008	NPT(3) = KP	00030900
	C	00031000
ISN 0009	DO 300 J = 1, 3	00031100
ISN 0010	IS = NPT(J)	00031200
ISN 0011	N = NPNM(IS)	00031300
ISN 0012	DO 100 I = 1, N	00031400
ISN 0013	NP = NPND(I,IS)	00031500
ISN 0014	IF (JP.EQ.NP) NMT(1) = I	00031600
ISN 0016	IF (JP.EQ.NP) NMT(2) = I	00031700
ISN 0018	IF (KP.EQ.NP) NMT(3) = I	00031800
ISN 0020	100 CONTINUE	00031900
	C	00032000
	C	00032100
ISN 0021	J1 = J*2 - 1	00032200
ISN 0022	J2 = J*2	00032300
ISN 0023	IS1 = IS*2 - 1	00032400
ISN 0024	IS2 = IS*2	00032500
ISN 0025	DO 200 I = 1, 3	00032600
ISN 0026	I1 = I*2 - 1	00032700
ISN 0027	I2 = I*2	00032800
ISN 0028	N = NMT(I)	00032900
ISN 0029	N1 = N*2 - 1	00033000
ISN 0030	N2 = N*2	00033100
ISN 0031	STF(N1,IS1) = STF(N1,IS1) + BDB(J1,I1)*ENG	00033200
ISN 0032	STF(N2,IS1) = STF(N2,IS1) + BDB(J1,I2)*ENG	00033300
ISN 0033	STF(N1,IS2) = STF(N1,IS2) + BDB(J2,I1)*ENG	00033400
ISN 0034	STF(N2,IS2) = STF(N2,IS2) + BDB(J2,I2)*ENG	00033500
ISN 0035	200 CONTINUE	00033600
ISN 0036	300 CONTINUE	00033700
	C	00033800
	C	00033900
ISN 0037	RETURN	00034000
ISN 0038	END	00034100

ISN 0002	C	SUBROUTINE CLMAIN	00000100
	C.....	HEAT & STRESS CALCULATION CONTROL	00000200
ISN 0003		IMPLICIT REAL*8(A-H,O-Z) , INTEGER*4(I-N)	00000300
ISN 0004	1	COMMON /CONTL/NSSC,NSSS,NICL,N2CL,N1PR,N2PR,IERR,NCLS,LCNT,	00000400
	2	NITT,NIT1,NIT2,IPGE	00000500
ISN 0005	1	/CONTL/OLTI,DLT1,CGMC,CGSC,TITL(10),AREA,DLTN,TIME	00000600
	2	BUSSEI/NPT1,NPT2,NPIC(5),NP2C(5),NP1E(5)	00000700
	3	/BUSSEI/DCFT(5),DENG(5),SPHT(5),CLEP(5),QEX1(5),QEX2(5),	00000800
	4	CEXP(5),CPSN(5),ENG1(5),ENG2(5),CENG(5),CEMT(6)	00000900
ISN 0006	1	COMMON /NDOEI /NNDU,NDOF,NDOU(500),NDNS(1000),NPTS(500),NPTP(500),	00001000
	2	NDC(1000),NPEN(500),NPEL(8,500),NPNN(500),	00001100
	3	NPND(2,500)	00001200
	4	/NDOER /XCDN(500),YCDN(500),TINT(500),QINT(500)	00001300
ISN 0007	1	COMMON /ELMNT/NELU,NELO(1000),NELS(1500),NNME(3,1000),	00001400
	2	NPE(1000),NPEM(3,1000),NPEI(3,1000)	00001500
	3	/ELMNT/SINT(4,1000)	00001600
ISN 0008	1	COMMON /NDTMP/NPT3,NP3C(5)	00001700
	2	/NDTMP/TESS(5),TES2(5),TPRS(5),TPHS(5)	00001800
ISN 0009	1	COMMON /BDTMP/NP4C(5)	00001900
	2	/BDTMP/TE1P(5),TE2P(5),TPRP(5),TPHP(5)	00002000
ISN 0010	1	COMMON /HTFLX/NPTS,NP5C(5)	00002100
	2	/HTFLX/EIN1(5),EIN2(5),EPRQ(5),EPHS(5),CEIN(5)	00002200
ISN 0011	1	COMMON /STRESR/DNRM(3,5),ELMC(7,1000),STFE(18,1000,2),	00002300
	2	STFX(18,1000),STFM(18,1000),FVEC(1000),DPLC(1000),	00002400
	3	TENH(1000),TELD(1000),STRS(4,1000),STRN(4,1000)	00002500
ISN 0012	1	COMMON /HEATR /OMAT(9,500),PMAT(9,500),AMAT(9,500),QEXL(5,500),	00002600
	2	QINL(5,500),PMAT(9,500),BVEC(500),TNMH(500),	00002700
	3	TNLD(500),GRTH(500),TPTR(500),QTEX(500)	00002800
ISN 0013	1	COMMON /WORKR /PVEC(1000),RVEC(1000),APVC(1000),SSWK(4,500),	00002900
	2	SRWK(4,500),QEXN(5),ENMN(5),ENMP(5),TEMN(5),	00003000
	3	TEON(5),FLXQ(5)	00003100
ISN 0014	1	COMMON /OUTPTI/NOIN,NQIP(500),NOFN,NDFP(500),NSEN,NREP(500)	00003200
	2	/OUTPTR/QTVL(500),QDFV(500),RFCV(2,500),FLND(2,500),	00003300
	3	ELEL(2,1000),SSND(4,500),SRND(4,500)	00003400
ISN 0015	C	DLTN = DLT1	00003500
ISN 0016		IF (NICL.EQ.0) DLTN = DLT2	00003600
ISN 0018		NIN2 = NICL * N2CL	00003700
ISN 0019		CALL INSET	00003800
ISN 0020		IF (IERR.NE.0) GO TO 9000	00003900
ISN 0022	C	CALL CHECKP(3)	00004000
		NITT = 0	00004100
ISN 0023		NIT1 = 0	00004200
ISN 0024		NIT2 = 0	00004300
ISN 0025		TIME = 0.00	00004400
	C		00004500
	C		00004600
ISN 0026		100 CONTINUE	00004700
ISN 0027		IF (IERR.NE.0) GO TO 9000	00004800
ISN 0029		NITT = NITT + 1	00004900
ISN 0030		IF (NITT.GT.NICL) GO TO 200	00005000
			00005100
			00005200

ISN 0032	NIT1 = NIT1 + 1	00005300
ISN 0033	NN = MOD(NIT1,NIPR)	00005400
ISN 0034	ISW = 0	00005500
ISN 0035	IF (NN.EQ.0)	ISW = 1
ISN 0037	IF (NIT1.EQ.N1CL)	ISW = 1
ISN 0039	GO TO 300	00005700
	C	00005800
	C	00005900
ISN 0040	200 CONTINUE	00006000
ISN 0041	IF (NITT.GT.NIN2)	GO TO 9000
ISN 0043	DLTN = DLT2	00006200
ISN 0044	NIT2 = NIT2 + 1	00006300
ISN 0045	NN = MOD(NIT2,N2PR)	00006400
ISN 0046	ISW = 0	00006500
ISN 0047	IF (NN.EQ.0)	ISW = 1
ISN 0049	IF (NIT2.EQ.N2CL)	ISW = 1
	C	00006700
	C	00006800
ISN 0051	300 CONTINUE	00006900
ISN 0052	TIME = TIME + DLTN	00007000
ISN 0053	CALL PRPCH	00007100
ISN 0054	CALL CGHOH(HMAT,TNNW,BVEC,PVEC,RVEC,APVC)	00007200
ISN 0055	IF (IERR.NE.0)	GO TO 9000
ISN 0057	CALL PSPCH	00007300
ISN 0058	IF (ISW.EQ.1)	CALL OUTPH
ISN 0060	IF (NSSC.EQ.0)	GO TO 100
	C	00007500
	C	00007600
ISN 0062	CALL PRPCD	00007700
ISN 0063	CALL CGHOD(STFM,DPLC,FVEC,PVEC,RVEC,APVC)	00007800
ISN 0064	IF (IERR.NE.0)	GO TO 9000
ISN 0066	CALL PSPCD	00007900
ISN 0067	IF (ISW.EQ.1)	CALL OUTPD
	C	00008000
ISN 0069	GO TO 100	00008100
	C	00008200
	C	00008300
ISN 0070	9000 CONTINUE	00008400
ISN 0071	RETURN	00008500
ISN 0072	END	00008600
		00008700
		00008800
		00008900
		00009000

ISN 0002	SUBROUTINE INSET	00009100
C		00009200
C.....	INITIAL VALUE SET FOR HEAT & STRESS CALCULATION	00009300
C		00009400
ISN 0003	IMPLICIT REAL*8(A-H,O-Z) , INTEGER*4(I-N)	00009500
ISN 0004	COMMON /CONTLI/NSSC,NPSS,NICL,N2CL,N1PR,N2PR,IERR,NCLS,LCNT,	00009600
1	NITT,NIT1,NIT2,IPGE	00009700
2	/CONTLR/DLT1,DLT2,CGHC,CGSC,TITL(10),AREA,DLTN,TIME	00009800
ISN 0005	COMMON /BUSSET/NPT1,NPT2,NPIC(5),NP2C(5),NP1E(5)	00009900
1	/BUSSET/DCET(5),DENC(5),SPHT(5),CLEP(5),QEX1(5),QEX2(5),	00010000
2	CEXP(5),CPSN(5),ENGI(5),ENG2(5),CENG(5),CEMT(6)	00010100
ISN 0006	COMMON /NODEI /NNDU,NDOF,NND(500),NONS(1000),NPTS(500),NP2P(500),	00010200
1	NADC(1000),NPEN(500),NPEL(8,500),NPNN(500),	00010300
2	NPND(9,500)	00010400
3	/NODER /XCDN(500),YCDN(500),TINT(500),QINT(500)	00010500
ISN 0007	COMMON /ELMNTI/NELU,NELO(1000),NELS(1500),NNME(3,1000),	00010600
1	NPTE(1000),NPEM(3,1000),NPET(3,1000)	00010700
2	/ELMNTI/SINT(4,1000)	00010800
ISN 0008	COMMON /NDTMP1/NPT3,NP3C(5)	00010900
1	/NDTMPR/TEST(5),TES2(5),TPRS(5),TPHS(5)	00011000
ISN 0009	COMMON /BDTMP1/NPT4,NP4C(5)	00011100
1	/BDTMPR/TE1P(5),TE2P(5),TPRP(5),TPMP(5)	00011200
ISN 0010	COMMON /HTFLX1/NPT5,NP5C(5)	00011300
1	/HTFLXR/EIN1(5),EIN2(5),EPRQ(5),EPHS(5),CEIN(5)	00011400
ISN 0011	COMMON /STRESR/DNRM(3,3,5),ELMC(7,1000),STFE(18,1000,2),	00011500
1	STFX(18,1000),STFM(18,1000),FVEC(1000),DPLC(1000),	00011600
2	TENW(1000),TELD(1000),STRS(4,1000),STRN(4,1000)	00011700
ISN 0012	COMMON /HEATR /DMAT(9,500),PMAT(9,500),AMAT(9,500),QEXL(5,500),	00011800
1	QTNL(5,500),HMAT(9,500),BVEC(500),TNNW(500),	00011900
2	TNLD(500),GRTH(500),TPTR(500),QTFX(500)	00012000
ISN 0013	COMMON /WORKR /PVEC(1000),RVEC(1000),APVC(1000),SSWK(4,500),	00012100
1	SRWK(4,500),QEXN(5),ENMN(5),ENMP(5),TEMN(5),	00012200
2	TEON(5),FLXQ(5)	00012300
ISN 0014	COMMON /OUTPTI/NQIN,NQIP(500),NDEN,NDFP(500),NRFN,NRFP(500)	00012400
1	/OUTPTR/QIVL(500),QDFV(500),RFCV(2,500),FLND(2,500),	00012500
2	FLEL(2,1000),SSND(4,500),SRND(4,500)	00012600
C		00012710
ISN 0015	DIMENSION TD20(5)	00012715
C		00012720
ISN 0016	NW = 6	00012730
ISN 0017	PAT2 = 2.00*3.141592653500	00012740
C		00012800
C	INITIAL Q & YOUNG PAT.	00012900
ISN 0018	DO 100 I = 1, 5	00013000
ISN 0019	IS = NPIC(I)	00013100
ISN 0020	IF (IS.EQ.0) GO TO 100	00013200
ISN 0022	WW = -CEXP(I)*DLTN/20.00	00013300
ISN 0023	QEXN(I) = QEX1(I) + QEX2(I)*DEXP(WW)	00013400
ISN 0024	ENMN(I) = ENGI(I)	00013500
ISN 0025	IF (NP1E(I).EQ.0) GO TO 100	00013600
ISN 0027	ENMN(I) = ENMN(I) + ENG2(I)	00013700
ISN 0028	100 CONTINUE	00013800
C	INITIAL NODE TEMP. PAT.	00013900

ISN 0029	DO 200 I = 1, 5	00014000
ISN 0030	IS = NP3C(I)	00014100
ISN 0031	IF (IS.EQ.0) GO TO 200	00014200
ISN 0033	PH = TPHS(I)	00014300
ISN 0034	TEMN(I) = TES1(I) + TES2(I)*DCOS(PH)	00014400
ISN 0035	PH = TPHS(I) + PAI2*DLTN/(20.00*TPRS(I))	00014410
ISN 0036	TD20(I) = TES1(I) + TES2(I)*DCOS(PH)	00014420
ISN 0037	200 CONTINUE	00014500
	C INITIAL BOUNDARY TEMP. PAT. (AT T = DLTN/20)	00014600
ISN 0038	DO 300 I = 1, 5	00014700
ISN 0039	IS = NP4C(I)	00014800
ISN 0040	IF (IS.EQ.0) GO TO 300	00014900
ISN 0042	PH = TPH2(I) + PAI2*DLTN/(20.00*TPRP(I))	00015000
ISN 0043	TEON(I) = TE1P(I) + TE2P(I)*DCOS(PH)	00015100
ISN 0044	300 CONTINUE	00015200
	C INITIAL FLUX PAT. (AT T = DLTN/20)	00015300
ISN 0045	DO 400 I = 1, 5	00015400
ISN 0046	IS = NP5C(I)	00015500
ISN 0047	IF (IS.EQ.0) GO TO 400	00015600
ISN 0049	PH = EPHS(I) + PAI2*DLTN/(20.00*EPRQ(I))	00015700
ISN 0050	WW = -CEIN(I)*DLTN/20.00	00015800
ISN 0051	FLXO(I) = EINI(I)*DCOS(PH) + EYN(I)*DEXP(WW)	00015900
ISN 0052	400 CONTINUE	00016000
	C INITIAL TEMP. OF NODE	00016100
ISN 0053	DO 500 I = 1, NNDU	00016200
ISN 0054	IS = NP5C(I)	00016300
ISN 0055	WH = TINT(I)	00016400
ISN 0056	IF (IS.NE.0) WW = TEMN(IS)	00016500
ISN 0058	TNNW(I) = WW	00016600
ISN 0059	500 CONTINUE	00016700
	C INITIAL TEMP. ON ELEMENT	00016800
ISN 0060	DO 600 I = 1, NELU	00016900
ISN 0061	IP = NNME(1,I)	00017000
ISN 0062	JP = NNME(2,I)	00017100
ISN 0063	KP = NNME(3,I)	00017200
ISN 0064	WW = TNNW(IP) + TNNW(JP) + TNNW(KP)	00017300
ISN 0065	TEMN(I) = WW/3.00	00017400
ISN 0066	600 CONTINUE	00017500
	C INITIAL BOUNDARY TEMP. OF NODE	00017600
ISN 0067	DO 700 I = 1, NNDU	00017700
ISN 0068	WH = 0.00	00017800
ISN 0069	NP = NP2P(I)	00017900
ISN 0070	IF (NP.NE.0) WW = TEON(NP)	00018000
ISN 0072	TP2P(I) = WW	00018100
ISN 0073	700 CONTINUE	00018200
	C INITIAL HEAT-FLUX & ITS CALCULATION TABLE	00018300
ISN 0074	NQIN = 0	00018400
ISN 0075	DO 1000 N = 1, NNDU	00018500
ISN 0076	ISN = 0	00018600
ISN 0077	QQ = QINT(N)	00018700
ISN 0078	QW = 0.00	00018800
ISN 0079	DO 800 I = 1, 5	00018900
ISN 0080	IS = NP5C(I)	00019000
ISN 0081	IF (IS.EQ.0) GO TO 800	00019100
ISN 0083	WH = QIN(I,N)	00019200
ISN 0084	IF (WH.EQ.0.00) GO TO 800	00019300
		00019400
		00019500

ISN 0086		WQ = FLXQ(I)	00019600
ISN 0087		ISW = 1	00019700
ISN 0088		QW = QW + WW*WQ	00019800
ISN 0089	800	CONTINUE	00019900
ISN 0090		IF (ISW.EQ.0) GO TO 900	00020000
ISN 0092		QQ = QW	00020100
ISN 0093		NQIN = NQIN + 1	00020200
ISN 0094		M = N	00020210
ISN 0095		IF (NPIS(N).NE.0) M = -N	00020300
ISN 0097		NQIP(NQIN) = M	00020400
ISN 0098		BVEC(N) = QQ	00020500
ISN 0099		GO TO 1000	00020600
ISN 0100	900	CONTINUE	00020700
ISN 0101		BVEC(N) = QQ	00020800
ISN 0102		IF (NPIS(N).EQ.0) GO TO 1000	00020900
ISN 0104		NQIN = NQIN + 1	00021000
ISN 0105		NQIP(NQIN) = -N	00021100
ISN 0106	1000	CONTINUE	00021200
	C		00021300
	C	ADD BVECTOR INITIAL Q (AT T = DLTN/20)	00021400
ISN 0107		DO 1200 I = 1, 5	00021500
ISN 0108		IS = NPIC(I)	00021600
ISN 0109		IF (IS.EQ.0) GO TO 1200	00021700
ISN 0111		WW = QEXN(I)	00021800
ISN 0112		DO 1100 N = 1, NNDU	00021900
ISN 0113		BVEC(N) = BVEC(N) + WW*QEXL(I,N)	00022000
ISN 0114	1100	CONTINUE	00022100
ISN 0115	1200	CONTINUE	00022200
	C		00022300
	C	ADD BVECTOR DIFFUSION TERM & RADIATION TERM	00022400
ISN 0116		WW = 20.DO/DLTN	00022410
ISN 0117		DO 1400 N = 1, NNDU	00022500
ISN 0118		NS = NPNN(N)	00022600
ISN 0119		W1 = 0.00	00022700
ISN 0120		DO 1300 I = 1, NS	00022800
ISN 0121		NP = NPND(I,N)	00022900
ISN 0122		TS = TNNW(NP)	00023000
ISN 0123		TD = TPTR(NP)	00023100
ISN 0124		W1 = W1 + WW*PMAT(I,N)*TS	00023200
ISN 0125		W1 = W1 + AMAT(I,N)*TD	00023300
ISN 0126	1300	CONTINUE	00023400
ISN 0127		BVEC(N) = BVEC(N) + W1	00023500
ISN 0128	1400	CONTINUE	00023600
	C		00023700
	C	INITIAL DERIVATIVE VALUE SET	00023800
ISN 0129		DO 1500 I = 1, NNDU	00023900
ISN 0130		J = NPIS(I)	00023910
ISN 0131		IF (J.NE.0) GRIM(I) = TD20(J)	00023920
ISN 0133	1500	CONTINUE	00023930
ISN 0134		DO 2000 I = 1, 9	00024000
ISN 0135		DO 1900 J = 1, NNDU	00024100
ISN 0136		HMAT(I,J) = DMAT(I,J) + AMAT(I,J) + WW*PMAT(I,J)	00024200
ISN 0137	1900	CONTINUE	00024300
ISN 0138	2000	CONTINUE	00024400
	C	WRITE(NH,6950) (BVEC(I),I=1,NNDU)	00024410
	C6950	FORMAT('0BVEC'/(I10D11.4))	00024420
	C	WRITE(NH,6960) (I, (HMAT(J,I), J=1,9), I=1, NNDU)	00024430
	C6960	FORMAT('0HMAT'/(I5,1P9D11.4/))	00024440

	C		00024500
ISN 0139	C	CALL CGHOM(HMAT,GRTM,BVEC,PVEC,RVEC,APVC)	00024600
ISN 0140	C	IF (IERR.NE.0) GO TO 9000	00024700
	C		00024800
	C	WRITE(NW,6900) (GRTM(I),I=1,NNDU)	00024900
	C	FORMAT('DEFIRST TEMP'/(IPIOD11.4))	00024910
ISN 0142		DO 2050 I = 1 , NNDU	00024920
ISN 0143		GRTM(I) = WW*(GRTM(I) - TNNW(I))	00024930
ISN 0144	2050	CONTINUE	00024940
	C	WRITE(NW,6920) (GRTM(I),I=1,NNDU)	00024950
	C	FORMAT('OFIRST DERIVATIVE'/(IPIOD11.4))	00024960
ISN 0145		WW = 2.00/DLTN	00024970
ISN 0146		DO 2100 I = 1 , NNDU	00025000
ISN 0147		GRTM(I) = GRTM(I) + WW*TNNW(I)	00025100
ISN 0148	2100	CONTINUE	00025200
	C		00025300
	C	HEAT RADIATION CALC. TABLE SET	00025400
ISN 0149		NDFN = 0	00025500
ISN 0150		DO 2300 J = 1 , NNDU	00025600
ISN 0151		ISW = 0	00025700
ISN 0152		DO 2200 I = 1 , 9	00025800
ISN 0153		WW = AMAT(I,J)	00025900
ISN 0154		IF (WW.NE.0.00) ISW = 1	00026000
ISN 0155	2200	CONTINUE	00026100
ISN 0157		IF (ISW.EQ.0) GO TO 2300	00026200
ISN 0159		NDFN = NDFN + 1	00026300
ISN 0160		NDFP(NDFN) = J	00026400
ISN 0161	2300	CONTINUE	00026500
	C		00026600
	C	HEAT CONDUCTION MATRIX SET	00026700
ISN 0162		WW = 2.00/DLTN	00026800
ISN 0163		DO 2500 J = 1 , NNDU	00026900
ISN 0164		DO 2400 I = 1 , 9	00027000
ISN 0165		HMAT(I,J) = DMAT(I,J) + WW*PMAT(I,J) + AMAT(I,J)	00027100
ISN 0166	2400	CONTINUE	00027200
ISN 0167	2500	CONTINUE	00027300
	C		00027400
	C		00027500
	C		00027600
ISN 0168		IF (NSSC.EQ.0) GO TO 9900	00027700
	C		00027800
	C	INITIAL STRESS SET (AVERAGE VALUE ON ELEMENT)	00027900
ISN 0170		CALL DATA(STRS,SINT,4000)	00028000
ISN 0171		DO 2700 J = 1 , NNDU	00028100
ISN 0172		NE = NPEN(J)	00028200
ISN 0173		W1 = 0.00	00028300
ISN 0174		W2 = 0.00	00028400
ISN 0175		W3 = 0.00	00028500
ISN 0176		W4 = 0.00	00028600
ISN 0177		DO 2600 I = 1 , NE	00028700
ISN 0178		IE = NPEN(I,J)	00028800
ISN 0179		W1 = W1 + STRS(1,IE)	00028900
ISN 0180		W2 = W2 + STRS(2,IE)	00029000
ISN 0181		W3 = W3 + STRS(3,IE)	00029100
ISN 0182		W4 = W4 + STRS(4,IE)	00029200
ISN 0183	2600	CONTINUE	00029300
ISN 0184		WW = 1.00/NE	00029400
ISN 0185		SSND(1,J) = W1*WW	00029500

ISN 0186	SSND(2,J) = W2*WW	00029600
ISN 0187	SSND(3,J) = W3*WW	00029700
ISN 0188	SSND(4,J) = W4*WW	00029800
ISN 0189	2700 CONTINUE	00029900
	C	00030000
	C REACTION CALC. TABLE SET	00030100
ISN 0190	NRFN = 0	00030200
ISN 0191	DO 2800 I = 1, NNDU	00030300
ISN 0192	I1 = I*2 - 1	00030400
ISN 0193	I2 = I*2	00030500
ISN 0194	NB = NBDC(I1) + NBDC(I2)	00030600
ISN 0195	IF (NB.EQ.0) GO TO 2800	00030700
ISN 0197	NRFN = NRFN + 1	00030800
ISN 0198	NRFN(NRFN) = I	00030900
ISN 0199	2800 CONTINUE	00031000
ISN 0200	GO TO 9900	00031030
	C	00031100
	C ERROR.... FIRST DERIVATIVE SOLUTION	00031200
	C	00031300
ISN 0201	9000 CONTINUE	00031400
ISN 0202	WRITE(NH,6000)	00031500
ISN 0203	6000 FORMAT(' *ERROR INITIAL DERIVATIVE(TEMP.) IS NOT SOLVED.*')	00031600
	C	00031700
ISN 0204	9900 CONTINUE	00031800
ISN 0205	RETURN	00031900
ISN 0206	END	00032000

ISN 0002	SUBROUTINE PRPCH	00000100
C.....		00000200
C.....	IN HEAT CONDUCTION CALC.	00000300
C.....		00000400
C.....	NEW TIME STEP PHYSICAL QUANTITY SET	00000500
C.....		00000600
C.....		00000700
ISN 0003	IMPLICIT REAL*8(A-H,O-Z) , INTEGER*4(I-N)	00000800
ISN 0004	COMMON /CONTLI/NSSC,NPSS,NICL,NZCL,NIPR,NZPR,IERR,NCLS,LCNT,	00000900
1	NITT,NIT1,NIT2,IPGE	00001000
2	/CONTLR/OLTI,OLT2,CGHC,CGSC,TITL(10),AREA,DLTN,TIME	00001100
ISN 0005	COMMON /BUSSEI/NPT1,NPT2,NPIC(5),NP2C(5),NP1E(5)	00001200
1	/BUSSEI/DCFT(5),DENC(5),SPHT(5),CLEP(5),QEX1(5),QEX2(5),	00001300
2	CEXP(5),CPSN(5),ENG1(5),ENG2(5),CENG(5),CEMT(6)	00001400
ISN 0006	COMMON /NODEI /NNDU,NDDF,NDDN(500),NDNS(1000),NPIS(500),NPPI(500),	00001500
1	NBDC(1000),NPEN(500),NPEL(8,500),NPNN(500),	00001600
2	NPND(9,500)	00001700
3	/NODER /XCDN(500),YCDN(500),TINT(500),QINT(500)	00001800
ISN 0007	COMMON /ELMNTI/NELU,NELD(1000),NELS(1500),NNME(3,1000),	00001900
1	NPTE(1000),NPFM(3,1000),NPEI(3,1000)	00002000
2	/ELMNTI/SINT(4,1000)	00002100
ISN 0008	COMMON /NDTMP1/NPT3,NP3C(5)	00002200
1	/NDTMPR/TES1(5),TES2(5),TPRS(5),TPHS(5)	00002300
ISN 0009	COMMON /BDTMP1/NPT4,NP4C(5)	00002400
1	/BDTMPR/TE1P(5),TE2P(5),TPRP(5),TPHP(5)	00002500
ISN 0010	COMMON /HTFLXI/NPTS,NP5C(5)	00002600
1	/HTFLXR/EINI(5),EIN2(5),EPRQ(5),EPHS(5),CEIN(5)	00002700
ISN 0011	COMMON /STRESR/DNRM(3,3,5),ELMC(7,1000),STFE(18,1000,2),	00002800
1	STFX(18,1000),STFM(18,1000),FVEC(1000),DPLC(1000),	00002900
2	TENW(1000),TELD(1000),STRS(4,1000),STRN(4,1000)	00003000
ISN 0012	COMMON /HEATR /DMAT(9,500),PMAT(9,500),AMAT(9,500),QEXL(5,500),	00003100
1	QINL(5,500),HMAT(9,500),BVEC(500),TNNW(500),	00003200
2	TNLD(500),GR TM(500),TPTR(500),QTFX(500)	00003300
ISN 0013	COMMON /WORKR /PVEC(1000),RVEC(1000),APVC(1000),SSWK(4,500),	00003400
1	SRWK(4,500),QEXN(5),ENMN(5),ENMP(5),TEMN(5),	00003500
2	TEON(5),ELXQ(5)	00003600
ISN 0014	COMMON /OUTPTI/NOIN,NQIP(500),NDFN,NDFP(500),NRFN,NRFP(500)	00003700
1	/OUTPTR/QTVI(500),QDFV(500),RECV(2,500),FLND(2,500),	00003800
2	FLLE(2,1000),SSND(4,500),SRND(4,500)	00003900
C		00003910
ISN 0015	DIMENSION WTMP(500)	00003920
C		00003930
C		00004000
ISN 0016	PAI2 = 2.00*3.141592653500	00004010
ISN 0017	CALL DVALUE(WTMP,NNDU,0.00)	00004020
C		00004100
C	TEMP VECTOR AT NODE	00004200
ISN 0018	DO 100 I = 1 , NNDU	00004300
ISN 0019	TNLO(I) = TNNW(I)	00004400
ISN 0020	100 CONTINUE	00004500
C		00004600
C	TEMP VECTOR ON ELEMENT	00004700
ISN 0021	DO 200 I = 1 , NELU	00004800

ISN 0022	TELD(I) = TENW(I)	00004900
ISN 0023	200 CONTINUE	00005000
	C	00005100
	C YOUNG RITSU	00005200
ISN 0024	DO 300 I = 1, 5	00005300
ISN 0025	ENMP(I) = ENMN(I)	00005400
ISN 0026	300 CONTINUE	00005500
	C	00005600
	C NEW TIME STEP QUANTITY	00005700
	C	00005800
	C MATSU-NETSU-RYO Q & YOUNG-RITSU	00005900
ISN 0027	DO 400 I = 1, 5	00006000
ISN 0028	J = NPIC(I)	00006100
ISN 0029	IF (J.EQ.0) GO TO 400	00006200
ISN 0031	WW = -CEXP(I)*TIME	00006300
ISN 0032	QEXN(I) = QEX1(I) + QEX2(I)*DEXP(WW)	00006400
ISN 0033	ENMN(I) = ENGL(I)	00006500
ISN 0034	J = NPIC(I)	00006600
ISN 0035	IF (J.EQ.0) GO TO 400	00006700
ISN 0037	WW = -CENG(I)*TIME	00006800
ISN 0038	ENMN(I) = ENMN(I) + ENG2(I)*DEXP(WW)	00006900
ISN 0039	400 CONTINUE	00007000
	C	00007100
	C NODE TEMP.	00007200
ISN 0040	DO 500 I = 1, 5	00007300
ISN 0041	J = NP3C(I)	00007400
ISN 0042	IF (J.EQ.0) GO TO 500	00007500
ISN 0044	PH = PAI2*TIME/TPRS(I) + TPRS(I)	00007600
ISN 0045	TEMN(I) = TES1(I) + TES2(I)*DCOS(PH)	00007700
ISN 0046	500 CONTINUE	00007800
	C	00007900
	C NODE BOUNDARY TEMP.	00008000
ISN 0047	DO 600 I = 1, 5	00008100
ISN 0048	J = NP4C(I)	00008200
ISN 0049	IF (J.EQ.0) GO TO 600	00008300
ISN 0051	PH = PAI2*TIME/TPRP(I) + TPRP(I)	00008400
ISN 0052	TEON(I) = TE1P(I) + TE2P(I)*DCOS(PH)	00008500
ISN 0053	600 CONTINUE	00008600
	C	00008700
	C HEAT FLUX	00008800
ISN 0054	DO 700 I = 1, 5	00008900
ISN 0055	J = NP5C(I)	00009000
ISN 0056	IF (J.EQ.0) GO TO 700	00009100
ISN 0058	PH = PAI2*TIME/EPRQ(I) + EPHS(I)	00009200
ISN 0059	WW = -CEIN(I)*TIME	00009300
ISN 0060	FLXQ(I) = EIN1(I)*DCOS(PH) + EIN2(I)*DEXP(WW)	00009400
ISN 0061	700 CONTINUE	00009500
	C	00009600
	C BVEC SET	00009700
ISN 0062	DO 800 I = 1, NNDU	00009800
ISN 0063	WW = 0.00	00009900
ISN 0064	NP = NPTP(I)	00010000
ISN 0065	IF (NP.NE.0) WW = TEON(NP)	00010100
ISN 0067	TPTR(I) = WW	00010200
ISN 0068	800 CONTINUE	00010300
	C	00010400
ISN 0069	CALL DVALUE(BVEC,NNDU,0.00)	00010500
	C	00010600

ISN 0070	DO 1000 J = 1, 5	00010700
ISN 0071	IP = NP5C(J)	00010800
ISN 0072	IF (IP.EQ.0) GO TO 1000	00010900
ISN 0074	WM = FLXQ(J)	00011000
ISN 0075	DO 900 I = 1, NNDU	00011100
ISN 0076	BVEC(I) = BVEC(I) + WM*QINL(J,I)	00011200
ISN 0077	900 CONTINUE	00011300
ISN 0078	1000 CONTINUE	00011400
	C	00011500
ISN 0079	DO 1200 J = 1, 5	00011600
ISN 0080	IP = NP1C(J)	00011700
ISN 0081	IF (IP.EQ.0) GO TO 1200	00011800
ISN 0083	WM = QEXN(J)	00011900
ISN 0084	DO 1100 I = 1, NNDU	00012000
ISN 0085	BVEC(I) = BVEC(I) + WM*QEXL(J,I)	00012100
ISN 0086	1100 CONTINUE	00012200
ISN 0087	1200 CONTINUE	00012300
	C	00012400
ISN 0088	IF (N1CL.EQ.0) GO TO 1270	00012410
ISN 0090	IF (N1T2.NE.1) GO TO 1270	00012420
ISN 0092	WM = 2.00/DLT2 - 2.00/DLT1	00012430
ISN 0093	DO 1250 I = 1, NNDU	00012440
ISN 0094	WTMP(I) = WM*TNWK(I)	00012450
ISN 0095	1250 CONTINUE	00012460
	C	00012470
ISN 0096	1270 CONTINUE	00012480
ISN 0097	DO 1400 J = 1, NNDU	00012500
ISN 0098	NN = NPNN(J)	00012600
ISN 0099	W1 = 0.00	00012700
ISN 0100	DO 1300 I = 1, NN	00012800
ISN 0101	NP = NPND(I,J)	00012900
ISN 0102	W1 = W1 + AMAT(I,J)*TPTR(NP)	00013000
ISN 0103	W1 = W1 + PMAT(I,J)*(GRTH(NP) + WTMP(NP))	00013100
ISN 0104	1300 CONTINUE	00013200
ISN 0105	BVEC(J) = BVEC(J) + W1	00013300
ISN 0106	1400 CONTINUE	00013400
	C	00013410
	WRITE(MW,6900) (I,BVEC(I),I=1,NNDU)	00013420
	C6900 FORMAT(' ',15,5X,1PD11.4)	00013430
	C	00013500
	C	00013600
ISN 0107	IF (N1CL.EQ.0) GO TO 1700	00013700
ISN 0109	IF (N1T2.NE.1) GO TO 1700	00013800
	C	00013900
	C A_MATRIX (A*X = B) MODIFICATION DLT1 --- DLT2	00014000
	C	00014100
ISN 0111	WM = 2.00/DLT2 - 2.00/DLT1	00014200
ISN 0112	DO 1600 J = 1, NNDU	00014300
ISN 0113	DO 1500 I = 1, 9	00014400
ISN 0114	HMAT(I,J) = HMAT(I,J) + WM*PMAT(I,J)	00014500
ISN 0115	1500 CONTINUE	00014600
ISN 0116	1600 CONTINUE	00014700
	C	00014800
	C GIVEN NODE TEMP. UPDATE	00014900
ISN 0117	1700 CONTINUE	00015000
ISN 0118	DO 1800 I = 1, NNDU	00015100
ISN 0119	J = NPIS(I)	00015200
ISN 0120	IF (J.EQ.0) GO TO 1800	00015300

ISN 0122	TNNM(I) = TEMN(J)	00015400
ISN 0123	1800 CONTINUE	00015500
	C	00015600
	C	00015700
ISN 0124	RETURN	00015800
ISN 0125	END	00015900

ISN 0002	SUBROUTINE PRPCD	00016000
C.....		00016100
C.....	IN THERMAL STRESS CALC. A*X = B	00016200
C.....		00016300
C.....	SET MATRIX A & VECTOR B AT NEW TIME STEP	00016400
C.....		00016500
C.....	AND CALCULATE THERMAL STRESS	00016600
C.....		00016700
ISN 0003	IMPLICIT REAL*8(A-H,O-Z) , INTEGER*4(I-N)	00016800
ISN 0004	COMMON /CONTL1/NSSC,NESS,NICL,NZCL,N1PR,N2PR,IERR,NGLS,LCNT,	00016900
1	NITF,NIT1,NIT2,IPGE	00017000
2	/CONTLR/DLT1,DLT2,CGHC,CGSC,TITL(10),AREA,DLTN,TIME	00017100
ISN 0005	COMMON /BUSSET/NPT1,NPT2,NPIC(5),NP2C(5),NP1E(5)	00017200
1	/BUSSEI/DGEI(5),DENC(5),SPHT(5),CLEP(5),QEX1(5),QEX2(5),	00017300
2	CEXP(5),CPSN(5),ENG1(5),ENG2(5),CENG(5),CEMT(6)	00017400
ISN 0006	COMMON /NODEI /NNDU,NDOP,NDNQ(500),NDMS(1000),NETS(500),NETP(500),	00017500
1	NBOC(1000),NPEN(500),NPEL(8,500),NPNN(500),	00017600
2	NEND(2,500)	00017700
3	/NODER /XCDN(500),YCDN(500),TINT(500),QINT(500)	00017800
ISN 0007	COMMON /ELMNTI/NELL,NELQ(1000),NELS(1500),NMME(3,1000),	00017900
1	NPE(1000),NPEM(3,1000),NPEI(3,1000)	00018000
2	/ELMNTI/SINT(4,1000)	00018100
ISN 0008	COMMON /NDTMP/NPT3,NP3C(5)	00018200
1	/NDTMP/TEST1(5),TES2(5),TPRS(5),TPHS(5)	00018300
ISN 0009	COMMON /BDTMP/NPT4,NP4C(5)	00018400
1	/BDTMP/TEIP(5),TE2P(5),TPRP(5),TPHP(5)	00018500
ISN 0010	COMMON /HTFLX/NPT5,NP5C(5)	00018600
1	/HTFLXR/EIN1(5),EIN2(5),EPRQ(5),EPHS(5),CEIN(5)	00018700
ISN 0011	COMMON /STRESS/DNRM(3,5),ELMC(7,1000),STFE(18,1000,2),	00018800
1	STFX(18,1000),STEM(18,1000),FVEC(1000),DPLC(1000),	00018900
2	TENN(1000),TELD(1000),STRS(4,1000),STRN(4,1000)	00019000
ISN 0012	COMMON /HEATR /DMAT(2,500),PHAT(2,500),AMAT(2,500),QEXL(5,500),	00019100
1	QINL(5,500),HMAT(2,500),BVEC(500),TNNH(500),	00019200
2	TNLD(500),GRTH(500),TPTR(500),QTEX(500)	00019300
ISN 0013	COMMON /WORKR /PVEC(1000),RVEC(1000),APVC(1000),SSWK(4,500),	00019400
1	SRWK(4,500),QEXN(5),ENMN(5),ENMP(5),TEMN(5),	00019500
2	TEON(5),FLXQ(5)	00019600
ISN 0014	COMMON /OUTPTI/NOIN,NPIP(500),NDEN,NDOP(500),NREN,NREP(500)	00019700
1	/OUTPTR/QIVL(500),QDFV(500),RFCV(2,500),FLND(2,500),	00019800
2	ELEL(2,1000),SSND(4,500),SRND(4,500)	00019900
C		00020000
C	STIFFNESS MATRIX SET	00020100
ISN 0015	CALL DATA(STFM,STFX,18000)	00020200
C		00020300
ISN 0016	DO 300 NP = 1 , 5	00020400
ISN 0017	NS = NPIC(NP)	00020500
ISN 0018	IF (NS.EQ.0) GO TO 300	00020600
ISN 0020	ENG = ENMN(NS)	00020700
ISN 0021	IP = NP1E(NP)	00020800
ISN 0022	IF (IP.EQ.0) GO TO 300	00020900
ISN 0024	DO 200 I = 1 , NOOF	00021000
ISN 0025	DO 100 J = 1 , 18	00021100
ISN 0026	STFM(J,I) = STFM(J,I) + STFE(J,I,IP)*ENG	00021200

ISN 0027	100	CONTINUE	00021300
ISN 0028	200	CONTINUE	00021400
ISN 0029	300	CONTINUE	00021500
	C		00021600
	C	STRESS & LOAD VECTOR SET	00021700
ISN 0030		CALL DVALUE(FVEC,1000,0.00)	00021800
ISN 0031		CALL DVALUE(SSWK,1000,0.00)	00021900
ISN 0032		DO 400 NE = 1, NELU	00022000
ISN 0033		IP = NNME(1,NE)	00022100
ISN 0034		JP = NNME(2,NE)	00022200
ISN 0035		KP = NNME(3,NE)	00022300
ISN 0036		TD = TELD(NE) - TENW(NE)	00022400
	C		00022500
ISN 0037		NP = NPTE(NE)	00022600
ISN 0038		CM = CPSN(NP)	00022700
ISN 0039		EA = 0.500*(ENMN(NP) + ENMP(NP))	00022800
ISN 0040		AL = CLEP(NP)	00022900
ISN 0041		W1 = 1.00 - CM	00023000
ISN 0042		IF (NPSS.EQ.1) W1 = W1 - CM	00023100
ISN 0044		SX = TD*AL*EA/W1	00023200
ISN 0045		SY = SX	00023300
ISN 0046		SZ = 0.00	00023400
ISN 0047		IF (NPSS.EQ.1) SZ = SX	00023500
	C		00023600
ISN 0049		STRS(1,NE) = STRS(1,NE) + SX	00023700
ISN 0050		STRS(2,NE) = STRS(2,NE) + SY	00023800
ISN 0051		STRS(3,NE) = STRS(3,NE) + SZ	00023900
	C		00024000
ISN 0052		SSWK(1,IP) = SSWK(1,IP) + SX	00024100
ISN 0053		SSWK(2,IP) = SSWK(2,IP) + SY	00024200
ISN 0054		SSWK(3,IP) = SSWK(3,IP) + SZ	00024300
ISN 0055		SSWK(1,JP) = SSWK(1,JP) + SX	00024400
ISN 0056		SSWK(2,JP) = SSWK(2,JP) + SY	00024500
ISN 0057		SSWK(3,JP) = SSWK(3,JP) + SZ	00024600
ISN 0058		SSWK(1,KP) = SSWK(1,KP) + SX	00024700
ISN 0059		SSWK(2,KP) = SSWK(2,KP) + SY	00024800
ISN 0060		SSWK(3,KP) = SSWK(3,KP) + SZ	00024900
	C		00025000
ISN 0061		DL = ELMC(7,NE)	00025100
ISN 0062		W1 = -SX*DL	00025200
ISN 0063		W2 = -SY*DL	00025300
	C		00025400
ISN 0064		IY = 2*IP	00025500
ISN 0065		IX = IY - 1	00025600
ISN 0066		JY = 2*JP	00025700
ISN 0067		JX = JY - 1	00025800
ISN 0068		KY = 2*KP	00025900
ISN 0069		KX = KY - 1	00026000
	C		00026100
ISN 0070		FVEC(IX) = FVEC(IX) + W1*ELMC(1,NE)	00026200
ISN 0071		FVEC(JX) = FVEC(JX) + W1*ELMC(2,NE)	00026300
ISN 0072		FVEC(KX) = FVEC(KX) + W1*ELMC(3,NE)	00026400
ISN 0073		FVEC(IY) = FVEC(IY) + W2*ELMC(4,NE)	00026500
ISN 0074		FVEC(JY) = FVEC(JY) + W2*ELMC(5,NE)	00026600
ISN 0075		FVEC(KY) = FVEC(KY) + W2*ELMC(6,NE)	00026700
ISN 0076		400 CONTINUE	00026800
	C		00026900
	C		00027000

ISN 0077 RETURN
ISN 0078 END

00027100
00027200

ISN 0002	SUBROUTINE CGHOH(A,X,B,P,R,AP)	00000100
C.....		00000200
C.....	SOLVE A*X = B BY C-G METHOD	00000300
C.....		00000400
C.....	(X NODE TEMPERATURE)	00000500
C.....		00000600
ISN 0003	IMPLICIT REAL*8(A-H,O-Z) , INTEGER*4(I-N)	00000700
ISN 0004	COMMON /CONTL/NSSC,NPSS,NJCL,NZCL,NIPR,NZPR,IERR,NCLS,LCNT,	00000800
1	NTTT,NTT1,NTT2,TPGE	00000900
2	/CONTLR/DLT1,DLT2,CGHC,CGSC,TITL(10),AREA,DLTN,TIME	00001000
ISN 0005	COMMON /BUSSEI/NPT1,NPT2,NP1C(5),NP2C(5),NP1E(5)	00001100
1	/BUSSEI/DCET(5),DENC(5),SPHT(5),CLEP(5),QEXI(5),QEX2(5),	00001200
2	CEXP(5),CPSN(5),ENGI(5),ENG2(5),CENG(5),CEMT(6)	00001300
ISN 0006	COMMON /NODEI /NNDU,NDOE,NDDN(500),NDNS(1000),NPTS(500),NPPT(500),	00001400
1	NBDC(1000),NPEH(500),NPEL(8,500),NPNN(500),	00001500
2	NPND(9,500)	00001600
3	/NODER /XCDN(500),YCDN(500),TINT(500),QINT(500)	00001700
ISN 0007	COMMON /ELMNTI/NELU,NELQ(10,00),NELS(1500),NNME(3,1000),	00001800
1	NPTE(1000),NPEH(3,1000),NPEI(3,1000)	00001900
2	/ELMNTI/SINT(4,1000)	00002000
ISN 0008	COMMON /NDTMPI/NPT3,NP3C(5)	00002100
1	/NDTMPI/TES1(5),TES2(5),TPRS(5),TPHS(5)	00002200
ISN 0009	COMMON /BDTMPI/NPT4,NP4C(5)	00002300
1	/BDTMPI/TE1P(5),TE2P(5),TPRP(5),TPHP(5)	00002400
ISN 0010	COMMON /HTFLXI/NPT5,NP5C(5)	00002500
1	/HTFLXI/EIN1(5),EIN2(5),EPRQ(5),EPHS(5),CEIN(5)	00002600
ISN 0011	COMMON /STRESR/DNRM(3,3,5),ELMC(7,1000),STFE(18,1000,2),	00002700
1	STFX(18,1000),STEM(18,1000),FVEC(1000),DPLC(1000),	00002800
2	TENW(1000),TELD(1000),STRS(4,1000),STRN(4,1000)	00002900
ISN 0012	COMMON /HEATR /DMAT(9,500),PMAT(9,500),AMAT(9,500),QEXL(5,500),	00003000
1	QINL(5,500),HMAT(9,500),BVEC(500),TNNW(500),	00003100
2	TNLD(500),GRTM(500),TPTR(500),STFX(500)	00003200
ISN 0013	COMMON /WORKR /PVEC(1000),RVEC(1000),APVC(1000),SSWK(4,500),	00003300
1	SRWK(4,500),QEXN(5),ENMN(5),ENMP(5),TEMN(5),	00003400
2	TEON(5),FLXO(5)	00003500
ISN 0014	COMMON /OUTPTI/NQIN,NQIP(500),NDEN,NDFP(500),NRFN,NRFP(500),	00003600
1	/OUTPTR/QIVL(500),QDFV(500),RCV(2,500),FLND(2,500),	00003700
2	FLFL(2,1000),SSND(4,500),SRND(4,500)	00003800
ISN 0015	DIMENSION A(9,1),X(1),B(1),P(1),R(1),AP(1)	00003900
C		00003910
C		00003920
ISN 0016	NW = 6	00003930
C		00004000
C	P1 , R1 = R - A*X1 AND (P1,R1) SET	00004100
C		00004200
ISN 0017	PRW = 0.00	00004300
ISN 0018	DO 300 NN = 1 , NNDU	00004400
ISN 0019	NS = NPNN(NN)	00004500
ISN 0020	NP = NPTS(NN)	00004600
ISN 0021	IF (NP.NE.0) GO TO 200	00004700
ISN 0023	W1 = B(NN)	00004800
ISN 0024	DO 100 I = 1 , NS	00004900
ISN 0025	NT = NPND(I,NN)	00005000

ISN 0026		W1 = W1 - A(Y,NN)*X(NT)	00005100
ISN 0027	100	CONTINUE	00005200
ISN 0028	200	CONTINUE	00005300
ISN 0029		IF (NP.NE.0) W1 = 0.00	00005400
ISN 0031		P(NN) = W1	00005500
ISN 0032		R(NN) = W1	00005600
ISN 0033		PRW = PRW + W1*W1	00005700
ISN 0034	300	CONTINUE	00005800
	C		00005900
ISN 0035		NIT = 0	00006000
ISN 0036	1000	CONTINUE	00006100
ISN 0037		NIT = NIT + 1	00006200
ISN 0038		IF (NIT.GT.NNDU) GO TO 7000	00006300
	C		00006400
	C	A*P AND (P,A*P) SET	00006500
ISN 0040		PAP = 0.00	00006600
ISN 0041		DO 1300 NN = 1, NNDU	00006700
ISN 0042		NS = NPNN(NN)	00006800
ISN 0043		NP = NPTS(NN)	00006900
ISN 0044		W1 = 0.00	00007000
ISN 0045		IF (NP.NE.0) GO TO 1200	00007100
ISN 0047		DO 1100 I = 1, NS	00007200
ISN 0048		NT = NPND(I,NN)	00007300
ISN 0049		W1 = W1 + A(I,NN)*P(NT)	00007400
ISN 0050	1100	CONTINUE	00007500
ISN 0051	1200	CONTINUE	00007600
ISN 0052		AP(NN) = W1	00007700
ISN 0053		PAP = PAP + W1*P(NN)	00007800
ISN 0054	1300	CONTINUE	00007900
	C		00008000
	C	ALPHA = (P,R)/(P,A*P) SET	00008100
ISN 0055		IF (PAP.EQ.0.00) GO TO 7500	00008200
ISN 0057		ALF = PRW/PAP	00008300
	C		00008400
	C	X(NEW) = X + ALF*P AND R(NEW) = R - ALF*A*P	00008500
ISN 0058		RAP = 0.00	00008600
ISN 0059		RRW = 0.00	00008700
ISN 0060		DO 1400 NN = 1, NNDU	00008800
ISN 0061		NP = NPTS(NN)	00008900
ISN 0062		IF (NP.NE.0) GO TO 1400	00009000
ISN 0064		W1 = X(NN) + ALF*P(NN)	00009100
ISN 0065		W2 = R(NN) - ALF*AP(NN)	00009200
ISN 0066		X(NN) = W1	00009300
ISN 0067		R(NN) = W2	00009400
ISN 0068		RAP = RAP + W2*AP(NN)	00009500
ISN 0069		RRW = RRW + W2*W2	00009600
ISN 0070	1400	CONTINUE	00009700
	C		00009800
ISN 0071		IF (RRW.LT.CGHC) GO TO 8000	00009900
	C		00010000
	C	BETA = -(R,A*P)/(P,A*P) AND P(ADD.1) = R + BETA*P SET	00010100
ISN 0073		BET = -RAP/PAP	00010200
ISN 0074		PRW = 0.00	00010300
ISN 0075		DO 1500 NN = 1, NNDU	00010400
ISN 0076		NP = NPTS(NN)	00010500
ISN 0077		IF (NP.NE.0) GO TO 1500	00010600
ISN 0079		W1 = R(NN)	00010700
ISN 0080		W2 = W1 + BET*P(NN)	00010800

ISN 0081	P(NN) = W2	00010900
ISN 0082	PRW = PRW + W1*W2	00011000
ISN 0083	1500 CONTINUE	00011100
	C	00011200
ISN 0084	GO TO 1000	00011300
	C	00011400
	C ERROR MESSAGE	00011500
	C	00011600
ISN 0085	7000 CONTINUE	00011700
ISN 0086	IERR = 1	00011710
ISN 0087	WRITE(NN,6000)	00011800
ISN 0088	6000 FORMAT(' *ERROR NOT CONVERGED IN SUBROUTINE CGH0H *')	00011900
ISN 0089	GO TO 8000	00012000
	C	00012100
ISN 0090	7500 CONTINUE	00012200
ISN 0091	IERR = 1	00012210
ISN 0092	WRITE(NN,6100)	00012300
ISN 0093	6100 FORMAT(' *ERROR (P,A*P) IS ZERO IN SUBROUTINE CGH0H *')	00012400
	C	00012500
	C	00012600
ISN 0094	8000 CONTINUE	00012700
ISN 0095	MW = 16	00012710
ISN 0096	WRITE(NN,6900) TIME , NIT , RRW	00012720
ISN 0097	6900 FORMAT('0*** TIME = ',1PD11.4/	00012730
	1 * NO. OF ITERATION IN CGH0H *.15/	00012740
	2 * RESIDUA (RRW) ',1PD11.4)	00012750
ISN 0098	RETURN	00012800
ISN 0099	END	00012900

ISN 0002	C.....	SUBROUTINE CGHOD(A,X,B,P,R,AP)	00013000
	C.....	SOLVE A*X = B BY C-G METHOD	00013100
	C.....	(X NODE DISPLACEMENT)	00013200
	C.....		00013300
	C.....		00013400
ISN 0003		IMPLICIT REAL*8(A-H,O-Z), INTEGER*4(I-N)	00013500
ISN 0004		COMMON /CONTL/NSSC,NPSS,N1CL,N2CL,N1PR,N2PR,TEPR,NCLS,LCNT,	00013600
	1	NITT,NITI,NIT2,IPGE	00013700
	2	/CONTLR/DLT1,DLT2,CGHC,CGSC,TITL(10),AREA,DLTN,TIME	00013800
ISN 0005		COMMON /BUSSEI/NPT1,NPT2,NPIC(5),NP2C(5),NP1E(5)	00013900
	1	/BUSSEI/OCET(5),DEHC(5),SPHT(5),CLEP(5),QEX1(5),QEX2(5),	00014000
	2	CEXP(5),CPSN(5),ENGL(5),ENG2(5),CENG(5),CEMT(6)	00014100
ISN 0006		COMMON /NODEI /NNDU,NDOE,NDOQ(500),NDNS(1000),NPTS(500),NPTP(500),	00014200
	1	NBDC(1000),NPEN(500),NPCL(8,500),NPNN(500),	00014300
	2	NPND(9,500)	00014400
	3	/NODER /XCON(500),YCON(500),TINT(500),QINT(500)	00014500
ISN 0007		COMMON /ELMNTI/NELU,NELO(1000),NELS(1500),NNMF(3,1000),	00014600
	1	NPTE(1000),NPEN(3,1000),NPEI(3,1000)	00014700
	2	/ELMNTI/SINT(4,1000)	00014800
ISN 0008		COMMON /NDTMP1/NPT3,NP3C(5)	00014900
	1	/NDTMP1/TEST1(5),TES2(5),TPRS(5),TPHS(5)	00015000
ISN 0009		COMMON /NDTMP1/NPT4,NP4C(5)	00015100
	1	/NDTMP1/TE1P(5),TE2P(5),TPRP(5),TPHP(5)	00015200
ISN 0010		COMMON /HTFLXI/NPT5,NP5C(5)	00015300
	1	/HTFLXI/EIN1(5),EIN2(5),EPRQ(5),EPHS(5),CEIN(5)	00015400
ISN 0011		COMMON /STRESR/DNRM(3,5),ELMC(7,1000),STFE(19,1000,2),	00015500
	1	STFX(18,1000),STFM(18,1000),FVEC(1000),DPLC(1000),	00015600
	2	TENW(1000),TELD(1000),STRS(4,1000),STRN(4,1000)	00015700
ISN 0012		COMMON /HEATR /DMAT(9,500),PMAT(9,500),AMAT(9,500),QEXL(5,500),	00015800
	1	QINL(5,500),HMAT(9,500),BVEC(500),TNNW(500),	00015900
	2	TNLD(500),GR TM(500),TPTR(500),QTFX(500)	00016000
ISN 0013		COMMON /MDRKR /PVEC(1000),R VEC(1000),APVC(1000),SSWK(4,500),	00016100
	1	SRWK(4,500),QEXN(5),ENMN(5),ENMP(5),TEMN(5),	00016200
	2	TEON(5),FLXQ(5)	00016300
ISN 0014		COMMON /OUTPTI/NQIN,NQIP(500),NDFN,NDFP(500),NRFN,NRFP(500)	00016400
	1	/OUTPTI/QIVL(500),QDFV(500),RFCV(2,500),FLND(2,500),	00016500
	2	FLFL(2,1000),SSND(4,500),SRND(4,500)	00016600
ISN 0015		DIMENSION A(18,1),X(1),B(1),P(1),R(1),AP(1)	00016700
	C		00016800
	C		00016810
ISN 0016		NW = 6	00016820
	C		00016830
	C	P1, R1 = 4 - A*X1 AND (P1,R1) SET	00016900
	C		00017000
ISN 0017		PRW = 0.00	00017100
ISN 0018		DO 500 NN = 1, NNDU	00017200
ISN 0019		IY = NN*2	00017300
ISN 0020		IX = IY - 1	00017400
ISN 0021		NX = NBDC(IX)	00017500
ISN 0022		NY = NBDC(IY)	00017600
ISN 0023		W1 = 0.00	00017700
ISN 0024		W2 = 0.00	00017800
			00017900

ISN 0025		NP = NPNN(NN)	00018000
	C		00018100
ISN 0026		IF (NX.EQ.1) GO TO 200	00018200
ISN 0028		DO 100 I = 1, NP	00018300
ISN 0029		I2 = I*2	00018400
ISN 0030		I1 = I2 - 1	00018500
ISN 0031		K2 = NPND(I,NN)*2	00018600
ISN 0032		K1 = K2 - 1	00018700
ISN 0033		W1 = W1 + A(I1,IX)*X(K1) + A(I2,IX)*X(K2)	00018800
ISN 0034	100	CONTINUE	00018900
ISN 0035		W1 = B(IX) - W1	00019000
	C		00019100
ISN 0036	200	CONTINUE	00019200
ISN 0037		IF (NY.EQ.1) GO TO 400	00019300
ISN 0039		DO 300 I = 1, NP	00019400
ISN 0040		I2 = I*2	00019500
ISN 0041		I1 = I2 - 1	00019600
ISN 0042		K2 = NPND(I,NN)*2	00019700
ISN 0043		K1 = K2 - 1	00019800
ISN 0044		W2 = W2 + A(I1,IY)*X(K1) + A(I2,IY)*X(K2)	00019900
ISN 0045	300	CONTINUE	00020000
ISN 0046		W2 = B(IY) - W2	00020100
	C		00020200
ISN 0047	400	CONTINUE	00020300
ISN 0048		P(IX) = W1	00020400
ISN 0049		R(IX) = W1	00020500
ISN 0050		P(IY) = W2	00020600
ISN 0051		R(IY) = W2	00020700
ISN 0052		PRW = PRW + W1*W1 + W2*W2	00020800
ISN 0053	500	CONTINUE	00020900
	C		00021000
	C		00021100
ISN 0054		NIT = 0	00021200
	C		00021300
ISN 0055	1000	CONTINUE	00021400
ISN 0056		NIT = NIT + 1	00021500
ISN 0057		IF (NIT.GT.NDOF) GO TO 7000	00021600
	C		00021700
	C	A*P AND (P,A*P) SET	00021800
ISN 0059		PAP = 0.00	00021900
ISN 0060		DO 1500 NN = 1, NNDO	00022000
ISN 0061		IY = 2*NN	00022100
ISN 0062		IX = IY - 1	00022200
ISN 0063		NX = NBDC(IX)	00022300
ISN 0064		NY = NBDC(IY)	00022400
ISN 0065		W1 = 0.00	00022500
ISN 0066		W2 = 0.00	00022600
ISN 0067		NP = NPNN(NN)	00022700
	C		00022800
ISN 0068		IF (NX.EQ.1) GO TO 1200	00022900
ISN 0070		DO 1100 I = 1, NP	00023000
ISN 0071		K2 = I*2	00023100
ISN 0072		K1 = K2 - 1	00023200
ISN 0073		I2 = NPND(I,NN)*2	00023300
ISN 0074		I1 = I2 - 1	00023400
ISN 0075		W1 = W1 + A(K1,IX)*P(I1) + A(K2,IX)*P(I2)	00023500
ISN 0076	1100	CONTINUE	00023600
	C		00023700

ISN 0077	1200	CONTINUE	00023800
ISN 0078		IF (NY.EQ.1) GO TO 1400	00023900
ISN 0080		DO 1300 I = 1, NP	00024000
ISN 0081		K2 = I*2	00024100
ISN 0082		K1 = K2 - 1	00024200
ISN 0083		I2 = NPND(I,NN)*2	00024300
ISN 0084		I1 = I2 - 1	00024400
ISN 0085		W2 = W2 + A(K1,IY)*P(I1) + A(K2,IY)*P(I2)	00024500
ISN 0086	1300	CONTINUE	00024600
	C		00024700
ISN 0087	1400	CONTINUE	00024800
ISN 0088		AP(IX) = W1	00024900
ISN 0089		AP(IY) = W2	00025000
ISN 0090		PAP = PAP + P(IX)*W1 + P(IY)*W2	00025100
ISN 0091	1500	CONTINUE	00025200
	C		00025300
	C	ALPHA = (P,R)/(P,A*P) SET	00025400
ISN 0092		IF (PAP.EQ.0.00) GO TO 7500	00025500
ISN 0094		ALF = PRW/PAP	00025600
	C		00025700
	C	X(NEW) = X + ALF*P AND R(NEW) = R - ALF*A*P	00025800
ISN 0095		RAP = 0.00	00025900
ISN 0096		RRW = 0.00	00026000
ISN 0097		DO 1700 NN = 1, NNDU	00026100
ISN 0098		IY = NN*2	00026200
ISN 0099		IX = IY - 1	00026300
ISN 0100		NX = NBDC(IX)	00026400
ISN 0101		NY = NBDC(IY)	00026500
	C		00026600
ISN 0102		IF (NX.EQ.1) GO TO 1600	00026700
ISN 0104		W1 = X(IX) + ALF*P(IX)	00026800
ISN 0105		W2 = R(IX) - ALF*AP(IX)	00026900
ISN 0106		X(IX) = W1	00027000
ISN 0107		R(IX) = W2	00027100
ISN 0108		RAP = RAP + W2*AP(IX)	00027200
ISN 0109		RRW = RRW + W2*W2	00027300
	C		00027400
ISN 0110	1600	CONTINUE	00027500
ISN 0111		IF (NY.EQ.1) GO TO 1700	00027600
ISN 0113		W1 = X(IY) + ALF*P(IY)	00027700
ISN 0114		W2 = R(IY) - ALF*AP(IY)	00027800
ISN 0115		X(IY) = W1	00027900
ISN 0116		R(IY) = W2	00028000
ISN 0117		RAP = RAP + W2*AP(IY)	00028100
ISN 0118		RRW = RRW + W2*W2	00028200
ISN 0119	1700	CONTINUE	00028300
	C		00028400
ISN 0120		IF (RRW.LT.CGSC) GO TO 8000	00028500
	C		00028600
	C	BETA = -(R,A*P)/(P,A*P) AND P(ADD 1) = R + BETA*P SET	00028700
ISN 0122		BET = -RAP/PAP	00028800
ISN 0123		PRW = 0.00	00028900
ISN 0124		DO 1900 NN = 1, NNDU	00029000
ISN 0125		IY = NN*2	00029100
ISN 0126		IX = IY - 1	00029200
ISN 0127		NX = NBDC(IX)	00029300
ISN 0128		NY = NBDC(IY)	00029400
	C		00029500

ISN 0129	IF (NX.EQ.1)	GO TO 1300	00029600
ISN 0131	W1 = R(IX)		00029700
ISN 0132	W2 = W1 + BET*P(IX)		00029800
ISN 0133	P(IX) = W2		00029900
ISN 0134	PRW = PRW + W1*W2		00030000
ISN 0135	C 1800 CONTINUE		00030100
ISN 0136	IF (NY.EQ.1)	GO TO 1900	00030200
ISN 0138	W1 = R(IY)		00030300
ISN 0139	W2 = W1 + BET*P(IY)		00030400
ISN 0140	P(IY) = W2		00030500
ISN 0141	PRW = PRW + W1*W2		00030600
ISN 0142	C 1900 CONTINUE		00030700
ISN 0143	C GO TO 1000		00030800
	C ERROR MESSAGE		00030900
	C		00031000
ISN 0144	C 7000 CONTINUE		00031100
ISN 0145	IERR = 1		00031200
ISN 0146	WRITE(MW,6000)		00031300
ISN 0147	6000 FORMAT(' *ERROR NOT CONVERGED IN SUBROUTINE CGHOD ')		00031400
ISN 0148	GO TO 8000		00031500
	C		00031600
ISN 0149	C 7500 CONTINUE		00031700
ISN 0150	IERR = 1		00031800
ISN 0151	WRITE(MW,6100)		00031900
ISN 0152	6100 FORMAT(' *ERROR (P,AP) IS ZERO IN SUBROUTINE CGHOD ')		00032000
	C		00032100
	C		00032200
ISN 0153	C 8000 CONTINUE		00032300
ISN 0154	MW = 16		00032400
ISN 0155	WRITE(MW,6900) NIT, RRW		00032500
ISN 0156	6900 FORMAT(' NO. OF ITERATION IN CGHOD ', I5/ ' RESIDUA (RRW) ', 1P011.4)		00032600
ISN 0157	RETURN		00032700
ISN 0158	END		00032800

ISN 0002	SUBROUTINE PSPCH		00000100
	C.....		00000200
	C.....	GRADIENT TERM & AVERAGE TEMP. SET	00000300
	C.....		00000400
	C.....	USING NEW TIME STEP TEMP. VECTOR	00000500
	C.....		00000600
	C		00000700
ISN 0003	IMPLICIT REAL*8(A-H,O-Z) , INTEGER*4(I-N)		00000800
ISN 0004	COMMON	/CONTLI/NSSC,NPSS,NICL,N2CL,N1PR,N2PR,TERR,NCLS,LCNT,	00000900
	1	NIIT,NIIT1,NIIT2,IPGE	00001000
	2	/CONTLR/DLT1,DLT2,CGHC,CGSC,TITL(10),AREA,DLTN,TIME	00001100
ISN 0005	COMMON	/BUSSEI/NPT1,NPT2,NPIC(5),NP2C(5),NP1E(5)	00001200
	1	/BUSSEI/OCFT(5),DENC(5),SPHT(5),CLEP(5),QEX1(5),QEX2(5),	00001300
	2	CEXP(5),CPSN(5),ENG1(5),ENG2(5),CENG(5),CEMT(6)	00001400
ISN 0006	COMMON	/NODEI /NNDU,NDOF,NDO(500),NDNS(1000),NPTS(500),NPTP(500),	00001500
	1	NBDC(1000),NPEN(500),NPEL(8,500),NPNN(500),	00001600
	2	NPND(9,500)	00001700
	3	/NODER /XCDN(500),YCDN(500),TINT(500),QINT(500)	00001800
ISN 0007	COMMON	/ELMNTI/NELU,NELO(1000),NELS(1500),NNME(3,1000),	00001900
	1	NPTE(1000),NPEM(3,1000),NPEI(3,1000)	00002000
	2	/ELMNTI/STNT(4,1000)	00002100
ISN 0008	COMMON	/NDTMP1/NPT3,NP3C(5)	00002200
	1	/NDTMPR/TES1(5),TES2(5),TPRS(5),TPHS(5)	00002300
ISN 0009	COMMON	/BDTMP1/NPT4,NP4C(5)	00002400
	1	/BDTMPR/TE1P(5),TE2P(5),TPRP(5),TPHP(5)	00002500
ISN 0010	COMMON	/HTFLXI/NPT5,NP5C(5)	00002600
	1	/HTFLXR/EINI(5),EIN2(5),EPRQ(5),EPHS(5),CEIN(5)	00002700
ISN 0011	COMMON	/STRESS/DNRM(3,3,5),ELMC(7,1000),STEE(18,1000,2),	00002800
	1	STFX(18,1000),STFM(18,1000),FVEC(1000),DPLC(1000),	00002900
	2	TENW(1000),TELO(1000),STRS(4,1000),STRN(4,1000)	00003000
ISN 0012	COMMON	/HEATR /DMAT(9,500),PMAT(9,500),AMAT(9,500),QEXL(5,500),	00003100
	1	QTNL(5,500),HMAT(9,500),BVEC(500),TNNW(500),	00003200
	2	TNLD(500),GRTH(500),TPTR(500),QTFX(500)	00003300
ISN 0013	COMMON	/WORKR /PVEC(1000),RVEC(1000),APVC(1000),SSWK(4,500),	00003400
	1	SRWK(4,500),QEXN(5),ENMN(5),ENMP(5),TEMN(5),	00003500
	2	TEON(5),FLXQ(5)	00003600
ISN 0014	COMMON	/OUTPTI/NOIN,NQIP(500),NDFN,NDFP(500),NRFN,NRFP(500)	00003700
	1	/OUTPTR/QIVL(500),QDEV(500),RECV(2,500),FLND(2,500),	00003800
	2	FLFL(2,1000),SSND(4,500),SRND(4,500)	00003900
	C		00004000
	C		00004100
ISN 0015	CALL DVALUE(QTEX,500,0.00)		00004200
ISN 0016	DO 200 I = 1 , 5		00004300
ISN 0017	IP = NPIC(I)		00004400
ISN 0018	IF (IP.EQ.0) GO TO 200		00004500
ISN 0020	WW = QEXN(I)		00004600
ISN 0021	DO 100 J = 1 , NNDU		00004700
ISN 0022	IS = NPTS(J)		00004800
ISN 0023	IF (IS.EQ.0) GO TO 100		00004900
ISN 0025	QTEX(I) = QTEX(I) - WW*QEXL(I,J)		00005000
ISN 0026	100	CONTINUE	00005100
ISN 0027	200	CONTINUE	00005200
	C		00005300

ISN 0028	DO 400 J = 1, NNDU	00005400
ISN 0029	IS = NPTS(J)	00005500
ISN 0030	IF (IS.EQ.0) GO TO 400	00005600
ISN 0032	NS = NPNN(J)	00005700
ISN 0033	W1 = 0.00	00005800
ISN 0034	DO 300 I = 1, NS	00005900
ISN 0035	NT = NPND(I,J)	00006000
ISN 0036	W1 = W1 + HMAT(I,J)*TNNW(NT)	00006100
ISN 0037	W1 = W1 - AMAT(I,J)*TPTR(NT)	00006200
ISN 0038	W1 = W1 - PMAT(I,J)*GRM(NT)	00006300
ISN 0039	300 CONTINUE	00006400
ISN 0040	QTFX(J) = QTFX(J) + W1	00006500
ISN 0041	400 CONTINUE	00006600
	C	00006700
	C	00006800
ISN 0042	W1 = 0.00	00006900
ISN 0043	WW = 4.00/DLTN	00007000
ISN 0044	IF (NIT2.EQ.1) W1 = 2.00/DLT1 - 2.00/DLT2	00007100
ISN 0046	DO 500 I = 1, NNDU	00007200
ISN 0047	GRM(I) = -GRM(I) + WW*TNNW(I) + W1*TNLD(I)	00007300
ISN 0048	500 CONTINUE	00007400
	C	00007500
	C	00007600
ISN 0049	WW = 1.00/3.00	00007700
ISN 0050	DO 600 I = 1, NELU	00007800
ISN 0051	IP = NNME(1,I)	00007900
ISN 0052	JP = NNME(2,I)	00008000
ISN 0053	KP = NNME(3,I)	00008100
ISN 0054	W1 = TNNW(IP) + TNNW(JP) + TNNW(KP)	00008200
ISN 0055	TENW(I) = W1*WW	00008300
ISN 0056	600 CONTINUE	00008400
	C	00008500
ISN 0057	RETURN	00008600
ISN 0058	END	00008700

ISN 0002	SUBROUTINE PSPCO	00008800
	C.....	00008900
	C..... CALCULATE STRESS & STRAIN ON EACH ELEMENT	00009000
	C.....	00009100
	C..... AND AVERAGE STRESS & STRAIN AT EACH NODE	00009200
	C.....	00009300
ISN 0003	IMPLICIT REAL*8(A-H,O-Z) , INTEGER*4(I-N)	00009400
ISN 0004	COMMON /CONT1/NSSC,NPSS,N1CL,N2CL,N1PR,N2PR,YERR,NCLS,LCNT,	00009500
	1 NITT,NIT1,NIT2,IPGE	00009600
	2 /CONTR/DLT1,DLT2,CGHC,CGSC,TITL(10),AREA,DLTN,TIME	00009700
ISN 0005	COMMON /BUSSEI/NPT1,NPT2,NPIC(5),NP2C(5),NP1E(5)	00009800
	1 /BUSSEI/DCET(5),DENC(5),SPHT(5),CLEP(5),QEX1(5),QEX2(5),	00009900
	2 CEXP(5),CPSN(5),ENGI(5),ENG2(5),CENG(5),CENT(6)	00010000
ISN 0006	COMMON /MODEI /NNOV,NDOF,NDO(500),NDNS(1000),NPTS(500),NPTP(500),	00010100
	1 NBDC(1000),NPEN(500),NPCL(8,500),NPNM(500),	00010200
	2 NPND(9,500)	00010300
	3 /NODER /XCON(500),YCON(500),TINT(500),QINT(500)	00010400
ISN 0007	COMMON /ELMNIT/NELU,NELO(1000),NELS(1500),NNME(3,1000),	00010500
	1 NPTE(1000),NPEM(3,1000),NPEI(3,1000)	00010600
	2 /ELMNTR/SINT(4,1000)	00010700
ISN 0008	COMMON /NDTMPI/NPT3,NP3C(5)	00010800
	1 /NDTMPI/TES1(5),TES2(5),TPRS(5),TPHS(5)	00010900
ISN 0009	COMMON /BDTMPI/NPT4,NP4C(5)	00011000
	1 /BDTMPI/TEP(5),TE2P(5),TPRP(5),TPHP(5)	00011100
ISN 0010	COMMON /HTFLXI/NPT5,NP5C(5)	00011200
	1 /HTFLXI/EIN1(5),EIN2(5),EPRQ(5),EPHS(5),CEIN(5)	00011300
ISN 0011	COMMON /STRESR/DNRH(3,3,5),ELMC(7,1000),STFE(18,1000,2),	00011400
	1 STFX(18,1000),STFM(18,1000),EVEC(1000),DPLC(1000),	00011500
	2 TENW(1000),TELD(1000),STRS(4,1000),STRN(4,1000)	00011600
ISN 0012	COMMON /HEATR /DMAT(9,500),PMAT(9,500),AMAT(9,500),QEXL(5,500),	00011700
	1 QINL(5,500),HMAT(9,500),BVEC(500),TNNH(500),	00011800
	2 TNLD(500),GATH(500),TPTR(500),QTFX(500)	00011900
ISN 0013	COMMON /WORKR /PVEC(1000),RVEC(1000),APVC(1000),SSWK(4,500),	00012000
	1 SRWK(4,500),QEXN(5),ENMN(5),ENMP(5),TEMN(5),	00012100
	2 TEON(5),FLXO(5)	00012200
ISN 0014	COMMON /OUTPTI/NQIN,NQIP(500),NOEN,NDEP(500),NRFN,NRFP(500)	00012300
	1 /OUTPTR/QIVL(500),QDFV(500),RFCV(2,500),FLND(2,500),	00012400
	2 FLEI(2,1000),SSND(4,500),SRND(4,500)	00012500
ISN 0015	COMMON /ADDVAR/OXDY(1000)	00012600
	C	00012700
	C	00012800
ISN 0016	DIMENSION STW(4),SRW(4)	00012900
	C	00013000
	C	00013100
	C	00013200
ISN 0017	CALL DVALUE(SRWK,2000,0.00)	00013300
ISN 0018	NPT = 0	00013400
	C	00013500
ISN 0019	100 CONTINUE	00013600
ISN 0020	NPT = NPT + 1	00013700
ISN 0021	IF (NPT.GT.5) GO TO 1500	00013800
ISN 0022	NS = NPIC(NPT)	00013900
ISN 0024	IF (NS.EQ.0) GO TO 100	00014000
	C	

	C MATRIX D SET	00014100
ISN 0026	EN = ENMN(NPT)	00014200
ISN 0027	D11 = EN*DNRM(1,1,NPT)	00014300
ISN 0028	D12 = EN*DNRM(1,2,NPT)	00014400
ISN 0029	D33 = EN*DNRM(3,3,NPT)	00014500
ISN 0030	CC = -CPSN(NPT)/EN	00014600
	C	00014700
ISN 0031	DO 1000 NE = 1, NELU	00014800
ISN 0032	NP = NPTE(NE)	00014900
ISN 0033	IF (LNP,NE,NPT) GO TO 1000	00015000
	C	00015100
ISN 0035	TP = NNME(1,NE)	00015200
ISN 0036	JP = NNME(2,NE)	00015300
ISN 0037	KP = NNME(3,NE)	00015400
	C	00015500
ISN 0038	IY = TP*2	00015600
ISN 0039	IX = IY - 1	00015700
ISN 0040	JY = JP*2	00015800
ISN 0041	JX = JY - 1	00015900
ISN 0042	KY = KP*2	00016000
ISN 0043	KX = KY - 1	00016100
	C	00016200
ISN 0044	XI = DPLC(IX)	00016300
ISN 0045	XJ = DPLC(JX)	00016400
ISN 0046	XK = DPLC(KX)	00016500
ISN 0047	YI = DPLC(IY)	00016600
ISN 0048	YJ = DPLC(JY)	00016700
ISN 0049	YK = DPLC(KY)	00016800
	C	00016900
ISN 0050	B1 = ELMC(1,NE)	00017000
ISN 0051	B2 = ELMC(2,NE)	00017100
ISN 0052	B3 = ELMC(3,NE)	00017200
ISN 0053	C1 = ELMC(4,NE)	00017300
ISN 0054	C2 = ELMC(5,NE)	00017400
ISN 0055	C3 = ELMC(6,NE)	00017500
	C	00017600
	C STRAIN	00017700
ISN 0056	EX = B1*XI + B2*XJ + B3*XK	00017800
ISN 0057	EY = C1*YI + C2*YJ + C3*YK	00017900
ISN 0058	GXY = C1*XI + B1*YI + C2*XJ + B2*YJ + C3*XK + B3*YK	00018000
	C	00018100
	C STRESS	00018200
ISN 0059	SX = D11*EX + D12*EY	00018300
ISN 0060	SY = D12*EX + D11*EY	00018400
ISN 0061	TXY = D33*GXY	00018500
	C	00018600
ISN 0062	EZ = 0.00	00018700
ISN 0063	SZ = 0.00	00018800
	C PLANE-STRAIN	00018900
ISN 0064	IF (NPSS,EQ.1) SZ = D12*(EX+EY)	00019000
	C PLANE-STRESS	00019100
ISN 0066	IF (NPSS,EQ.2) EZ = CC*(SX+SY)	00019200
	C	00019300
ISN 0068	STW(1) = SX	00019400
ISN 0069	STW(2) = SY	00019500
ISN 0070	STW(3) = SZ	00019600
ISN 0071	STW(4) = TXY	00019700
		00019800

ISN 0072	SRW(1) = EX	00019900
ISN 0073	SRW(2) = EY	00020000
ISN 0074	SRW(3) = EZ	00020100
ISN 0075	SRW(4) = GXY	00020200
	C	00020300
ISN 0076	DO 300 I = 1, 4	00020400
ISN 0077	WW = STM(I)	00020500
ISN 0078	STRS(I,NE) = STRS(I,NE) + WW	00020600
ISN 0079	SSWK(I,IP) = SSWK(I,IP) + WW	00020700
ISN 0080	SSWK(I,JP) = SSWK(I,JP) + WW	00020800
ISN 0081	SSWK(I,KP) = SSWK(I,KP) + WW	00020900
ISN 0082	300 CONTINUE	00021000
	C	00021100
ISN 0083	DO 400 I = 1, 4	00021200
ISN 0084	WW = SRW(I)	00021300
ISN 0085	STRN(I,NE) = STRN(I,NE) + WW	00021400
ISN 0086	SRWK(I,IP) = SRWK(I,IP) + WW	00021500
ISN 0087	SRWK(I,JP) = SRWK(I,JP) + WW	00021600
ISN 0088	SRWK(I,KP) = SRWK(I,KP) + WW	00021700
ISN 0089	400 CONTINUE	00021800
	C	00021900
ISN 0090	1000 CONTINUE	00022000
	C	00022100
ISN 0091	GO TO 100	00022200
	C	00022300
ISN 0092	1500 CONTINUE	00022400
ISN 0093	DO 1700 NN = 1, NNDU	00022500
ISN 0094	WW = NPEN(NN)	00022600
ISN 0095	WW = 1.00/WW	00022700
ISN 0096	DO 1600 I = 1, 4	00022800
ISN 0097	SSND(I,NN) = SSND(I,NN) + WW*SSWK(I,NN)	00022900
ISN 0098	SRND(I,NN) = SRND(I,NN) + WW*SRWK(I,NN)	00023000
ISN 0099	1600 CONTINUE	00023100
ISN 0100	1700 CONTINUE	00023200
	C	00023300
ISN 0101	DO 1800 I = 1, NDOF	00023400
ISN 0102	DXDY(I) = OXDY(I) + DPLC(I)	00023500
ISN 0103	1800 CONTINUE	00023600
	C	00023700
ISN 0104	C REACTION AT NODE	00023800
	DO 2300 J = 1, NREN	00023900
ISN 0105	NN = NRFP(J)	00024000
ISN 0106	IY = NN*2	00024100
ISN 0107	IX = IY - 1	00024200
ISN 0108	NX = NBDC(IY)	00024300
ISN 0109	NY = NBDC(IY)	00024400
ISN 0110	W1 = 0.00	00024500
ISN 0111	W2 = 0.00	00024600
ISN 0112	NP = NPNN(NN)	00024700
ISN 0113	IF (NX.NE.1) GO TO 2000	00024800
	C	00024900
ISN 0115	DO 1900 I = 1, NP	00025000
ISN 0116	K2 = I*2	00025100
ISN 0117	K1 = K2 - 1	00025200
ISN 0118	I2 = NPND(I,NN)*2	00025300
ISN 0119	I1 = I2 - 1	00025400
ISN 0120	W1 = W1 + STEM(K1,IX)*DPLC(I1) + STEM(K2,IX)*DPLC(I2)	00025500
ISN 0121	1900 CONTINUE	00025600

ISN 0122		W1 = W1 - FVEC(IX)	00025700
	C		00025800
ISN 0123	2000	CONTINUE	00025900
ISN 0124		IF (NY.NE.1) GO TO 2200	00026000
	C		00026100
ISN 0126		DO 2100 I = 1, NP	00026200
ISN 0127		K2 = I*2	00026300
ISN 0128		K1 = K2 - 1	00026400
ISN 0129		I2 = NPND(I,NN)*2	00026500
ISN 0130		I1 = I2 - 1	00026600
ISN 0131		W2 = W2 + STEM(K1,IY)*DPLC(I1) + STEM(K2,IY)*DPLC(I2)	00026700
ISN 0132	2100	CONTINUE	00026800
ISN 0133		W2 = W2 - FVEC(IY)	00026900
	C		00027000
ISN 0134	2200	CONTINUE	00027100
ISN 0135		RFCV(1,NN) = RFCV(1,NN) - W1	00027200
ISN 0136		RECV(2,NN) = RECV(2,NN) - W2	00027300
ISN 0137	2300	CONTINUE	00027400
	C		00027500
ISN 0138		RETURN	00027600
ISN 0139		END	00027800

ISN 0002	SUBROUTINE OUTPH	00000100
C.....		00000200
C.....	OUTPUT ROUTINE OF HEAT CONDUCTION	00000300
C.....		00000400
ISN 0003	IMPLICIT REAL*8(A-H,O-Z) , INTEGER*4(I-N)	00000500
ISN 0004	COMMON /CONTLI/NSSC,NPSS,NICL,NZCL,NIPR,NZPR,IERR,NCLS,LCNT,	00000600
1	NITT,NIT1,NIT2,IPGE	00000700
2	/CONTLR/DLT1,DLT2,CGHC,CGSC,TITL(10),AREA,DLTN,TIME	00000800
ISN 0005	COMMON /BUSSET/NPT1,NPT2,NPIC(5),NP2C(5),NP1E(5)	00000900
1	/BUSSE/DCET(5),DENC(5),SPHT(5),CLEP(5),QEX1(5),QEX2(5),	00001000
2	CEXP(5),CPSN(5),ENGI(5),ENG2(5),CENG(5),CEMT(6)	00001100
ISN 0006	COMMON /NODEI /NNDU,NDOF,NDO(500),NDNS(1000),NPTS(500),NPTP(500),	00001200
1	NBDC(1000),NPEN(500),NPEL(8,500),NPNM(500),	00001300
2	NPND(9,500)	00001400
3	/NODER /XCON(500),YCON(500),TINT(500),QINT(500)	00001500
ISN 0007	COMMON /ELMNTI/NELU,NELQ(1000),NELS(1500),NMME(3,1000),	00001600
1	NPTE(1000),NPEM(3,1000),NPEI(3,1000)	00001700
2	/ELMNTR/SINT(4,1000)	00001800
ISN 0008	COMMON /NDTMPI/NPT3,NP3C(5)	00001900
1	/NDTMPI/TES1(5),TES2(5),TPRS(5),TPHS(5)	00002000
ISN 0009	COMMON /BDTMPI/NPT4,NP4C(5)	00002100
1	/BDTMPI/TEIP(5),TE2P(5),TPRP(5),TPHP(5)	00002200
ISN 0010	COMMON /HTFLXR/NPTS,NP5C(5)	00002300
1	/HTFLXR/EIN1(5),EIN2(5),EPRQ(5),EPHS(5),CEIN(5)	00002400
ISN 0011	COMMON /STRESR/DNRM(3,3,5),ELMC(7,1000),STFE(18,1000,2),	00002500
1	STFX(18,1000),STFM(18,1000),FVEC(1000),DPLC(1000),	00002600
2	TENW(1000),TELD(1000),STRS(4,1000),STRN(4,1000)	00002700
ISN 0012	COMMON /HEATR /DMAT(9,500),PMAT(9,500),AMAT(9,500),QEXL(5,500),	00002800
1	QINL(5,500),PMAT(9,500),BVEC(500),TNMW(500),	00002900
2	TNLD(500),GRIM(500),TPTR(500),QTFX(500)	00003000
ISN 0013	COMMON /WORKR /PVEC(1000),RVEC(1000),APVC(1000),SSWK(4,500),	00003100
1	SRWK(4,500),QEXN(5),ENMN(5),ENMP(5),TEMN(5),	00003200
2	TEON(5),FLXQ(5)	00003300
ISN 0014	COMMON /OUTPTI/NQIN,NQIP(500),NDFN,NDFP(500),NRFN,NRFP(500)	00003400
1	/OUTPTR/QIVL(500),QDFV(500),RFCV(2,500),FLND(2,500),	00003500
2	FLLE(2,1000),SSND(4,500),SRND(4,500)	00003600
C		00003650
ISN 0015	DIMENSION GENQ(500)	00003660
C		00003670
C		00003680
ISN 0016	NW = 6	00003690
C		00003700
C	HEAT FLUX AT NODE	00003800
ISN 0017	IF (NQIN.EQ.0) GO TO 300	00003900
ISN 0019	DO 200 I = 1 , NQIN	00004000
ISN 0020	NN = NQIP(I)	00004100
ISN 0021	IF (NN.LT.0) GO TO 150	00004200
ISN 0023	W1 = 0.00	00004300
ISN 0024	DO 100 J = 1 , 5	00004400
ISN 0025	NS = NP5C(I)	00004500
ISN 0026	IF (NS.EQ.0) GO TO 100	00004600
ISN 0028	W1 = W1 + FLXQ(J)*QINL(J,NN)	00004700
ISN 0029	100 CONTINUE	00004800

ISN 0030	GO TO 170	00004900
ISN 0031	150 CONTINUE	00005000
ISN 0032	NN = -NN	00005100
ISN 0033	W1 = QTPX(NN)	00005200
ISN 0034	170 CONTINUE	00005300
ISN 0035	Q1VL(NN) = W1	00005400
ISN 0036	200 CONTINUE	00005500
	C	00005600
	C HEAT RADIATION AT NODE	00005700
ISN 0037	300 CONTINUE	00005800
ISN 0038	IF (NDEN.EQ.0) GO TO 600	00005900
ISN 0040	DO 500 J = 1 , NDFN	00006000
ISN 0041	NN = NDFP(J)	00006100
ISN 0042	NS = NPNN(NN)	00006200
ISN 0043	WW = 0.00	00006300
ISN 0044	DO 400 I = 1 , NS	00006400
ISN 0045	NT = NPNO(I,NN)	00006500
ISN 0046	WW = WW + AMAT(I,NN)*(TNNW(NT) - TPTR(NT))	00006600
ISN 0047	400 CONTINUE	00006700
ISN 0048	QDFV(NN) = WW	00006800
ISN 0049	500 CONTINUE	00006900
	C	00007000
	C HEAT FLUX ON ELEMENT	00007100
ISN 0050	600 CONTINUE	00007200
ISN 0051	CALL DVALUE(FLND,1000,0.00)	00007300
ISN 0052	DO 700 NE = 1 , NELU	00007400
ISN 0053	IP = NNNE(1,NE)	00007500
ISN 0054	JP = NNNE(2,NE)	00007600
ISN 0055	KP = NNNE(3,NE)	00007700
ISN 0056	T1 = TNNW(IP)	00007800
ISN 0057	T2 = TNNW(JP)	00007900
ISN 0058	T3 = TNNW(KP)	00008000
ISN 0059	NP = NPTE(NE)	00008100
ISN 0060	D = DCFT(NP)	00008200
ISN 0061	B1 = ELMC(1,NE)	00008300
ISN 0062	B2 = ELMC(2,NE)	00008400
ISN 0063	B3 = ELMC(3,NE)	00008500
ISN 0064	C1 = ELMC(4,NE)	00008600
ISN 0065	C2 = ELMC(5,NE)	00008700
ISN 0066	C3 = ELMC(6,NE)	00008800
ISN 0067	QX = B1*T1 + B2*T2 + B3*T3	00008900
ISN 0068	QY = C1*T1 + C2*T2 + C3*T3	00009000
ISN 0069	QX = -D*QX	00009100
ISN 0070	QY = -D*QY	00009200
ISN 0071	FLEL(1,NE) = QX	00009300
ISN 0072	FLEL(2,NE) = QY	00009400
ISN 0073	FLND(1,IP) = FLND(1,IP) + QX	00009500
ISN 0074	FLND(2,IP) = FLND(2,IP) + QY	00009600
ISN 0075	FLND(1,JP) = FLND(1,JP) + QX	00009700
ISN 0076	FLND(2,JP) = FLND(2,JP) + QY	00009800
ISN 0077	FLND(1,KP) = FLND(1,KP) + QX	00009900
ISN 0078	FLND(2,KP) = FLND(2,KP) + QY	00010000
ISN 0079	700 CONTINUE	00010100
	C	00010200
	C HEAT GENERATION AT NODE	00010202
ISN 0080	CALL DVALUE(GENQ , 500 , 0.00)	00010204
ISN 0081	DO 750 I = 1 , 5	00010206
ISN 0082	IS = NPIC(I)	00010208
		00010210

ISN 0083	IF (IS.EQ.0)	GO TO 750	00010212
ISN 0085	WM = QEXN(I)		00010214
ISN 0086	DO 730 J = 1, NNDU		00010216
ISN 0087	GENQ(J) = GENQ(J) + WM*CEXL(I,J)		00010218
ISN 0088	730 CONTINUE		00010220
ISN 0089	750 CONTINUE		00010222
	C		00010300
	C AVERAGE HEAT FLUX AT NODE		00010400
ISN 0090	DO 800 I = 1, NNDU		00010500
ISN 0091	WM = NPEN(I)		00010600
ISN 0092	FLND(1,I) = FLND(1,I)/WM		00010700
ISN 0093	FLND(2,I) = FLND(2,I)/WM		00010800
ISN 0094	800 CONTINUE		00010900
	C		00011000
	C PRINT ROUTINE		00011100
	C		00011200
ISN 0095	CALL HEAD2(0)		00011300
ISN 0096	WRITE(NW,6000)		00011400
ISN 0097	WRITE(NW,6010)		00011500
ISN 0098	WRITE(NW,6020)		00011600
ISN 0099	LCNT = 10		00011700
ISN 0100	DO 1000 J = 1, NNDU		00012100
ISN 0101	LCNT = LCNT + 1		00012500
ISN 0102	IF (LCNT.GT.50)	CALL HEAD2(1)	00012600
ISN 0104	WRITE(NW,6040)	NNDU(J),TNM(J),QIVL(J),QDEV(J),GENQ(J), FLND(1,J),FLND(2,J)	00013400
	1		00013500
ISN 0105	1000 CONTINUE		00013600
	C		00013700
ISN 0106	WRITE(NW,6050)		00013800
ISN 0107	WRITE(NW,6060)		00013900
ISN 0108	LCNT = LCNT + 4		00014000
ISN 0109	IL = NELU/4		00014100
ISN 0110	I = MOD(NELU,4)		00014200
ISN 0111	IF (I.NE.0)	IL = IL + 1	00014300
ISN 0113	DO 2000 I = 1, IL		00014400
ISN 0114	JL = I*4		00014500
ISN 0115	JS = JL - 3		00014600
ISN 0116	IF (I.EQ.IL)	JL = NELU	00014700
ISN 0118	LCNT = LCNT + 1		00014800
ISN 0119	IF (LCNT.GT.50)	CALL HEAD2(2)	00014900
ISN 0121	K = JL - JS		00015000
ISN 0122	IF (K.EQ.1)	GO TO 1100	00015100
ISN 0124	IF (K.EQ.2)	GO TO 1200	00015200
ISN 0126	IF (K.EQ.3)	GO TO 1300	00015300
ISN 0128	J = JS		00015400
ISN 0129	WRITE(NW,6070)	NELO(J),FLEL(1,J),FLEL(2,J)	00015500
ISN 0130	GO TO 2000		00015600
ISN 0131	1100 CONTINUE		00015700
ISN 0132	WRITE(NW,6080)	(NELO(J),FLEL(1,J),FLEL(2,J), J = JS, JL)	00015800
ISN 0133	GO TO 2000		00015900
ISN 0134	1200 CONTINUE		00016000
ISN 0135	WRITE(NW,6090)	(NELO(J),FLEL(1,J),FLEL(2,J), J = JS, JL)	00016100
ISN 0136	GO TO 2000		00016200
ISN 0137	1300 CONTINUE		00016300
ISN 0138	WRITE(NW,6100)	(NELO(J),FLEL(1,J),FLEL(2,J), J = JS, JL)	00016400
ISN 0139	2000 CONTINUE		00016500
ISN 0140	6000 FORMAT('	HEAT CONDUCTION	00016600
	1		00016700

ISN 0141	2	6010	FORMAT('O 1 NODE ' //	00016800
	1		TEMP TEMPERATURE (DEGREE CENTIGRADE) '//	00016900
	2		FLOW HEAT FLOW (KCAL/DAY) '//	00017000
	3		RADQ HEAT RADIATION (KCAL/DAY) '//	00017100
	4		GENO HEAT GENERATION (KCAL/DAY) '//	00017200
	5		FLUX HEAT FLUX AVERAGED ON ELEMENT (KCAL/'	00017250
	6		'M**2/DAY)')'	00017300
ISN 0142		6020	FORMAT('ONODE NO.,3X,TEMP,11X,FLOW,11X,RADQ,11X,	00017400
	1		GENO,10X,FLUX(X),8X,FLUX(Y)')	00017500
ISN 0143		6040	FORMAT('.,('.,I4,.)',1X,6(IPE11.4,4X))	00017600
ISN 0144		6050	FORMAT('O 2 ELEMENT HEAT FLUX (KCAL/M**2/DAY) ')	00017800
ISN 0145		6060	FORMAT('O,4(' (MNT NO, X Y '))	00017900
ISN 0146		6070	FORMAT('., ('.,I4,')',2(I1X,1PD11.4))	00018000
ISN 0147		6080	FORMAT('.,2('.,('.,I4,')',2(I1X,1PD11.4)))	00018100
ISN 0148		6090	FORMAT('.,3('.,('.,I4,')',2(I1X,1PD11.4)))	00018200
ISN 0149		6100	FORMAT('.,4('.,('.,I4,')',2(I1X,1PD11.4)))	00018300
		C		00018400
		C		00018500
ISN 0150			RETURN	00018600
ISN 0151			END	00018700
				00018800

ISN 0002	SUBROUTINE OUTPD	00018900
	C.....	00019000
	C..... OUTPUT ROUTINE OF THERMAL STRESS	00019100
	C.....	00019200
ISN 0003	IMPLICIT REAL*8(A-H,O-Z) , INTEGER*4(I-N)	00019300
ISN 0004	COMMON /CONTL/NSSC,NPSS,N1CL,N2CL,N1PR,N2PR,TERR,NCLS,LCNT,	00019400
	1 NITT,NIT1,NIT2,IPGE	00019500
	2 /CONTLR/DLT1,DLT2,CGHG,GGSC,TITL(10),AREA,DLTN,TIME	00019600
ISN 0005	COMMON /BUSSEI/NPT1,NPT2,NP1C(5),NP2C(5),NP1E(5)	00019700
	1 /BUSSEI/DCET(5),DENC(5),SPHT(5),CLEP(5),QEX1(5),QEX2(5),	00019800
	2 CEXP(5),CPSN(5),ENGL(5),ENG2(5),CENG(5),CEMT(6)	00019900
ISN 0006	COMMON /NODEI /NNDU,NDOE,NDNO(500),NDNS(1000),NPIS(500),NPIS(500),	00020000
	1 NBDC(1000),NPEN(500),NPEL(8,500),NPNN(500),	00020100
	2 NPND(9,500)	00020200
	3 /NODER /XCDN(500),YCDN(500),TINT(500),QINT(500)	00020300
ISN 0007	COMMON /ELMNTI/NELU,NELQ(1000),NELS(1500),NNME(3,1000),	00020400
	1 NPTE(1000),NPEM(3,1000),NPEI(3,1000)	00020500
	2 /ELMNTI/SINT(4,1000)	00020600
ISN 0008	COMMON /NDTMP1/NPT3,NP3C(5)	00020700
	1 /NDTMPR/TE1P(5),TE2P(5),TPRS(5),TPHS(5)	00020800
ISN 0009	COMMON /BDTMP1/NPT4,NP4C(5)	00020900
	1 /BDTMPR/TE1P(5),TE2P(5),TPRP(5),TPMP(5)	00021000
ISN 0010	COMMON /HTFLXI/NPTS,NP5C(5)	00021100
	1 /HTFLXR/EIN1(5),EIN2(5),EPRQ(5),EPHS(5),CEIN(5)	00021200
ISN 0011	COMMON /STRESR/ONRM(3,3,5),ELMC(7,1000),STFE(18,1000,2),	00021300
	1 STFX(18,1000),STFM(18,1000),FVEC(1000),DPLC(1000),	00021400
	2 TENN(1000),TELD(1000),STRS(4,1000),STRN(4,1000)	00021500
ISN 0012	COMMON /HEATR /DMAT(9,500),PMAT(9,500),AMAT(9,500),QEXL(5,500),	00021600
	1 QINL(5,500),HMAT(9,500),BVEC(500),TNNW(500),	00021700
	2 TNLD(500),GRTM(500),TPTR(500),QTEX(500)	00021800
ISN 0013	COMMON /WORKR /PVEC(1000),RVEC(1000),APVC(1000),SSWK(4,500),	00021900
	1 SRWK(4,500),QEXN(5),ENMN(5),ENMP(5),TEMN(5),	00022000
	2 TEON(5),FLXQ(5)	00022100
ISN 0014	COMMON /OUTPTI/NQIN,NQIP(500),NDEN,NDEP(500),NREN,NREP(500)	00022200
	1 /OUTPTR/QIVL(500),QDFV(500),RFCV(2,500),FLND(2,500),	00022300
	2 FLEL(2,1000),SSND(4,500),SRND(4,500)	00022400
ISN 0015	COMMON /ADDVAR/OXOY(1000)	00022410
	C	00022420
ISN 0016	NW = 6	00022430
	C	00022610
	C PRINT ROUTINE	00022620
	C	00022630
ISN 0017	CALL HEAD2(0)	00022640
ISN 0018	WRITE(NW,6000)	00022650
ISN 0019	WRITE(NW,6010)	00022660
ISN 0020	WRITE(NW,6020)	00022670
ISN 0021	LCNT = 15	00022680
ISN 0022	IL = NNDU/2	00022690
ISN 0023	I = MOD(NNDU,2)	00022700
ISN 0024	IF (I.EQ.0) IL = IL + 1	00022710
ISN 0026	DO 800 I = 1 , IL	00022720
ISN 0027	JL = I*2	00022730
ISN 0028	JS = JL - 1	00022740

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ISN 0029      LCNT = LCNT + 1                                00027500
ISN 0030      IF (LCNT.GT.50)      CALL HEAD2(3)            00027600
ISN 0032      IF (I.EQ.IJ)        JL = NNDU                00027700
ISN 0034      K = JL - JS                                00027800
ISN 0035      IY1 = JS*2                                00027900
ISN 0036      IX1 = IY1 - 1                                00028000
ISN 0037      IF (K.EQ.0)          GO TO 700                00028100
ISN 0039      IY2 = JL*2                                00028200
ISN 0040      IX2 = IY2 - 1                                00028300
ISN 0041      WRITE(NW,6030) NDND(J),DXDY(IX1),DXDY(IY1),RFCV(1,JS),
1                                     RECVC(2,JS), NDND(JL),DXDY(IX2),DXDY(IY2),
2                                     RFCV(1,JL),RFCV(2,JL)    00028400
ISN 0042      GO TO 800                                00028500
ISN 0043      700 CONTINUE                                00028600
ISN 0044      WRITE(NW,6040) NDND(J),DXDY(IX1),DXDY(IY1),
1                                     RFCV(1,JS),RFCV(2,JS)    00028700
ISN 0045      800 CONTINUE                                00028800
C                                                    00028900
ISN 0046      LCNT = LCNT + 2                                00029000
ISN 0047      IF (LCNT.GT.48)      CALL HEAD2(3)            00029100
ISN 0049      WRITE(NW,6050)                                00029200
ISN 0050      DO 900 I = 1, NNDU                            00029300
ISN 0051      LCNT = LCNT + 1                                00029400
ISN 0052      IF (LCNT.GT.50)      CALL HEAD2(4)            00029500
ISN 0054      WRITE(NW,6060) NDND(I),(SSND(J,I),J=1,4),(SRND(J,I),J=1,4)
ISN 0055      900 CONTINUE                                00029600
C                                                    00029700
ISN 0056      LCNT = LCNT + 4                                00029800
ISN 0057      IF (LCNT.GT.48)      CALL HEAD2(10)           00029900
ISN 0059      WRITE(NW,6070)                                00030000
ISN 0060      DO 1000 I = 1, NELU                            00030100
ISN 0061      LCNT = LCNT + 1                                00030200
ISN 0062      IF (LCNT.GT.50)      CALL HEAD2(5)            00030300
ISN 0064      WRITE(NW,6060) NELD(I),(STRS(J,I),J=1,4),(STRN(J,I),J=1,4)
ISN 0065      1000 CONTINUE                                00030400
C                                                    00030500
ISN 0066      6000 FORMAT(' ',THERMAL STRESS, ' ')          00030600
1                                     ' '                    00030700
2                                     ' '                    00030800
ISN 0067      6010 FORMAT(' ',DX,DY, ' ',DISPLACEMENT (M), ' ')
1                                     ' '                    00030900
2                                     ' '                    00031000
3                                     ' '                    00031100
4                                     ' '                    00031200
5                                     ' '                    00031300
6                                     ' '                    00031400
7                                     ' '                    00031500
8                                     ' '                    00031600
9                                     ' '                    00031700
A                                     ' '                    00031800
ISN 0068      6020 FORMAT(' ',1,NODE, ' ',R-X, ' ',R-Y, ' ',R-Z, ' ',
1                                     ' ',2(4X,' ',NODE NO., ' ',3X,' ',DX, ' ',6X,' ',DY, ' ',7X,' ',
2                                     ' ',R-X, ' ',8X,' ',R-Y, ' ',3X))
ISN 0069      6030 FORMAT(' ',2(4X,' ',I4,' '),4(1X,IPD11.4),1X)
ISN 0070      6040 FORMAT(' ',4X,' ',I4,' '),4(1X,IPD11.4))
ISN 0071      6050 FORMAT(' ',0,4X,' ',NODE NO., ' ',4X,' ',S(X), ' ',8X,' ',S(Y), ' ',8X,' ',S(Z), ' ',8X,' ',
1                                     ' ',T(XY), ' ',7X,' ',E(X), ' ',8X,' ',E(Y), ' ',8X,' ',E(Z), ' ',7X,' ',E(XY))

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ISN 0072	6060	FORMAT('	(,I4,)',8(1X,1PD11.4)).	00033300
ISN 0073	6070	FORMAT('0 2 ELEMENT'//		00033400
	1	'	,4X,'LMNT NO.',4X,'S(X)',8X,'S(Y)',8X,'S(Z)',8X,	00033500
	2	'	T(XY)',7X,'E(X)',8X,'E(Y)',8X,'E(Z)',7X,'E(XY)')	00033600
	C			00033700
	C			00033800
ISN 0074		RETURN		00033900
ISN 0075		END		00034000

ISN 0002	SUBROUTINE HEAD2(IH)		00034100
	C.....		00034200
	C.....	OUTPUT LIST HEADING ROUTINE	00034300
	C.....		00034400
ISN 0003	IMPLICIT REAL*8(A-H,O-Z) , INTEGER*4(I-N)		00034500
ISN 0004	COMMON /CONTLI/NSSC,NPSS,NICL,N2CL,N1PR,N2PR,IERR,NCLS,LCNT,		00034600
	1	NITT,NIT1,NIT2,IPGE	00034700
	2	/CONTLR/DLT1,DLT2,CGHC,CGSC,TITL(10),AREA,DLTN,TIME	00034800
	C		00034810
	C		00034820
ISN 0005	NW = 6		00034830
ISN 0006	LCNT = 0		00034900
ISN 0007	IPGE = IPGE + 1		00035000
ISN 0008	WRITE(NW,6000) TITL , IPGE		00035100
ISN 0009	WRITE(NW,6100) TIME		00035200
ISN 0010	WRITE(NW,6200) NITT		00035300
ISN 0011	IF (IH.EQ.0) GO TO 9000		00035305
ISN 0013	IF (IH.EQ.1) WRITE(NW,7100)		00035310
ISN 0015	IF (IH.EQ.2) WRITE(NW,7200)		00035320
ISN 0017	IF (IH.EQ.3) WRITE(NW,7300)		00035330
ISN 0019	IF (IH.EQ.4) WRITE(NW,7400)		00035340
ISN 0021	IF (IH.EQ.5) WRITE(NW,7500)		00035350
	C		00035400
ISN 0023	6000	FORMAT('1 *****10A8,***** PAGE',I6)	00035500
ISN 0024	6100	FORMAT('0',T101,TIME 'F7.1,' (DAY)*)	00035600
ISN 0025	6200	FORMAT(' ',T101,CALC. COUNT, I7/)	00035700
ISN 0026	7100	FORMAT('0NODE NO.,3X,TEMP,11X,FLOW,11X,RADO,11X,	00035710
	1	'GENQ,10X,'FLUX(X)',8X,'FLUX(Y)'	00035720
ISN 0027	7200	FORMAT('0',4(' LMNT NO. X Y '))	00035750
ISN 0028	7300	FORMAT('0',2(4X,'NODE NO.,3X,' DX ',6X,' DY ',7X,	00035770
	1	'R-X ',8X,'R-Y ',3X))	00035780
ISN 0029	7400	FORMAT('0',4X,'NODE NO.,4X,'S(X)',8X,'S(Y)',8X,'S(Z)',8X,	00035810
	1	'T(XY)',7X,'E(X)',8X,'E(Y)',8X,'E(Z)',7X,'E(XY)')	00035820
ISN 0030	7500	FORMAT('0',4X,'LMNT NO.,4X,'S(X)',8X,'S(Y)',8X,'S(Z)',8X,	00035850
	1	'T(XY)',7X,'E(X)',8X,'E(Y)',8X,'E(Z)',7X,'E(XY)')	00035860
	C		00035861
ISN 0031	9000	CONTINUE	00035862
ISN 0032	RETURN		00035900
ISN 0033	END		00036000

ISN 0002	SUBROUTINE CHECKP(IN)	00000100
C.....		00000200
C.....	CHECK PRINT OF COMMON VARIABLES	00000300
C.....		00000400
ISN 0003	IMPLICIT REAL*8(A-H,O-Z), INTEGER*4(I-N)	00000500
ISN 0004	COMMON /CONTL/ NSCC, NESS, N1CL, N2CL, N1PR, N2PR, IERR, NCLS, LCNT,	00000600
1	NTT, N1T1, N1T2, IPGE	00000700
2	/CONTLR/ DLT1, DLT2, CGHC, CGSC, TTTL(10), AREA, DLTN, TIME	00000800
ISN 0005	COMMON /BUSSEI/ NPT1, NPT2, NP1C(5), NP2C(5), NP1E(5)	00000900
1	/BUSSEI/ DCE1(5), DENC(5), SPHT(5), CLEP(5), QEX1(5), QEX2(5),	00001000
2	CEXP(5), CPSN(5), ENG1(5), ENG2(5), CENG(5), CEMT(6)	00001100
ISN 0006	COMMON /NODEI/ NNDU, NDOF, NDNQ(500), NDNS(1000), NPTS(500), NPTP(500),	00001200
1	NBDC(1000), NPEN(500), NPEL(8,500), NPHN(500),	00001300
2	NPND(2,500)	00001400
3	/NODER/ XCON(500), YCON(500), TINT(500), QINT(500)	00001500
ISN 0007	COMMON /ELMNTI/ NELU, NELQ(1000), NELS(1500), NMME(3,1000),	00001600
1	NPTE(1000), NPEM(3,1000), NPEI(3,1000)	00001700
2	/ELMNTI/ SINT(4,1000)	00001800
ISN 0008	COMMON /NDTMP/ NPT3, NP3C(5)	00001900
1	/NDTMP/ TES1(5), TES2(5), TPRS(5), TPHS(5)	00002000
ISN 0009	COMMON /BDTMP/ NP4C(5)	00002100
1	/BDTMP/ TE1P(5), TE2P(5), TPRP(5), TPMP(5)	00002200
ISN 0010	COMMON /HTFLX/ NP5C(5)	00002300
1	/HTFLX/ EIN1(5), EIN2(5), EPRQ(5), EPMS(5), CEIN(5)	00002400
ISN 0011	COMMON /STRESR/ DNRM(3,3,5), ELMC(7,1000), STFE(18,1000,2),	00002500
1	STEX(18,1000), STEM(18,1000), FVEC(1000), DPLC(1000),	00002600
2	TENW(1000), TELD(1000), STRS(4,1000), STRN(4,1000)	00002700
ISN 0012	COMMON /HEATR/ DMAT(2,500), PMAT(2,500), AMAT(2,500), QEXL(5,500),	00002800
1	QINL(5,500), HMAT(9,500), BVEC(500), TNNW(500),	00002900
2	TNLD(500), GRAM(500), TPTR(500), STEX(500)	00003000
ISN 0013	COMMON /WORKR/ PVEC(1000), RVEC(1000), APVC(1000), SRWK(4,500),	00003100
1	SRWK(4,500), QEXN(5), ENMN(5), ENMP(5), TENW(5),	00003200
2	TEON(5), FLXO(5)	00003300
ISN 0014	COMMON /OUTPTI/ NQIN, NQIP(500), NDEF, NDEF(500), NREF, NREF(500)	00003400
1	/OUTPTR/ QIVL(500), QDFV(500), RFCV(2,500), FLND(2,500),	00003500
2	FILEL(2,1000), SSND(4,500), SRND(4,500)	00003600
C		00003700
C		00003800
ISN 0015	MW = 16	00003900
ISN 0016	IF (IN.EQ.2) GO TO 1000	00004000
ISN 0018	IF (IN.EQ.3) GO TO 2000	00004100
ISN 0020	WRITE(MH,6000) NSCC, NPSS, N1CL, N2CL, N1PR, N2PR, NCLS,	00004200
1	DLT1, DLT2, CGHC, CGSC, TTTL	00004300
ISN 0021	WRITE(MH,6010) NPT1, NP1C, NP1E, DCE1, DENC, SPHT, CLEP, CPSN,	00004400
1	QEX1, QEX2, CEXP, ENG1, ENG2, CENG	00004500
ISN 0022	WRITE(MH,6020) NPT2, NP2C, CEMT	00004600
ISN 0023	WRITE(MH,6030) NPT3, NP3C, TES1, TES2, TPRS, TPHS	00004700
ISN 0024	WRITE(MH,6040) NP4C, TE1P, TE2P, TPRP, TPMP	00004800
ISN 0025	WRITE(MH,6050) NPTS, NP5C, EIN1, EIN2, EPRQ, EPMS, CEIN	00004900
ISN 0026	WRITE(MH,6060) NNDU, NDOF	00005000
ISN 0027	DO 100 I = 1, NNDU	00005100
ISN 0028	N = NDNO(I)	00005200
ISN 0029	J = NPEN(I)	00005300

ISN 0030	K = NPNN(I)	00005400
ISN 0031	I2 = 2*I	00005500
ISN 0032	I1 = I2 - 1	00005600
ISN 0033	WRITE(MW,6065) NDNS(N),N,NPTS(I),NPPT(I),NBDC(I1),NBDC(I2), XCDN(I1),YCDN(I1),TINT(I),QINT(I)	00005700
ISN 0034	1 WRITE(MW,6070) (NPND(L,I),L=1,K)	00005800
ISN 0035	WRITE(MW,6080) (NPEL(M,I),M=1,J)	00005900
ISN 0036	100 CONTINUE	00006000
ISN 0037	WRITE(MW,6090) NELU	00006100
ISN 0038	DO 200 I = 1, NELU	00006200
ISN 0039	N = NELO(I)	00006300
ISN 0040	1 WRITE(MW,6100) NELS(N),N,NPTE(I), 2 (NNME(J,I),J=1,3), (NPFM(K,I),K=1,3), (NPEI(L,I),L=1,3), (SINT(M,I),M=1,4)	00006400
ISN 0041	200 CONTINUE	00006500
ISN 0042	GO TO 9000	00006600
	C	00006700
	C	00006800
ISN 0043	1000 CONTINUE	00006900
ISN 0044	WRITE(MW,6110) ((DNRM(I,J,K),J=1,3),I=1,3),K=1,5)	00007000
ISN 0045	WRITE(MW,6120)	00007100
ISN 0046	DO 1100 I = 1, NNDU	00007200
ISN 0047	N = NPNN(I)	00007300
ISN 0048	WRITE(MW,6130) I, (DMAT(J,I),J=1,N)	00007400
ISN 0049	1100 CONTINUE	00007500
ISN 0050	WRITE(MW,6140)	00007600
ISN 0051	DO 1200 I = 1, NNDU	00007700
ISN 0052	N = NPNN(I)	00007800
ISN 0053	WRITE(MW,6150) I, (PMAT(J,I),J=1,N)	00007900
ISN 0054	1200 CONTINUE	00008000
ISN 0055	WRITE(MW,6160)	00008100
ISN 0056	DO 1300 I = 1, NNDU	00008200
ISN 0057	N = NPNN(I)	00008300
ISN 0058	WRITE(MW,6170) I, (AMAT(J,I),J=1,N)	00008400
ISN 0059	1300 CONTINUE	00008500
ISN 0060	WRITE(MW,6180)	00008600
ISN 0061	WRITE(MW,6170) (J,(QEXL(I,J),I=1,5),J=1,NNDU)	00008700
ISN 0062	WRITE(MW,6180)	00008800
ISN 0063	WRITE(MW,6170) (J,(QINL(I,J),I=1,5),J=1,NNDU)	00008900
ISN 0064	WRITE(MW,6190)	00009000
ISN 0065	DO 1400 I = 1, NELU	00009100
ISN 0066	WRITE(MW,6200) I, (ELMC(J,I),J = 1, 7)	00009200
ISN 0067	1400 CONTINUE	00009300
ISN 0068	WRITE(MW,6210)	00009400
ISN 0069	DO 1500 I = 1, NNDU	00009500
ISN 0070	I2 = I*2	00009600
ISN 0071	I1 = I2 - 1	00009700
ISN 0072	JJ = 2*NPNN(I)	00009800
ISN 0073	WRITE(MW,6220) I, (STFX(J,I1), J = 1, JJ)	00009900
ISN 0074	WRITE(MW,6230) (STFX(J,I2), J = 1, JJ)	00010000
ISN 0075	1500 CONTINUE	00010100
ISN 0076	WRITE(MW,6215)	00010200
ISN 0077	DO 1600 I = 1, NNDU	00010300
ISN 0078	I2 = I*2	00010400
ISN 0079	I1 = I2 - 1	00010500
ISN 0080	JJ = 2*NPNN(I)	00010600
ISN 0081	WRITE(MW,6220) I, (STFE(J,I1,1), J = 1, JJ)	00010700
ISN 0082	WRITE(MW,6230) (STFE(J,I2,1), J = 1, JJ)	00010800

ISN 0083	1600	CONTINUE	00010480
ISN 0084		GO TO 9000	00010500
	C		00010600
	C		00010700
ISN 0085	2000	CONTINUE	00010800
ISN 0086		WRITE(MH,6240)	00010900
ISN 0087		DO 2100 I = 1, 5	00011000
ISN 0088		WRITE(MH,6250) I, QEXN(I),ENMN(I),TEMN(I),TEON(I),FLXQ(I)	00011100
ISN 0089	2100	CONTINUE	00011200
ISN 0090		WRITE(MH,6260)	00011300
ISN 0091		WRITE(MH,6290) (NQIP(I), I = 1, NQIN)	00011400
ISN 0092		WRITE(MH,6270)	00011500
ISN 0093		WRITE(MH,6290) (NDIP(I), I = 1, NDIN)	00011600
ISN 0094		WRITE(MH,6280)	00011700
ISN 0095		WRITE(MH,6290) (NREP(I), I = 1, NREN)	00011800
ISN 0096		WRITE(MH,6300)	00011900
ISN 0097		WRITE(MH,6310) (J,GRIM(J), I = 1, NNDU)	00012000
ISN 0098		WRITE(MH,6320)	00012100
ISN 0099		DO 2200 I = 1, NNDU	00012200
ISN 0100		N = NPNN(I)	00012300
ISN 0101		WRITE(MH,6330) I, (HMAI(J,I), J=1, N)	00012400
ISN 0102	2200	CONTINUE	00012500
	C		00012600
	C		00012700
ISN 0103	6000	FORMAT('N SSC.....',I5 /	00012800
	1	' NPSS.....',I5 /	00012900
	2	' N1CL.....',I5 /	00013000
	3	' N2CL.....',I5 /	00013100
	4	' N1PR.....',I5 /	00013200
	5	' N2PR.....',I5 /	00013300
	6	' NCLS.....',I5 /	00013400
	7	' DLT1.....',1PD11.4 /	00013500
	8	' DLT2.....',1PD11.4 /	00013600
	9	' CGHC.....',1PD11.4 /	00013700
	A	' CGSC.....',1PD11.4 /	00013800
	B	' TITL.....',10A8)	00013900
ISN 0104	6010	FORMAT('CNPT1.....',I5 /	00014000
	1	' NPIC.....',5I5/	00014100
	2	' NP1E.....',5I5/	00014200
	3	' DCFT.....',5(1PD11.4)/	00014300
	4	' DEHC.....',5(1PD11.4)/	00014400
	5	' SPHT.....',5(1PD11.4)/	00014500
	6	' CLIP.....',5(1PD11.4)/	00014600
	7	' CPSN.....',5(1PD11.4)/	00014700
	8	' QEX1.....',5(1PD11.4)/	00014800
	9	' QEX2.....',5(1PD11.4)/	00014900
	A	' CEXP.....',5(1PD11.4)/	00015000
	B	' ENG1.....',5(1PD11.4)/	00015100
	C	' ENG2.....',5(1PD11.4)/	00015200
	D	' CENG.....',5(1PD11.4)/	00015300
ISN 0105	6020	FORMAT('CNPT2.....',I5/	00015400
	1	' NP2C.....',5I5/	00015500
	2	' CEMT.....',6(1PD11.4)/	00015600
ISN 0106	6030	FORMAT('CNPT3.....',I5/	00015700
	1	' NP3C.....',5I5/	00015800
	2	' TES1.....',5(1PD11.4)/	00015900
	3	' TES2.....',5(1PD11.4)/	00016000
	4	' TPRS.....',5(1PD11.4)/	00016100

	5	* TPHS.....,5(1PD11.4))	
ISN 0107	6040	FORMAT(*ONPT4....., 15/	00016200
	1	* NP4C.....,5I5/	00016300
	2	* TE1P.....,5(1PD11.4)/	00016400
	3	* TE2P.....,5(1PD11.4)/	00016500
	4	* TPRP.....,5(1PD11.4)/	00016600
	5	* TPHP.....,5(1PD11.4))	00016700
ISN 0108	6050	FORMAT(*ONPTS....., 15/	00016800
	1	* NP5C.....,5I5/	00016900
	2	* EIN1.....,5(1PD11.4)/	00017000
	3	* EIN2.....,5(1PD11.4)/	00017100
	4	* EPRQ.....,5(1PD11.4)/	00017200
	5	* EPHS.....,5(1PD11.4)/	00017300
	6	* CEIN.....,5(1PD11.4))	00017400
ISN 0109	6060	FORMAT(*ONNDU....., 15/	00017500
	1	* NDOF....., 15)	00017600
ISN 0110	6065	FORMAT(*ONODE SEQ. & NODE NO.....,2I5 /	00017700
	1	* NPTS , 15 /	00017800
	2	* NPTP , 15 /	00017900
	3	* NBDC(X),NBDC(Y) ,2I5 /	00018000
	4	* XCON ,YCON ,2(1PD11.4)/	00018100
	5	* TINT ,1PD11.4 /	00018200
	6	* QINT ,1PD11.4)	00018300
ISN 0111	6070	FORMAT(* NPNO ,9I5)	00018400
ISN 0112	6080	FORMAT(* NPEL ,8I5)	00018500
ISN 0113	6090	FORMAT(*ONELU....., 15)	00018600
ISN 0114	6100	FORMAT(*OELMT SEQ. & ELMT NO.....,2I5 /	00018700
	1	* NPTE , 15 /	00018800
	2	* NNME ,3I5 /	00018900
	3	* NPEM ,3I5 /	00019000
	4	* NPET ,3I5 /	00019100
	5	* SINT ,4(1PD11.4))	00019200
ISN 0115	6110	FORMAT(*ODNRM*/(3(5X,1P3D11.4/)))	00019300
ISN 0116	6120	FORMAT(*ODMAT*)	00019400
ISN 0117	6140	FORMAT(*OPMAT*)	00019500
ISN 0118	6150	FORMAT(*OAMAT*)	00019600
ISN 0119	6130	FORMAT(15,5X,9(1PD11.4))	00019700
ISN 0120	6160	FORMAT(*OQEXL*)	00019800
ISN 0121	6170	FORMAT(15,5X,1P5D11.4)	00019900
ISN 0122	6180	FORMAT(*OOINL*)	00020000
ISN 0123	6190	FORMAT(*OELMC*)	00020100
ISN 0124	6200	FORMAT(15,5X,7(1PD11.4))	00020200
ISN 0125	6210	FORMAT(*OSTEX*)	00020300
ISN 0126	6215	FORMAT(*OSTFE*)	00020400
ISN 0127	6220	FORMAT(15,5X,1P10D11.4/(10X,1P10D11.4))	00020410
ISN 0128	6230	FORMAT(10X,1P10D11.4)	00020500
ISN 0129	6240	FORMAT(*O*,1X,11X,*QEXN*,11X,*ENMN*,11X,*TEMN*,11X,*TEON*,	00020600
	1	11X,*FLXQ*)	00020700
ISN 0130	6250	FORMAT(15,5(4X,1PD11.4))	00020800
ISN 0131	6260	FORMAT(*ONQIP*)	00020900
ISN 0132	6270	FORMAT(*ONDFP*)	00021000
ISN 0133	6280	FORMAT(*ONRFP*)	00021100
ISN 0134	6290	FORMAT(20I5)	00021200
ISN 0135	6300	FORMAT(*OGRTH*)	00021300
ISN 0136	6310	FORMAT(15,5X,1PD11.4)	00021400
ISN 0137	6320	FORMAT(*OHMAT*)	00021500
ISN 0138	6330	FORMAT(15,5X,9(1PD11.4))	00021600
ISN 0139	9000	CONTINUE	00021700
			00021800

ISN 0140
ISN 0141

RETURN
END

00021900
00022000