

分置

熱応力評価法の開発

第4報;非定常熱応力計算におけるDuhamelの定理の応用

1993年6月

動力炉・核燃料開発事業団
東海事業所

複製又はこの資料の入手については、下記にお問い合わせください。

〒311-13 茨城県東茨城郡大洗町成田町4002

動力炉・核燃料開発事業団

大洗工学センター システム開発推進部・技術管理室

Enquires about copyright and reproduction should be addressed to: Technology Management Section O-arai Engineering Center, Power Reactor and Nuclear Fuel Development Corporation 4002 Narita-cho, O-arai-machi, Higashi-Ibaraki, Ibaraki-ken, 311-13, Japan

動力炉・核燃料開発事業団 (Power Reactor and Nuclear Fuel Development Corporation)

熱応力評価法の開発

第4報；非定常熱応力計算における Duhamelの定理の応用

報告者 古橋一郎*，千葉仁**

実施責任者 笠原直人***

要 旨

実用価値の高い熱応力評価法の開発を目的に非定常熱伝導の理論解析を行い、以下の知見を得た。

- (1) 線形の非定常熱伝導問題では、重ね合わせ手法が有効である。
- (2) 境界値問題は、部分境界問題の重ね合わせに分解できる。
- (3) 境界値が時間変化する問題の解は、境界値が時間変化しない問題の解の積分重ね合わせとなる。
- (4) 温度分布と弾性体の熱応力は線形対応し、これらの結論は、弾性熱応力に関しても成立する。

高温プラントの機器・配管の熱応力評価に、これらの知見が以下のように応用できる。

- (5) 各機器・配管の固有の使用環境、運転形態および過渡事象に応じた基本解を数ケース用意し、これらを重ね合わせることで複雑な事象の非定常熱伝導および熱応力が容易に評価できる。
- (6) 境界値が時間変化しない場合の基本解を求めておき、時間変化曲線を用いた積分重ね合わせにより、各過渡事象に対する非定常熱伝導および過渡熱応力を容易に評価することができ

本報告ではさらに以下の数値解析を実施し、応用例を示した。

- (7) ノズル構造の熱過渡解析を行い、上記(3)、(4)および(6)を検証した。

* (株)CRC総合研究所

** アイ・ティ・ジェイ(株)

*** 大洗工学センター 機器構造開発部 構造工学室

目 次

| | |
|--------------------------------|----|
| 1. 序 論 | 1 |
| 2. 非定常熱伝導 | 3 |
| 2.1 場の方程式 | 3 |
| 2.2 境界条件と初期条件 | 4 |
| 2.3 重ね合わせ (その1) | 5 |
| 2.4 重ね合わせ (その2) | 6 |
| 2.5 重ね合わせ (その3) | 8 |
| 2.6 重ね合わせ (その4) | 8 |
| 2.7 Duhamelの定理の応用 | 10 |
| 3. 検証解析 | 13 |
| 3.1 解析条件 | 13 |
| 3.2 基本ケースの解析結果 | 14 |
| 3.3 ケース2 (コールドショック)の解析結果 | 14 |
| 3.4 ケース3 (ホットショック)の解析結果 | 14 |
| 4. まとめ | 17 |
| 5. 参考文献 | 18 |

図表リスト

- 図1 解析モデル
 図2 熱伝導解析の境界条件
 図3 熱応力解析の境界条件
 図4. 1 流体温度の時間変化特性 (基本ケース)
 図4. 2 流体温度の時間変化特性 (コールドショック)
 図4. 3 流体温度の時間変化特性 (ホットショック)
 図5 評価断面図
 図6. 1～図6. 7 温度コンター $t=2 \text{ sec} \sim t=300 \text{ sec}$
 図7. 1～図7. 7 ミーゼスの等価応力コンター $t=2 \text{ sec} \sim t=300 \text{ sec}$
 図8. 1～図8. 7 評価断面1～7の温度
 表1. 1～表1. 7 評価断面1～7の温度
 図9. 1(1)～(4) 評価断面1の応力テンソル成分1～4
 図9. 2(1)～(4) 評価断面2の応力テンソル成分1～4
 図9. 3(1)～(4) 評価断面3の応力テンソル成分1～4
 図9. 4(1)～(4) 評価断面4の応力テンソル成分1～4
 図9. 5(1)～(4) 評価断面5の応力テンソル成分1～4
 図9. 6(1)～(4) 評価断面6の応力テンソル成分1～4
 図9. 7(1)～(4) 評価断面7の応力テンソル成分1～4
 表2. 1(1) 評価断面1の応力テンソル成分1、2
 表2. 1(2) 評価断面1の応力テンソル成分3、4
 表2. 2(1) 評価断面2の応力テンソル成分1、2
 表2. 2(2) 評価断面2の応力テンソル成分3、4
 表2. 3(1) 評価断面3の応力テンソル成分1、2
 表2. 3(2) 評価断面3の応力テンソル成分3、4
 表2. 4(1) 評価断面4の応力テンソル成分1、2
 表2. 4(2) 評価断面4の応力テンソル成分3、4
 表2. 5(1) 評価断面5の応力テンソル成分1、2
 表2. 5(2) 評価断面5の応力テンソル成分3、4
 表2. 6(1) 評価断面6の応力テンソル成分1、2
 表2. 6(2) 評価断面6の応力テンソル成分3、4
 表2. 7(1) 評価断面7の応力テンソル成分1、2
 表2. 7(2) 評価断面7の応力テンソル成分3、4
 図10. 1～図10. 10 温度コンター $t=5 \text{ sec} \sim t=500 \text{ sec}$
 図11. 1～図11. 10 ミーゼスの等価応力コンター $t=5 \text{ sec} \sim t=500 \text{ sec}$
 図12. 1～図12. 7 評価断面1～7の温度
 表3. 1～表3. 7 評価断面1～7の温度
 図13. 1(1)～(4) 評価断面1の応力テンソル成分1～4
 図13. 2(1)～(4) 評価断面2の応力テンソル成分1～4
 図13. 3(1)～(4) 評価断面3の応力テンソル成分1～4

図13. 4(1)～(4) 評価断面4の応力テンソル成分1～4

図13. 5(1)～(4) 評価断面5の応力テンソル成分1～4

図13. 6(1)～(4) 評価断面6の応力テンソル成分1～4

図13. 7(1)～(4) 評価断面7の応力テンソル成分1～4

表4. 1(1)～(4) 評価断面1の応力テンソル成分1～4

表4. 2(1)～(4) 評価断面2の応力テンソル成分1～4

表4. 3(1)～(4) 評価断面3の応力テンソル成分1～4

表4. 4(1)～(4) 評価断面4の応力テンソル成分1～4

表4. 5(1)～(4) 評価断面5の応力テンソル成分1～4

表4. 6(1)～(4) 評価断面6の応力テンソル成分1～4

表4. 7(1)～(4) 評価断面7の応力テンソル成分1～4

表5 温度曲げ成分が最大となる時点のFINAS解と簡易計算値の比較 (コールドショック)

図14. 1～図14. 8 温度コンター $t=5 \text{ sec} \sim t=300 \text{ sec}$

図15. 1～図15. 8 ミーゼスの等価応力コンター $t=5 \text{ sec} \sim t=300 \text{ sec}$

図16. 1～図16. 7 評価断面1～7の温度

表6. 1～表6. 7 評価断面1～7の温度

図17. 1(1)～(4) 評価断面1の応力テンソル成分1～4

図17. 2(1)～(4) 評価断面2の応力テンソル成分1～4

図17. 3(1)～(4) 評価断面3の応力テンソル成分1～4

図17. 4(1)～(4) 評価断面4の応力テンソル成分1～4

図17. 5(1)～(4) 評価断面5の応力テンソル成分1～4

図17. 6(1)～(4) 評価断面6の応力テンソル成分1～4

図17. 7(1)～(4) 評価断面7の応力テンソル成分1～4

表7. 1(1)～(4) 評価断面1の応力テンソル成分1～4

表7. 2(1)～(4) 評価断面2の応力テンソル成分1～4

表7. 3(1)～(4) 評価断面3の応力テンソル成分1～4

表7. 4(1)～(4) 評価断面4の応力テンソル成分1～4

表7. 5(1)～(4) 評価断面5の応力テンソル成分1～4

表7. 6(1)～(4) 評価断面6の応力テンソル成分1～4

表7. 7(1)～(4) 評価断面7の応力テンソル成分1～4

表8 温度曲げ成分が最大となる時点のFINAS解と簡易計算値の比較 (ホットショック)

1. 序論

高温プラントの機器・配管の設計では内圧、地震などによる一次応力の評価に加えて、熱応力の評価が重要不可欠である。これらの機器・配管の熱応力評価手段には大きく分けて以下の2つの手法があり、それぞれに長所および短所がある。

- (1) 理論解、公式、近似式および線図などによる簡易評価法または工学的評価法
 - ・長所—計算が簡単である。電卓、パソコンにより机上で容易に計算可能である。
 - ・短所—適用範囲がせまい。単純形状、単純な条件に適用範囲が限定される。
- (2) スーパーコンピュータと汎用FEMコードによる伝熱解析および応力解析
 - ・長所—適用範囲が広い。任意の複雑形状、任意の複雑な条件が計算できる。
 - ・短所—計算コストが大きい。汎用FEMコードを自在に使いこなすには高度の知識と経験を有する構造解析技術者の多大の労力を要する。

このように、一方の長所が他方の短所となっていて、両者を相互補完的に併用することが大切であると考える。スーパーコンピュータおよび汎用FEMコードが普及した現在は(2)が主流であり、機器・配管の熱応力評価に多大な労力とコストが消費されている現状である。

このような現状のもと、著者らは簡易熱応力評価法あるいは工学的な熱応力評価法の開発を進めている。その目的は以下のように述べることができる。

- (3) 発生熱応力の概略値の敏速な評価。

現実の形状および条件を単純化したモデルに工学的評価法を適用し、応力集中係数等に乗じて、発生熱応力の概略値を敏速に評価する。

- (4) 敏速なパラメータ感度解析。

現実の形状および条件を単純化したモデルに工学的評価法を適用し、パラメータ感度解析をおこない、熱応力発生要因(原因)と熱応力の大きさ(結果)の関係の概略傾向を敏速に把握する。

- (5) FEM解析と工学的評価法を相互補完的に併用し、熱応力計算の効率を上げる。

工学的評価法による敏速な机上計算、パラメータ感度解析を参考にして、高価なFEM解析の解析ケースを適切にしばりこみ、解析コストを節約し計算効率を上げる。あるいは、重ね合わせの手法などを積極的に活用し、高価なFEM解析結果の普遍的な有効活用を図り、計算効率を上げる。

- (6) 最適設計に応用する。

工学的評価法によるパラメータ感度解析により、熱応力発生要因の最適化を行う。例えば、過渡事象時の流量特性や熱出力特性あるいは部材形状を最適化し、発生熱応力を経済的に許容値以下に制御することなどが考えられる。一般にFEM解析のみで、このような最適設計をおこなうのは、コストおよび計算期間の両面から無理である場合が多い。

著者らは以上の考えに基づき、以下の理論解析および工学的評価法の開発を行ってきた。

- 第1報(文献1) 平板の非定常熱伝導および熱応力の理論解析および線図化
- 第2報(文献2) 軸対称非定常熱応力のシェル理論解析、計算コード化および線図化
- 第3報(文献3) 軸対称非定常熱応力のシェル理論解析、計算コードSIMPLEの開発改良

本報告（第4報）では、非定常熱伝導問題の理論解析をおこない、場の方程式と境界条件式が線形となる場合、「重ね合わせの原理」に基づく幾つかの手法が工学的に重要な応用価値を有することを示した。本報告では特に「境界条件（温度規定境界、熱流束規定境界、熱伝達境界）の係数が時間に依存せず位置のみの関数であり、境界値（規定温度、規定熱流束、流体温度）が位置のみの関数と時間の関数の積に変数分離される場合」に着目し、Duhamelの定理を応用することを試みた。本手法によると、境界値が位置のみの関数であり時間に依存しない場合の基本的な解を用いて、簡単な数値積分により、境界値が任意の時間変化する場合の解が容易に計算できる。例題として内面で熱伝達を受けるノズル構造の非定常熱伝導および過渡熱応力の計算に本手法を適用し、その有効性を検証した。また理論的な検討を行い、複数の部分境界ごとに境界条件が与えられた複雑な場合に対して、あるいは同様の時間依存の発熱問題に対して、重ね合わせの手法を併用して本手法が有効であることを示した。

高温プラントの機器・配管の非定常熱伝導および熱応力計算に本手法を応用し、計算効率を大幅に改善すること、あるいは最適熱過渡設計を得るための各種感度解析の計算ツールとして本手法を応用すること、あるいは非定常熱伝導および過渡熱応力の高速評価およびモニタリングに本手法を応用することが期待できる。

固有関数展開法やGreen関数法を含めた「重ね合わせの手法」のより一般的な応用法、あるいは境界条件式の係数が時間に依存する場合の近似解法、などの工学的な応用価値が大きい問題に関する議論検討は引き続き次報以降でおこなう予定である。

2. 非定常熱伝導

非定常熱伝導問題が数学的にどのように表現されるかを取り扱う。どのような条件で線形の方程式となるかを考える。線形の方程式では「重ね合わせの原理」が成立し、工学的な応用価値の大きい幾つかの手法が考えられることを示す。境界条件式の係数が時間に依存しない場合、境界値が時間変化する問題の解が、Duhamelの定理を応用して、境界値が時間に依存しない問題の解を用いて、簡単な積分重ね合わせにより計算できることを示す。本章の記述全般に関する分かり易い参考書として文献4をすすめる。

次式で表される固体（あるいは静止した流体）の有限領域V内の非定常熱伝導問題を考える。

$$\text{場の方程式} \quad \text{領域V内で} \quad \rho c \frac{\partial T}{\partial t} - \lambda \nabla^2 T = Q(x, y, z, t) \quad (1.1)$$

$$\text{境界条件} \quad \text{境界S上で} \quad \alpha T + \beta \frac{\partial T}{\partial n} = R(x, y, z, t) \quad (1.2)$$

$$\text{初期条件} \quad t=0 \text{で} \quad T(x, y, z, 0) = \Phi(x, y, z) \quad (1.3)$$

ここで ∇^2 はラプラス演算子($\partial^2 / \partial x^2 + \partial^2 / \partial y^2 + \partial^2 / \partial z^2$)を表す。 $\partial / \partial n$ は境界Sの外向き法線方向の偏微分を表す。任意位置(x, y, z)および任意時間tの温度をT(x, y, z, t)とし、単位時間当たりの発熱密度をQ(x, y, z, t)とする。 ρ 、cおよび λ はそれぞれ構成材料の密度、比熱および熱伝導率を表す。(1)式はx、y、z、tを独立変数とし、Tを従属変数(未知数)とする、偏微分方程式の初期値境界値問題である。

(注) 以下、(1.1)式～(1.3)式をまとめて単に(1)式と記すことにする。

2.1 場の方程式

材料特性(密度 ρ 、比熱c、熱伝導率 λ)が一定値で与えられ、内部発熱がある固体内の非定常熱伝導は「線形非同次の偏微分方程式」(1.1)式で記述される。空間内の物理現象を記述する方程式を総称して「場の方程式」という。線形であるとは、未知数TあるいはTの偏微分の掛け算または巾乗が現れないこと、TあるいはTの偏微分の係数および右辺がTに依存しないことである。TあるいはTの偏微分を含まない右辺(Q)が恒等的には0とならない場合、方程式は非同次であるという。右辺(Q)を非同次項という。右辺が恒等的に0となる場合、方程式は同次であるという。線形非同次の偏微分方程式では左辺の未知数(T)と右辺の非同次項(Q)に関して「重ね合わせの原理」が成立する。すなわち「非同次項がQ_jの解をT_jとしa_jを任意定数とすると(j=1, n)、非同次項を線形和Q=Σ a_j Q_jで与えた場合の解は線形和T=Σ a_j T_jで与えられる」が成立する。

一般に材料特性(密度 ρ 、比熱c、熱伝導率 λ)は材料により異なり、また温度に依存する。従って、複数材料から構成される系では位置(材料種類)および温度Tの関数となる。実際上は温度変化に対する材料特性の変化は緩やかであり、温度変動範囲がそれほど大きくない場合は、各材料ごとに一定の材料特性を仮定しても良い場合が多い。

ここでは便宜上、材料特性は全領域内で一定値(すなわち単一材料で構成される系)を取り扱うものとするが、以下のような系でも場の方程式は線形であり「重ね合わせの原理」が成立し、次節以降の記述が成立することを断っておく。

- ・複数材料から構成される系（材料特性が位置の関数として不連続変化する系）

全領域を材料ごとの部分領域に分割し、各部分領域で場の方程式(1.1) 式を仮定し、材料境界で温度 T および境界を通過する熱流束 $(\lambda \partial T / \partial n)$ の連続性を仮定すれば良い。

- ・材料特性が位置の関数として連続的に変化する系

場の方程式(1.1) の左辺の熱伝導を表す項 $(\lambda \nabla^2 T)$ を、 λ が位置の連続関数であることを考慮した次式に変更すればよい。すなわち(1.1) 式の左辺に $-\text{grad } \lambda \cdot \text{grad } T$ を付け加えれば良い。

$$\text{div}(\lambda \text{grad } T) = \text{grad } \lambda \cdot \text{grad } T + \lambda \nabla^2 T \quad (\text{a})$$

2.2 境界条件と初期条件

非定常熱伝導問題では領域内の現象を記述する「場の方程式」に加えて、境界上の現象を記述する「境界条件」と、時間変数の開始点における領域内の状態を記述する「初期条件」を与えねばならない。初期条件は時間 $t = 0$ の温度分布として与えられる。境界条件には次の4種類がある。

- ・温度規定境界条件（境界上の温度 T_s を与える。）

$$\text{境界 } S_1 \text{ 上で } T = T_s \quad (2.1)$$

- ・熱流束規定境界条件（境界上の外向きの熱流束 q_s を与える。）

$$\text{境界 } S_2 \text{ 上で } -\lambda \partial T / \partial n = q_s \quad (2.2)$$

- ・熱伝達境界条件（境界で雰囲気流体との熱伝達がある。流体温度； T_r 、熱伝達係数； h ）

$$\text{境界 } S_3 \text{ 上で } -\lambda \partial T / \partial n = h(T - T_r) \quad (2.3)$$

- ・熱放射境界条件（境界で熱放射源と熱放射がある。放射源温度； T_r 、Stefan-Boltzmann定数； σ 、放射率と幾何学条件から定まる修正形態係数； F 、 T および T_r の単位は絶対温度 K ）

$$\text{境界 } S_4 \text{ 上で } -\lambda \partial T / \partial n = \sigma F(T^4 - T_r^4) \quad (2.4)$$

温度規定、熱流束規定および熱伝達（ h が温度に依存しない場合）は線形境界条件である。ここでは複数の温度規定境界、複数の熱流束規定境界および複数の熱伝達境界をまとめて、「単一の線形境界条件式(1.2)」で記述することにする。すなわち α 、 β および R は各部分境界の境界条件に応じて以下のように設定されるものとする。

- ・温度規定境界条件(2.1) 式 $\rightarrow \alpha = 1, \beta = 0, R = T_s$
- ・熱流束規定境界条件(2.2) 式 $\rightarrow \alpha = 0, \beta = -\lambda, R = q_s$
- ・熱伝達境界条件(2.3) 式 $\rightarrow \alpha = 1, \beta = \lambda/h, R = T_r$

境界条件式(1.2) の左辺の係数 α 、 β および非同次項 R は位置および時間の関数とする。すなわち、 $\alpha(x, y, z, t)$ 、 $\beta(x, y, z, t)$ 、 $R(x, y, z, t)$ とする。この場合、境界条件式(1.2) は線形非同次の偏微分方程式となり、左辺の未知数 T と右辺の非同次項 R に関して「重ね合わせの原理」が成立する。初期条件式(1.3) も同様に線形非同次の式である。

(注意) ここでは熱放射境界条件 (T の 4 乗が現れるので非線形である) は除外した。一般に熱放射境界条件を以下のように熱伝達境界条件で近似することがよく行われる。

(2.4) 式を次式に書き換える。

$$\text{境界 } S_1 \text{ 上で } -\lambda \partial T / \partial n = h_r (T - T_r) \quad (2.5)$$

$$h_r = \sigma F (T^2 + T_r^2) (T + T_r) \quad (2.6)$$

これにより位置および温度 T 、 T_r に依存する熱伝達係数 h_r として、非線形の熱伝達境界条件で置き換えることができる。温度 T 、 T_r の変動範囲が相対的に小さい場合、(2.6) 式の T 、 T_r を一定値で置き換え、 h_r を温度に依存しないものと近似し、線形の熱伝達境界条件で近似的に置き換えることが考えられる。

2.3 重ね合わせ (その1)

非定常熱伝導問題 (1) 式は場の方程式、境界条件、初期条件がすべて線形非同次となる。重ね合わせの原理を用いると、(1) 式を以下の 3 つの問題に分解することができる。すなわち、以下の 3 つの問題の解を求め、それらを加え合わせると元の問題 (1) 式の解が得られる。

- ・初期温度分布の拡散減衰問題 (場の方程式と境界条件は右辺が 0、解を T_1 とする)

$$\text{場の方程式 領域 } V \text{ 内で } \rho c \partial T / \partial t - \lambda \nabla^2 T = 0 \quad (3.1)$$

$$\text{境界条件 境界 } S \text{ 上で } \alpha T + \beta \partial T / \partial n = 0 \quad (3.2)$$

$$\text{初期条件 } t = 0 \text{ で } T(x, y, z, 0) = \Phi(x, y, z) \quad (3.3)$$

- ・時間依存発熱問題 (境界条件と初期条件は右辺が 0、解を T_2 とする)

$$\text{場の方程式 領域 } V \text{ 内で } \rho c \partial T / \partial t - \lambda \nabla^2 T = Q(x, y, z, t) \quad (4.1)$$

$$\text{境界条件 境界 } S \text{ 上で } \alpha T + \beta \partial T / \partial n = 0 \quad (4.2)$$

$$\text{初期条件 } t = 0 \text{ で } T(x, y, z, 0) = 0 \quad (4.3)$$

- ・時間依存境界値問題 (場の方程式と初期条件は右辺が 0、解を T_3 とする)

$$\text{場の方程式 領域 } V \text{ 内で } \rho c \partial T / \partial t - \lambda \nabla^2 T = 0 \quad (5.1)$$

$$\text{境界条件 境界 } S \text{ 上で } \alpha T + \beta \partial T / \partial n = R(x, y, z, t) \quad (5.2)$$

$$\text{初期条件 } t = 0 \text{ で } T(x, y, z, 0) = 0 \quad (5.3)$$

(証明) (3)、(4)、(5) 式の T をそれぞれの解 T_1 、 T_2 、 T_3 で置き換え、場の方程式、境界条件式、初期条件式を加え合わせる。

$$\partial T_1 / \partial t + \partial T_2 / \partial t + \partial T_3 / \partial t = \partial (T_1 + T_2 + T_3) / \partial t$$

$$\nabla^2 T_1 + \nabla^2 T_2 + \nabla^2 T_3 = \nabla^2 (T_1 + T_2 + T_3)$$

$$\partial T_1 / \partial n + \partial T_2 / \partial n + \partial T_3 / \partial n = \partial (T_1 + T_2 + T_3) / \partial n$$

などと整理し括弧でくくると、 $T = (T_1 + T_2 + T_3)$ が (1) 式をすべて満たすこと、すなわち (1) 式の解であることが容易に確かめられる。

本節の結論は工学的に重要である。評価対象機器の初期温度分布が N_1 ケース、発熱密度が N_2 ケース、境界値が N_3 ケースとすると、組み合わせは $N_1 \times N_2 \times N_3$ ケースとなる。本節の重ね合わせの手法を用いれば、初期温度分布 N_1 ケース、発熱密度 N_2 ケース、境界値 N_3 ケースの合計 $N_1 + N_2 + N_3$ ケースの計算結果を、任意に重ね合わせるにより、全ケース ($N_1 \times N_2 \times N_3$) の解を得ることができる。

2.4 重ね合わせ (その2)

(1) 式の境界条件式の左辺係数 α 、 β が時間に依存せず、位置 (x, y, z) のみの関数で与えられる場合は、時間に依存しない定常熱伝導問題の解をも含めて、重ね合わせの原理が成立する。

実際問題として、時間 $t = 0$ まで十分に長い時間、右辺の非同次項 Q 、 R が時間変化せずに保持され、 $t = 0$ では定常状態 ($\partial T / \partial t = 0$) に達して、 $t = 0$ 以後に Q 、 R が時間変化を開始するようなケースが非常に多い。プラントの例で言えば、運転停止状態から $t = 0$ で運転を開始するケース、長い定常運転状態から $t = 0$ で過渡事象が開始されるケースなどである。

時間 $t = 0$ で定常状態には達していない、より一般的なケースを考える。重ね合わせの原理を用いると、(1) 式の非定常熱伝導問題を以下に示すような定常熱伝導問題と 3 つの問題の和に分解することができる。

- ・定常熱伝導問題 (場の方程式と境界条件の右辺は $t = 0$ の値、解を T_0 とする)

$$\text{場の方程式} \quad \text{領域 } V \text{ 内で} \quad -\lambda \nabla^2 T = Q(x, y, z, 0) \quad (6.1)$$

$$\text{境界条件} \quad \text{境界 } S \text{ 上で} \quad \alpha T + \beta \partial T / \partial n = R(x, y, z, 0) \quad (6.2)$$

定常熱伝導問題では $\partial T / \partial t = 0$ であり、場の方程式 (1.1) の左辺第 1 項が消える。この問題の解を $T_0(x, y, z)$ とし、初期温度分布 Φ を定常成分 T_0 と非定常成分 ϕ の和に分解する。非同次項 Q および R も同様に初期定常値と非定常成分の和に分解する。

$$\Phi(x, y, z) = T_0(x, y, z) + \phi(x, y, z) \quad (7.1)$$

$$Q(x, y, z, t) = Q(x, y, z, 0) + g(x, y, z, t) \quad (7.2)$$

$$R(x, y, z, t) = R(x, y, z, 0) + f(x, y, z, t) \quad (7.3)$$

ここで式から明らかなように、非定常成分 g 、 f の $t = 0$ での初期値は一般には 0 である。ただし、ステップ状の瞬間的な変化も許すものとすれば、 g 、 f の初期値は必ずしも 0 である必要はない。

- ・初期温度の非定常成分 ϕ の拡散減衰問題（場の方程式と境界条件の右辺は 0、解を T_1 とする）

| | | | |
|-------|-----------|---|-------|
| 場の方程式 | 領域 V 内で | $\rho c \partial T / \partial t - \lambda \nabla^2 T = 0$ | (8.1) |
|-------|-----------|---|-------|

| | | | |
|------|-----------|--|-------|
| 境界条件 | 境界 S 上で | $\alpha T + \beta \partial T / \partial n = 0$ | (8.2) |
|------|-----------|--|-------|

| | | | |
|------|-----------|---------------------------------|-------|
| 初期条件 | $t = 0$ で | $T(x, y, z, 0) = \phi(x, y, z)$ | (8.3) |
|------|-----------|---------------------------------|-------|

- ・時間依存発熱問題（境界条件と初期条件の右辺は 0、解を T_2 とする）

| | | | |
|-------|-----------|---|-------|
| 場の方程式 | 領域 V 内で | $\rho c \partial T / \partial t - \lambda \nabla^2 T = g(x, y, z, t)$ | (9.1) |
|-------|-----------|---|-------|

| | | | |
|------|-----------|--|-------|
| 境界条件 | 境界 S 上で | $\alpha T + \beta \partial T / \partial n = 0$ | (9.2) |
|------|-----------|--|-------|

| | | | |
|------|-----------|---------------------|-------|
| 初期条件 | $t = 0$ で | $T(x, y, z, 0) = 0$ | (9.3) |
|------|-----------|---------------------|-------|

- ・時間依存境界値問題（場の方程式と初期条件の右辺は 0、解を T_3 とする）

| | | | |
|-------|-----------|---|--------|
| 場の方程式 | 領域 V 内で | $\rho c \partial T / \partial t - \lambda \nabla^2 T = 0$ | (10.1) |
|-------|-----------|---|--------|

| | | | |
|------|-----------|--|--------|
| 境界条件 | 境界 S 上で | $\alpha T + \beta \partial T / \partial n = f(x, y, z, t)$ | (10.2) |
|------|-----------|--|--------|

| | | | |
|------|-----------|---------------------|--------|
| 初期条件 | $t = 0$ で | $T(x, y, z, 0) = 0$ | (10.3) |
|------|-----------|---------------------|--------|

（証明）（6）、（8）、（9）、（10）式の T をそれぞれの解 T_0 、 T_1 、 T_2 、 T_3 に置き換え、加え合わせる。（7）式および $\partial T_3 / \partial t = 0$ を用いれば、 $T = T_0 + T_1 + T_2 + T_3$ が元の方程式（1）式を満足することが容易に確かめられる。

境界条件式の左辺係数が時間に依存しない場合の本節の結論は工学的に重要である。第一に、定常熱伝導問題の解も重ね合わせの対象範囲に含めることができることである。これにより、時間 $t = 0$ で発熱密度 0、境界値 0、初期温度 0 の問題に変換でき、数学的な取扱いが簡明になることである。

2.5 重ね合わせ (その3)

(5) 式の時間依存境界値問題を考える。全境界 S を N 個の部分境界 S_j ($j = 1, N$) の集合として、各部分境界 S_j 上で次式の境界条件が与えられた場合を考える。

$$\alpha_j (x, y, z, t) T + \beta_j (x, y, z, t) \partial T / \partial n = R_j (x, y, z, t) \quad (a)$$

すなわち (5.2) 式の境界条件が N 個の部分境界ごとに分割して与えられた場合である。このような場合、(5) 式の解は次の N 個の問題の解の総和で与えられる。

- ・問題 j (部分境界 S_j のみ非同次項 R_j を与え、その他の境界では右辺 0 とする。 $j = 1, N$)

| | | | |
|-------|-------------|--|--------|
| 場の方程式 | 領域 V 内で | $\rho c \partial T / \partial t - \lambda \nabla^2 T = 0$ | (11.1) |
| 境界条件 | 境界 S_j 上で | $\alpha_j T + \beta_j \partial T / \partial n = R_j (x, y, z, t)$ | (11.2) |
| | 境界 S_k 上で | $\alpha_k T + \beta_k \partial T / \partial n = 0$ (for all $k \neq j$) | (11.3) |
| 初期条件 | $t = 0$ で | $T(x, y, z, 0) = 0$ | (11.4) |

(証明) (11) 式の T を解 T_j に置き換える ($j = 1, N$)。 N 個の式を加え合わせて整理すると、 $T = \sum T_j$ が N 個の部分境界で境界条件 (a) 式をすべて満たすことが容易に確かめられる。

2.6 重ね合わせ (その4)

前節では (5) 式の時間依存境界値問題を取り扱ったが、(4) 式の時間依存発熱問題に対しても、同様な重ね合わせが可能である。すなわち全領域 V を N 個の部分領域 V_j ($j = 1, N$) の集合とし、各部分領域の発熱密度 Q_j が与えられた場合の解が、各部分領域のみ発熱密度を与えて他の領域では発熱 0 とした場合の N 個の解の総和となる。また (3) 式の初期温度分布の拡散減衰問題に対しても、全領域を部分領域に分割する同様な重ね合わせが可能である。

実際のプラント機器においても各部分領域ごとに境界条件、発熱密度および初期温度分布が与えられる場合が多く、重ね合わせの手法は工学的な応用価値が大きいものと考えられる。非定常熱伝導問題以外に、弾性問題、線形応答系、制御、拡散問題、電磁気問題、振動問題など工学の広い分野で、線形方程式系における「重ね合わせの原理」は応用範囲が広く、非常に重要である。本報告における基本的な重ね合わせ以外に、広く一般的に応用されている以下のような手法も「重ね合わせの原理」の異なった数学形式と解釈することもできる。

- ・Fourier 級数展開法

非同次項 Q (R あるいは Φ) を $\sin(n\pi x)$, $\cos(n\pi x)$ などの関数列の重ね合わせで級数表示し、各項に対する解を求める。各項に対する解を重ね合わせて級数解を得る。

- ・固有関数展開法

境界条件と場の方程式 ($Q = 0$; 同次) を満たす既知の固有関数列の重ね合わせで、初期条件 (Φ) を満たすような級数解を求める。 $Q \neq 0$ の場合はさらに (Q に対する) 特解を重ねる。

・ Fourier変換法

Fourier級数展開は離散的な周波数の解の重ね合わせであるが、これを連続的な周波数の連続的な重ね合わせ（積分形式の重ね合わせ）に拡張した手法がFourier変換法と考えられる。積分変換法の一つである。

・ Laplace変換法

積分変換法の一つであり、非定常熱伝導問題へ応用する場合は一般に、時間変数 t を「関数の時間に伴う減衰増加傾向を表すパラメータ変数 s 」に変換する。既知の関数 $f(t)$ と変換後の $F(s)$ を対比した変換テーブルが用意されている。このテーブルを参照して、問題をパラメータ s を含み位置を独立変数とする偏微分方程式に変換し、求めた解 (x, y, z, s) を変換テーブルを参照して逆変換し、解 (x, y, z, t) を得る。既知の関数の重ね合わせにより解を求める手法の一つと解釈することができる。

・ Green関数法

非同次項 R （または Q ）が時間に依存しない場合の非定常問題、あるいは初期温度分布 Φ の拡散問題では以下のような重ね合わせが考えられる。

境界問題→微小境界 dS で R （単位インパルス）の解 $G_B \rightarrow T = \int (G_B \times \text{分布関数 } R) dS$

発熱問題→微小領域 dV で Q （単位インパルス）の解 $G_Q \rightarrow T = \int (G_Q \times \text{分布関数 } Q) dV$

温度拡散→微小領域 dV で Φ （単位インパルス）の解 $G_T \rightarrow T = \int (G_T \times \text{分布関数 } \Phi) dV$

ここで G_B 、 G_Q 、 G_T はGreen関数あるいはインパルス応答関数と呼ばれる。Green関数法は、空間内の連続分布関数を入力した場合の解を求める手段として、空間を無限に細分割し、重ね合わせの原理を積分形式で応用したものと解釈できる。 R （または Q ）が時間に依存する場合は、時間軸上でのインパルス応答に関する積分形式の重ね合わせが追加され、空間と時間に関する2重積分となる。この場合は空間に関する積分重ね合わせと時間軸に関する積分重ね合わせの2回の重ね合わせと解釈できる。単位インパルスは、数学的には一点で値が ∞ になり積分値が1になるDiracの δ 関数として定義されるが、FEM等の数値解析では微小有限領域（ dS または dV ）で積分値が1になるような近似的な δ 関数として与えられる。上記の他の手法が解析関数の数学的な取扱いであり、複雑な形状に対して解析解を得るのが困難である場合が多いのに対して、Green関数法ではFEM解析などによる数値近似解を得ることが可能であり、実用価値が大きいといえる。Green関数法と良く似た概念に次節のDuhamelの定理がある。Duhamelの定理は、単位ステップ関数を入力した場合の応答（ステップ応答関数あるいはインディシャル応答関数と呼ばれる）を用いた「積分重ね合わせの定理」である。

本報告ではこれ以上議論しないが、これらの手法の工学的な応用可能性についての議論検討は次報で報告予定である。

2.7 Duhamelの定理の応用

時間依存境界値問題(5)式、(10)式または(11)式を考える。境界条件の左辺係数が時間に依存せず、右辺の非同次項が分布関数 $R(x, y, z)$ と時間の関数 $f(t)$ の積に変数分離される場合を考える。(11)式では部分境界 S_1 のみ非同次項 R_1 を与え、その他の部分境界 S_2 では右辺を0(同次)とした。ここでは非0(非同次)と0(同次)も含めて分布関数 $R(x, y, z)$ を全領域で定義し、(11)式も含めて考える。次式で与えられる問題を考える。

$$\text{場の方程式} \quad \text{領域} V \text{内で} \quad \rho c \partial T / \partial t - \lambda \nabla^2 T = 0 \quad (12.1)$$

$$\text{境界条件} \quad \text{境界} S \text{上で} \quad \alpha T + \beta \partial T / \partial n = R(x, y, z) f(t) \quad (12.2)$$

$$\text{初期条件} \quad t = 0 \text{で} \quad T(x, y, z, 0) = 0 \quad (12.3)$$

ここで境界条件の左辺の係数は $\alpha(x, y, z)$ 、 $\beta(x, y, z)$ と位置のみの関数で与えられるものとする。境界値が分布関数と時間ファクターの積として変数分離できる場合であり、実際のプラント機器でもこのようなケースは非常に多いものと考えられる。

この問題の解を求めるのに良く知られた「Duhamelの定理」を応用することを考えてみる。Duhamelの定理は以下のように記述される。

入力と出力に関し「線形重ね合わせ」が成立する線形の系では以下が成立する。時間 $t = 0$ で単位値1の信号を入力し、維持した時の出力信号が既知の場合、すなわち単位ステップ関数 $H(t)$ を入力した時の出力 $D(t)$ が既知の場合、時間に依存する信号 $f(t)$ を入力した時の出力信号 $V(t)$ が次式で与えられる。

$$V(t) = \int_0^t D(t-s) f'(s) ds + D(t) f(0) \quad (13)$$

ここで $H(t)$ はHeavisideのステップ関数であり、 $t < 0$ で $H = 0$ 、 $t \geq 0$ で $H = 1$ である。 $D(t)$ はステップ応答関数あるいはインディシャル応答関数と呼ばれる。

(証明) 微小時間区間 $(s, s + ds)$ の入力信号の変化量は $f'(s) ds$ であり、これは微小時間区間の微小入力と見なせる。この微小入力による経過時間 $(t - s)$ 後の出力(即ち時間 t における出力)は $D(t - s) f'(s) ds$ である。これを全区間 $(0 < s \leq t)$ で積分すると入力信号の時間変化分に対する出力が(13)式の右辺第1項として得られる。 $t = 0$ の入力 $f(0)$ に対する時間 t の出力 $D(t) f(0)$ を加えると(13)式が得られる。

境界値が時間に依存しない次式の問題を考える。

$$\text{場の方程式} \quad \text{領域} V \text{内で} \quad \rho c \partial T / \partial t - \lambda \nabla^2 T = 0 \quad (14.1)$$

$$\text{境界条件} \quad \text{境界} S \text{上で} \quad \alpha T + \beta \partial T / \partial n = R(x, y, z) \quad (14.2)$$

$$\text{初期条件} \quad t = 0 \text{で} \quad T(x, y, z, 0) = 0 \quad (14.3)$$

(12)式、(14)式とも左辺未知数 T と右辺非同次項に関して「重ね合わせの原理」が成立する、線形の系である。右辺非同次項を入力信号と見なし、未知数 T を出力信号と見なすことができる。Duhamelの定理を応用すると次の結果が得られる。

境界値が時間に依存しない(14)式の解を $T_1(x, y, z, t)$ とすると、境界値が時間に依存する(12)式の解 T は次式で与えられる。

$$T(x, y, z, t) = \int_0^t T_1(x, y, z, t-s) f'(s) ds + T_1(x, y, z, t) f(0) \quad (15)$$

(証明) 微小時間区間 $(s, s+ds)$ の入力信号の変化量は $R(x, y, z) f'(s) ds$ であり、これは微小時間区間の微小入力と見なせる。この微小入力による経過時間 $(t-s)$ 後の出力(即ち時間 t における出力)は $T_1(x, y, z, t-s) f'(s) ds$ である。これを全区間 $(0 < s \leq t)$ で積分すると入力信号の時間変化分に対する出力が得られる。これに時間 $t=0$ の入力 $R(x, y, z) f(0)$ に対する時間 t の出力 $T_1(x, y, z, t) f(0)$ を加えると(15)式が得られる。

(補足1) ここでは時間軸上のステップ応答関数を用いた「積分重ね合わせ」を考えたが、一般的には空間上でも同様の「積分重ね合わせ」を考えることができる。例えば均一断面をもつ十分に長い弾性体円筒の場合、長手方向を x 軸で表し、単位ステップ内圧分布荷重 $H(x)$ に対する円筒の半径方向変位 $D(x)$ が既知の場合、任意の内圧分布荷重 $f(x)$ に対する変位 $V(x)$ が(13)式と同様の積分重ね合わせにより計算できる。すなわちDuhamelの定理は「線形系ではステップ応答関数を用いた(13)式の積分重ね合わせが成立する」ことを述べたものである。一般にインパルス応答関数を用いた積分重ね合わせがGreen関数法と呼ばれ、ステップ応答関数を用いた積分重ね合わせがDuhamelの定理と呼ばれる。

(補足2) 本節では時間依存の境界値問題を取り扱ったが、時間依存の発熱問題に関しても、発熱密度が分布関数と時間の関数の積で与えられる場合に、同様の結果を得ることができる。

機器の力学的境界条件が不変の場合、一般に弾性熱応力は温度分布と線形に対応し、温度分布と熱応力に関しても「線形重ね合わせの原理」が成立する。すなわち(14)式の非定常温度分布解 T_1 に対応する弾性熱応力テンソルを $S_1(x, y, z, t)$ とすると、(12)の非定常温度分布解 T に対応する弾性熱応力テンソル $S(x, y, z, t)$ は次式で与えられる。

$$S(x, y, z, t) = \int_0^t S_1(x, y, z, t-s) \cdot f'(s) ds + S_1(x, y, z, t) \cdot f(0) \quad (16)$$

実際のプラント機器において、このような例は非常に多い。境界条件式の左辺（温度規定の式、熱流束規定の式、熱伝達の式）と右辺（規定温度、規定熱流束、流体温度）の分布パターンが、機器固有の使用環境に応じて具体的に数ケース既知である場合が多い。この数ケースに対して、右辺の時間ファクター $f(t)$ が、さまざまな運転形態および過渡事象に応じて数10ケース設定される場合が多い。すべてのケースを計算すると〔分布パターン；数ケース〕 \times 〔事象パターン；数10ケース〕となる。本節の手法を応用すれば、分布パターンに対する数ケースの計算のみを行い、これを参照して、各事象パターンに対する結果は(15)式の積分により求めることができる。これにより、計算費用、計算期間および計算労力を数10分の1に低減できる可能性がある。また最適設計の手段として応用することが考えられる。時間ファクター（すなわち過渡特性） $f(t)$ をうまくコントロールして、発生熱応力を最小にする問題、そのための各種パラメータ感度評価の手段として本手法は利用価値が大きいと考えられる。例えば熱伝達の場合、流体流量特性と $f(t)$ の関係あるいは熱出力特性と $f(t)$ の関係から、流量特性と発生熱応力の関係あるいは熱出力特性と発生熱応力の関係を計算し、最適な流量特性あるいは最適な熱出力特性を決定することなどが考えられる。

（補足3）本報告では熱伝達問題における(15)、(16)式の検証および応用例を次章で紹介する。(1) 固有関数展開法あるいはGreen関数法などを含めた、重ね合わせの手法のより一般的な応用法、(2) 境界条件式の左辺係数が時間に依存する場合の近似解法、などの工学的に重要な問題に関する議論検討は次報以降で取り扱う予定である。

3. 検証解析

3.1 解析条件

Duhamelの定理に基づく(15)、(16)式を検証し、また応用例を示すために、図1の軸対称ノズル構造についてFINASによる非定常熱伝導解析および弾性熱応力解析を実施した。

熱伝導解析の境界条件を図2に示す。内表面で流体と熱伝達があり、その他の境界は断熱境界である。すなわち境界条件は次式である。

$$\text{内表面で} \quad T + (\lambda/h) \partial T / \partial n = f(t) \quad (17.1)$$

$$\text{その他の境界で} \quad \partial T / \partial n = 0 \quad (17.2)$$

ここで $f(t)$ は流体温度である。用いた材料特性および熱伝達係数は以下のとおりである。

$$\text{密度} \quad \rho = 7.76 \times 10^{-6} \text{ kg/mm}^3$$

$$\text{比熱} \quad c = 0.138 \text{ kcal/(kg} \cdot \text{}^\circ\text{C)}$$

$$\text{熱伝導率} \quad \lambda = 5.34 \times 10^{-6} \text{ kcal/(mm} \cdot \text{sec} \cdot \text{}^\circ\text{C)}$$

$$\text{熱伝達係数} \quad h = 2.7778 \times 10^{-6} \text{ kcal/(mm}^2 \cdot \text{sec} \cdot \text{}^\circ\text{C)}$$

弾性熱応力解析の境界条件を図3に示す。用いた材料特性は以下のとおりである。

$$\text{ヤング率} \quad E = 15200 \text{ kgf/mm}^2$$

$$\text{ポアソン比} \quad \nu = 0.310$$

$$\text{線膨張率} \quad \alpha = 20.87 \times 10^{-6} \text{ mm/(mm} \cdot \text{}^\circ\text{C)}$$

解析ケースは次の3ケースである。

- ・ケース1 (基本ケース)

初期温度分布 0°C一様温度

流体温度一定 $t=0$ まで0°C、 $t>0$ で1°Cに一定保持

流体温度の時間変化特性を図4.1に示す。FINASではステップ関数($t=0$ の瞬間的な上昇)を取り扱えないので、 $t=0 \sim 0.01\text{sec}$ で1°C上昇を与えた。

- ・ケース2 (コールドショック)

初期温度分布 600°C一様温度

流体温度 (600°C→300°C、単調減少)

流体温度の時間変化特性を図4.2に示す。

- ・ケース3 (ホットショック)

初期温度分布 300°C一様温度

流体温度 (300°C→600°C→550°C→600°C、単調増加→単調減少→単調増加)

流体温度の時間変化特性を図4.3に示す。

ケース2、3の結果がケース1の結果を用いて(15)式および(16)式で計算できることを検証する。ただしケース2、3では初期温度が0でないので、初期温度からの変化分が計算されることになる。ケース2、3の計算では、(15)式および(16)式における $f(t)$ として、初期温度からの変化分を使用することになる。(15)式および(16)式による簡易計算を解析領域全体で行うのは大変なので、図5に示す7つの評価断面について、内面值、外面値、断面内平均値および曲げ成分について簡易計算を行い、FINASによるFEM数値解と比較した。

3.2 基本ケースの解析結果

$t = 2, 5, 10, 20, 40, 100, 300 \text{ sec}$ 時点の温度コンターを図6. 1～図6. 7に示す。同時点のミーゼスの等価応力コンターを図7. 1～図7. 7に示す。

評価断面1～7の温度の内面值、外面値、平均値、曲げ成分を図8. 1～図8. 7および表1. 1～表1. 7に示す。

評価断面1～7の応力テンソル成分1～4の内面值、外面値、平均値、曲げ成分を図9. 1～図9. 7および表2. 1～表2. 7に示す。

ここで応力成分1（以下テンソルは省略する）は (r, z) 面内の板厚方向の応力成分であり、応力成分2は (r, z) 面内の長手方向の応力成分であり、応力成分3は円周方向の応力成分であり、応力成分4は剪断応力成分である。FINASの結果は応力成分1、2が基準座標系 (r, z) における (S_r, S_z) に対応しているが、ここでは各評価断面について座標変換を行い、板厚方向応力成分と表面に沿った方向の応力成分に変換した。

ケース2、3の簡易計算では、表1. 1～表1. 7および表2. 1～表2. 7を時系列データとしてDASDに記録保存し、これを基本解として参照して、(15)式および(16)式の数値積分を実施した。なお数値積分の時間刻みはケース2、3のFINAS解析の時間刻みと同一とした。

3.3 ケース2（コールドショック）の解析結果

$t = 5, 15, 25, 35, 45, 70, 100, 200, 300, 500 \text{ sec}$ 時点の温度コンターを図10. 1～図10. 10に示す。同時点のミーゼスの等価応力コンターを図11. 1～図11. 10に示す。

評価断面1～7の温度の内面值、外面値、平均値、曲げ成分を図12. 1～図12. 7および表3. 1～表3. 7に示す。図および表には(15)式による簡易計算値を併記した。

評価断面1～7の応力成分1～4の内面值、外面値、平均値、曲げ成分を図13. 1～図13. 7および表4. 1～表4. 7に示す。図および表には(16)式による簡易計算値を併記した。

各評価断面で、温度の曲げ成分の絶対値が最大となる時点について、温度および応力成分のFINAS解と簡易計算値の比較結果を表5および次ページに示す。

3.4 ケース3（ホットショック）の解析結果

$t = 5, 10, 30, 70, 80, 100, 160, 300 \text{ sec}$ 時点の温度コンターを図14. 1～図14. 8に示す。同時点のミーゼスの等価応力コンターを図15. 1～図15. 8に示す。

評価断面1～7の温度の内面值、外面値、平均値、曲げ成分を図16. 1～図16. 7および表6. 1～表6. 7に示す。図および表には(15)式による簡易計算値を併記した。

評価断面1～7の応力成分1～4の内面值、外面値、平均値、曲げ成分を図17. 1～図17. 7および表7. 1～表7. 7に示す。図および表には(16)式による簡易計算値を併記した。

各評価断面で、温度の曲げ成分の絶対値が最大となる時点について、温度および応力成分のFINAS解と簡易計算値の比較結果を表8および次ページに示す。

温度曲げ最大時点の F I N A S 解と簡易計算値の比較 (ケース 2、コールドショック)

| 評価 断面 | 時点 t (sec) | 項目 | F I N A S 解 | | | | 簡易計算値 | | | |
|----------|---------------|-------------------|-------------|--------|--------|--------|--------|--------|--------|--------|
| | | | 内面值 | 外面値 | 平均値 | 曲げ | 内面值 | 外面値 | 平均値 | 曲げ |
| 1 | 5.0 | 温度 T | 562.08 | 572.58 | 568.90 | -5.32 | 562.00 | 572.56 | 568.88 | -5.43 |
| | | 応力 S ₁ | 0.014 | 0.015 | 0.025 | 0.003 | -0.003 | -0.007 | 0.024 | 0.002 |
| | | S ₂ | 3.249 | -1.576 | 0.113 | 2.445 | 3.271 | -1.587 | 0.114 | 2.496 |
| | | S ₃ | 3.249 | -1.577 | 0.097 | 2.442 | 3.271 | -1.586 | 0.098 | 2.493 |
| | | S ₄ | -0.000 | 0.000 | 0.000 | 0.000 | -0.000 | -0.000 | 0.000 | 0.000 |
| 2 | 5.0 | 温度 T | 563.28 | 573.86 | 570.35 | -5.29 | 563.16 | 573.98 | 570.33 | -5.41 |
| | | 応力 S ₁ | 0.018 | 0.023 | 0.252 | 0.175 | 0.006 | 0.006 | 0.258 | 0.177 |
| | | S ₂ | 6.853 | -4.208 | 0.122 | 5.395 | 6.945 | -4.301 | 0.122 | 5.477 |
| | | S ₃ | 3.726 | -2.994 | -0.525 | 3.374 | 3.777 | -3.075 | -0.529 | 3.436 |
| | | S ₄ | -0.050 | 0.031 | 0.149 | -0.002 | -0.055 | 0.030 | 0.152 | 0.002 |
| 3 | 5.0 | 温度 T | 562.92 | 577.35 | 572.66 | -7.05 | 562.70 | 577.41 | 572.66 | -7.19 |
| | | 応力 S ₁ | 0.016 | 0.062 | -0.217 | 0.031 | 0.033 | 0.039 | -0.221 | 0.038 |
| | | S ₂ | 5.721 | -4.481 | -0.038 | 4.928 | 5.823 | -4.507 | -0.039 | 4.989 |
| | | S ₃ | 4.569 | -3.115 | -0.393 | 3.747 | 4.667 | -3.158 | -0.404 | 3.811 |
| | | S ₄ | -0.031 | 0.107 | 0.169 | -0.134 | -0.032 | 0.106 | 0.171 | -0.141 |
| 4 | 16.0 | 温度 T | 513.89 | 558.62 | 543.65 | -22.33 | 513.57 | 558.41 | 543.68 | -22.33 |
| | | 応力 S ₁ | 0.28 | 0.24 | -0.38 | 0.21 | 0.39 | 0.25 | -0.37 | 0.23 |
| | | S ₂ | 27.78 | -20.33 | 0.37 | 24.51 | 27.94 | -20.34 | 0.38 | 24.54 |
| | | S ₃ | 14.90 | -13.81 | -3.39 | 14.48 | 15.11 | -13.72 | -3.37 | 14.50 |
| | | S ₄ | -2.38 | -0.34 | 1.74 | -1.78 | -2.40 | -0.35 | 1.74 | -1.81 |
| 5 | 37.0 | 温度 T | 450.82 | 515.66 | 492.86 | -33.01 | 450.75 | 515.39 | 492.82 | -33.13 |
| | | 応力 S ₁ | 14.88 | -0.66 | 2.04 | 9.84 | 14.75 | -0.63 | 2.02 | 9.84 |
| | | S ₂ | 18.36 | -44.01 | -1.06 | 26.93 | 18.03 | -44.17 | -1.10 | 26.96 |
| | | S ₃ | 26.12 | -30.78 | -4.17 | 27.80 | 26.05 | -30.70 | -4.13 | 27.85 |
| | | S ₄ | 16.07 | -2.87 | 1.98 | 11.79 | 16.07 | -2.87 | 1.98 | 11.80 |
| 6 | 73.0 | 温度 T | 373.27 | 516.66 | 475.42 | -69.51 | 373.26 | 516.76 | 475.63 | -69.71 |
| | | 応力 S ₁ | 0.54 | -0.03 | -2.44 | 1.20 | 0.47 | 0.04 | -2.42 | 1.23 |
| | | S ₂ | 31.09 | 1.22 | 1.02 | 14.36 | 30.91 | 1.42 | 1.04 | 14.35 |
| | | S ₃ | 68.60 | -37.79 | 1.06 | 52.24 | 68.59 | -37.67 | 1.07 | 52.30 |
| | | S ₄ | 3.02 | 0.11 | -0.07 | 5.77 | 3.06 | 0.14 | -0.07 | 5.75 |
| 7 | 97.0 | 温度 T | 352.60 | 548.20 | 484.62 | -97.44 | 352.90 | 548.19 | 484.89 | -97.62 |
| | | 応力 S ₁ | 0.41 | 0.20 | 0.92 | 0.26 | 0.50 | 0.20 | 0.88 | 0.23 |
| | | S ₂ | 54.05 | -21.04 | 0.24 | 37.00 | 53.97 | -20.85 | 0.18 | 36.98 |
| | | S ₃ | 60.87 | -24.60 | 2.00 | 42.52 | 60.85 | -24.47 | 1.94 | 42.56 |
| | | S ₄ | -0.48 | 0.17 | 0.08 | -0.44 | -0.36 | 0.13 | 0.08 | -0.39 |

温度曲げ最大時点のF I N A S解と簡易計算値の比較 (ケース3、ホットショック)

| 評価 断面 | 時点 t (sec) | 評価 項目 | F I N A S 解 | | | | 簡易計算値 | | | |
|----------|---------------|-------------------|-------------|--------|--------|--------|--------|--------|--------|--------|
| | | | 内面值 | 外面値 | 平均値 | 曲げ | 内面值 | 外面値 | 平均値 | 曲げ |
| 1 | 10.0 | 温度 T | 386.73 | 375.10 | 379.19 | 5.90 | 386.69 | 375.11 | 379.21 | 6.04 |
| | | 応力 S ₁ | -0.014 | -0.016 | -0.028 | -0.003 | 0.049 | 0.034 | -0.022 | 0.006 |
| | | S ₂ | -3.591 | 1.753 | -0.125 | -2.713 | -3.540 | 1.776 | -0.124 | -2.774 |
| | | S ₃ | -3.591 | 1.753 | -0.107 | -2.710 | -3.540 | 1.776 | -0.106 | -2.771 |
| | | S ₄ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2 | 10.0 | 温度 T | 384.97 | 372.87 | 376.91 | 6.06 | 385.11 | 372.66 | 376.94 | 6.15 |
| | | 応力 S ₁ | -0.045 | -0.026 | -0.354 | -0.256 | -0.030 | 0.034 | -0.369 | -0.255 |
| | | S ₂ | -9.573 | 6.316 | -0.151 | -7.786 | -9.696 | 6.504 | -0.152 | -7.877 |
| | | S ₃ | -4.582 | 4.083 | 0.782 | -4.369 | -4.652 | 4.234 | 0.774 | -4.426 |
| | | S ₄ | 0.057 | -0.046 | -0.244 | -0.011 | 0.076 | -0.041 | -0.251 | -0.026 |
| 3 | 10.0 | 温度 T | 384.66 | 367.03 | 372.82 | 8.67 | 384.90 | 366.89 | 372.77 | 8.88 |
| | | 応力 S ₁ | -0.031 | -0.094 | 0.323 | -0.059 | -0.061 | -0.035 | 0.329 | -0.070 |
| | | S ₂ | -8.235 | 7.091 | 0.030 | -7.414 | -8.357 | 7.110 | 0.032 | -7.487 |
| | | S ₃ | -6.123 | 4.141 | 0.319 | -5.029 | -6.245 | 4.207 | 0.338 | -5.119 |
| | | S ₄ | 0.044 | -0.170 | -0.258 | 0.203 | 0.047 | -0.161 | -0.262 | 0.214 |
| 4 | 30.0 | 温度 T | 477.64 | 419.21 | 439.06 | 29.30 | 478.27 | 419.73 | 439.03 | 29.33 |
| | | 応力 S ₁ | -0.48 | -0.46 | 0.89 | -0.32 | -0.65 | -0.47 | 0.89 | -0.36 |
| | | S ₂ | -49.12 | 39.44 | -0.66 | -45.31 | -49.39 | 39.44 | -0.67 | -45.35 |
| | | S ₃ | -18.89 | 25.99 | 8.78 | -22.80 | -19.27 | 25.79 | 8.75 | -22.84 |
| | | S ₄ | 4.19 | 0.67 | -3.67 | 3.24 | 4.23 | 0.67 | -3.67 | 3.30 |
| 5 | 32.0 | 温度 T | 477.76 | 391.22 | 421.68 | 44.12 | 477.67 | 391.58 | 421.73 | 44.15 |
| | | 応力 S ₁ | -18.76 | 0.79 | -2.74 | -12.27 | -18.59 | 0.75 | -2.72 | -12.25 |
| | | S ₂ | -23.08 | 52.43 | 1.20 | -32.73 | -22.65 | 52.59 | 1.24 | -32.72 |
| | | S ₃ | -33.96 | 37.26 | 4.52 | -34.88 | -33.80 | 37.13 | 4.47 | -34.89 |
| | | S ₄ | -20.26 | 3.44 | -2.33 | -14.80 | -20.23 | 3.45 | -2.33 | -14.79 |
| 6 | 70.0 | 温度 T | 578.23 | 398.96 | 450.02 | 86.23 | 578.48 | 398.84 | 449.78 | 86.51 |
| | | 応力 S ₁ | -0.76 | 0.04 | 3.04 | -1.46 | -0.67 | -0.04 | 3.03 | -1.50 |
| | | S ₂ | -39.27 | -1.72 | -1.26 | -17.74 | -39.16 | -1.98 | -1.28 | -17.74 |
| | | S ₃ | -85.34 | 46.64 | -1.14 | -64.46 | -85.43 | 46.50 | -1.15 | -64.56 |
| | | S ₄ | -3.80 | -0.16 | 0.08 | -7.12 | -3.86 | -0.19 | 0.08 | -7.10 |
| 7 | 76.0 | 温度 T | 576.20 | 338.04 | 413.31 | 117.78 | 575.70 | 338.03 | 412.98 | 117.89 |
| | | 応力 S ₁ | -0.43 | -0.22 | -1.13 | -0.35 | -0.59 | -0.24 | -1.08 | -0.32 |
| | | S ₂ | -67.40 | 25.20 | -0.32 | -45.24 | -67.27 | 24.99 | -0.26 | -45.20 |
| | | S ₃ | -75.37 | 29.05 | -2.55 | -51.55 | -75.30 | 28.90 | -2.49 | -51.56 |
| | | S ₄ | 0.61 | -0.21 | -0.10 | 0.55 | 0.49 | -0.17 | -0.10 | 0.49 |

4. まとめ

場の方程式と境界条件が線形となる非定常熱伝導問題について理論解析をおこない、以下のことを示した。

(1) 任意の時間依存発熱、任意の時間依存境界条件および任意の初期温度分布条件が与えられた複合問題は以下の3つの問題の重ね合わせとして表せる。

- ・初期温度分布の拡散減衰問題――発熱および境界値は0
- ・時間依存発熱問題――境界値および初期温度は0
- ・時間依存境界値問題――発熱および初期温度は0

(2) 時間依存境界値問題は部分境界問題（一つの部分境界のみ境界値を与え、その他の境界では境界値を0とした問題）の重ね合わせとして表せる。

同様に、時間依存発熱問題は部分領域問題（一つの部分領域のみ発熱を与え、その他の領域では発熱を0とした問題）の重ね合わせとして表せる。初期温度分布の拡散減衰問題においても同様の部分領域問題の重ね合わせが成立する。

(3) 上記(2)における境界分割（領域分割）を細かくした極限では、境界（領域）に関する積分形式の「重ね合わせ」となり、これがGreen関数法である。

(4) 時間依存境界値問題において、境界条件式の左辺係数が時間に依存せず位置のみの関数で与えられ、右辺の境界値が位置のみの分布関数と時間のみ関数の積で与えられる場合、Duhamelの定理を応用することができる。すなわち時間に依存しない境界値（分布関数形状は同一）問題の解を用いて、時間応答に関する積分重ね合わせにより容易に計算できる。

(5) 力学的な境界条件が不変の線形弾性体の熱応力は温度分布と線形に対応し、線形な非定常熱伝導に関する上記の結論は、熱応力に関しても共通に成立する。

「重ね合わせの原理」から導かれるこれらの知見は重要であり、工学的な応用価値が大きい。本報告では上記(4)、(5)を検証し、具体的応用例を示すために以下の数値解析をおこなった。

(6) 内面で流体から熱伝達を受けるノズル構造の非定常熱伝導および熱応力解析をFINASを用いて、以下の3ケース実施した。

- ・ケース1――基本解析、初期温度0℃、流体温度1℃一定保持。
- ・ケース2――初期温度600℃、流体温度(600℃→300℃)のコールドショック。
- ・ケース3――初期温度300℃、流体温度(300℃→600℃)のホットショック。

(7) ケース1（基本解析）の結果を用い、Duhamelの定理に基づく数値積分を、ケース2および3に対して実施した。

(8) ケース2、3の非定常温度分布および熱応力について、数値積分による予測計算値はFINAS解と実用上十分な精度で一致する。これにより、(4)および(5)を検証した。また本報告で得られた知見は、高温プラントの機器・構造・配管の非定常熱伝導および熱応力の計算評価において、以下のような応用価値があるものと考えられる。

(9) 計算効率の向上改善のための応用

(10) 感度解析による最適設計への応用

(11) 非定常熱伝導および過渡熱応力的高速評価およびモニタシステムへの応用

固有関数展開法やGreen関数法を含めた「重ね合わせの手法」のより一般的な応用例、および境界条件式の左辺係数が時間に依存する場合の近似解法、などの工学的に重要な問題の議論検討は引き続き次報以降で行う予定である。

5. 参考文献

- 文献1 古橋他、簡易熱応力評価線図（第1報）平板の非定常熱応力の理論解析、PNC N9410 87-028、1987年2月
- 文献2 古橋他、大型高速増殖炉要素技術設計研究（Ⅱ）簡易熱応力評価線図（不連続熱応力の簡易解析）、PNC N9410 87-158、1987年11月
- 文献3 古橋他、シェル理論による簡易熱応力評価プログラム（SIMPLE）の開発、PNC PN9410 93-050、1992年4月
- 文献4 スタンリー・ファーロウ著、偏微分方程式 科学者・技術者のための使い方と解き方、伊理正夫・伊理由美訳、啓学出版、昭和61年1月31日 初版2刷発行

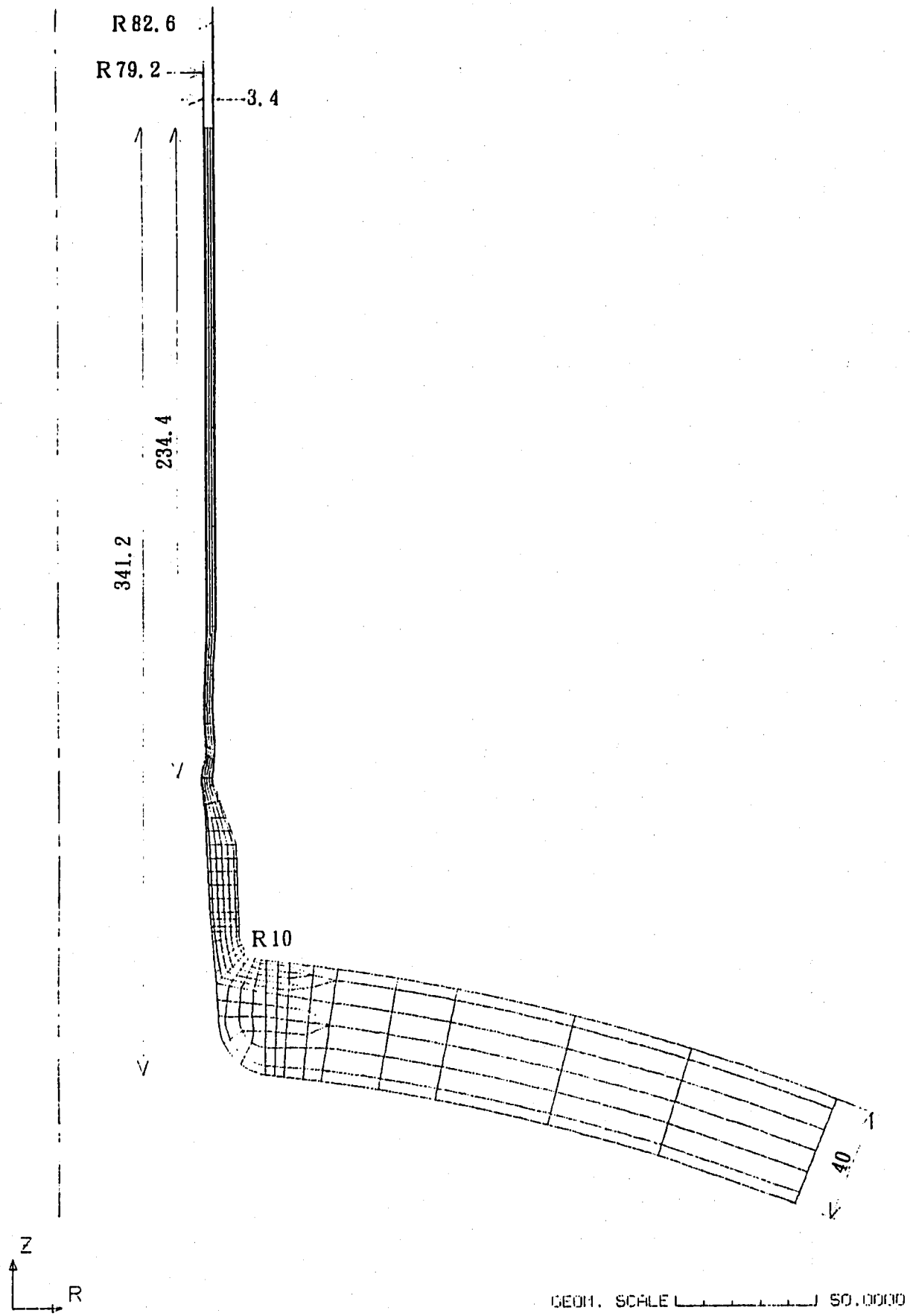


図1 解析モデル

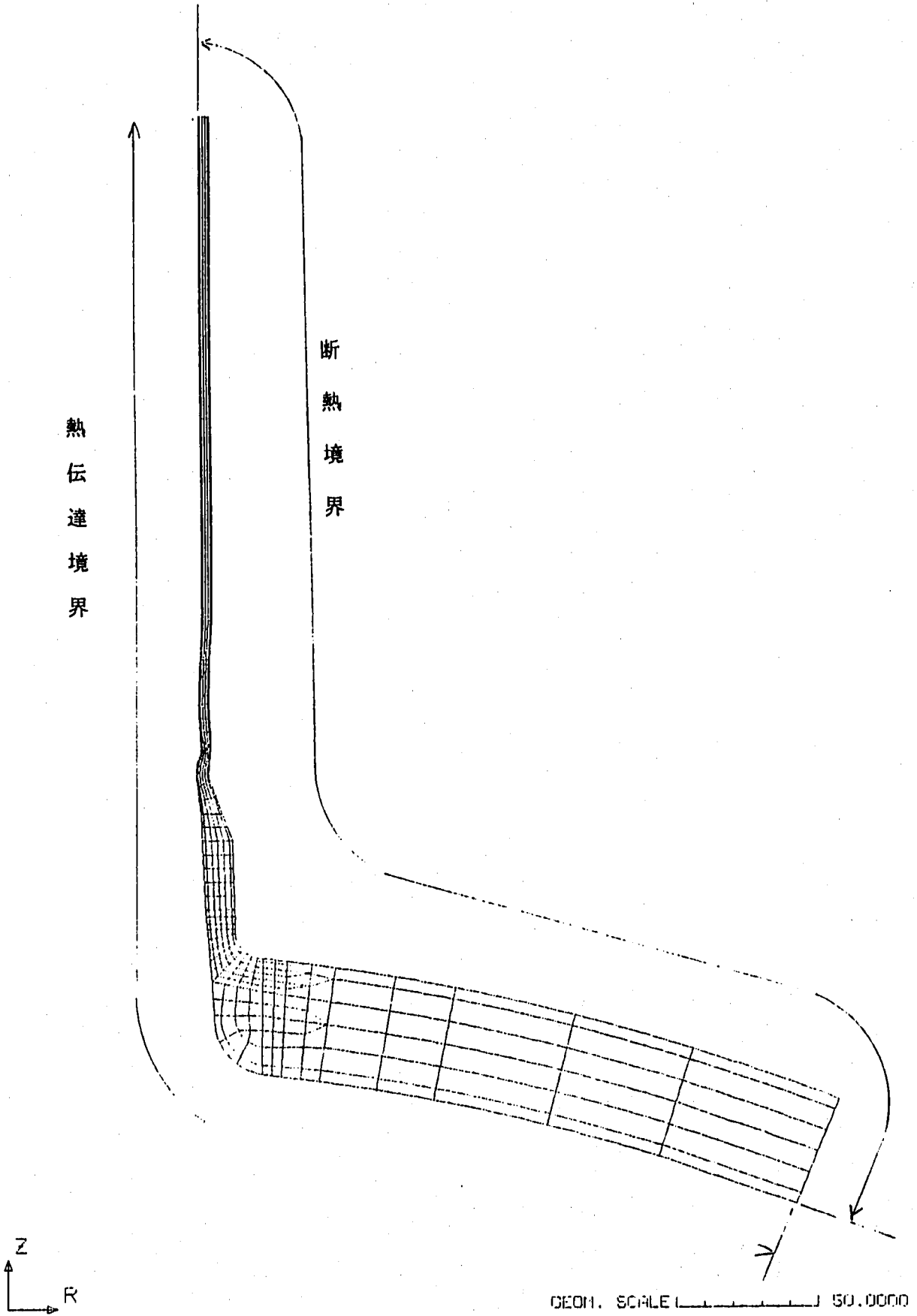


図2 熱伝導解析の境界条件

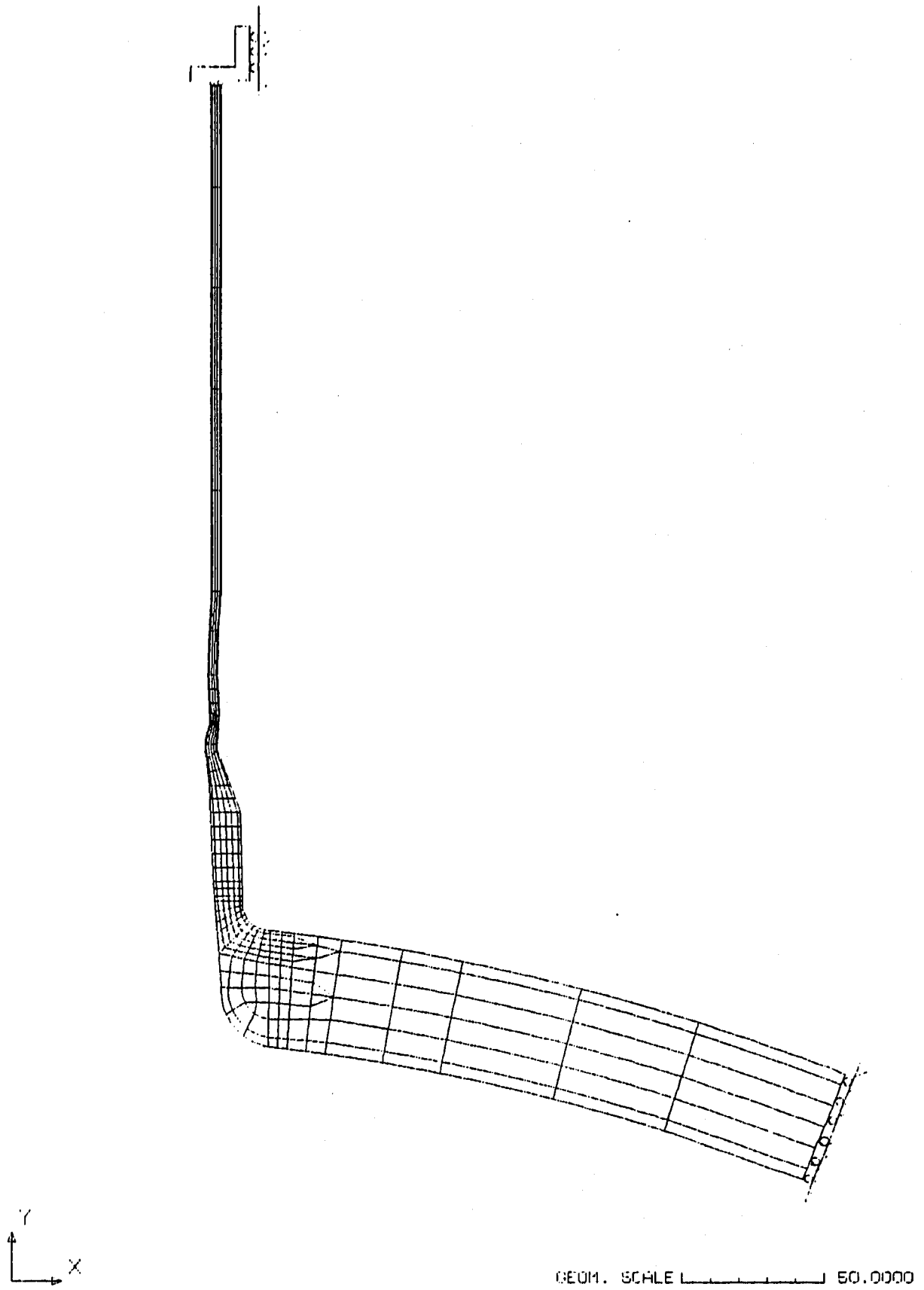


図3 熱応力解析の境界条件

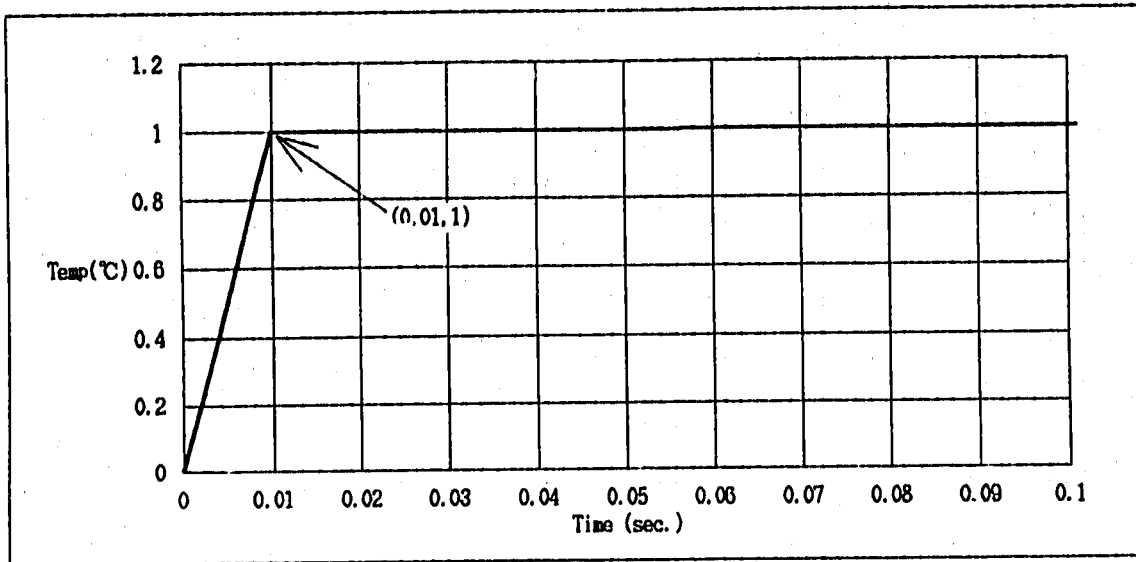


図4. 1 流体温度の時間変化特性 (基本ケース)

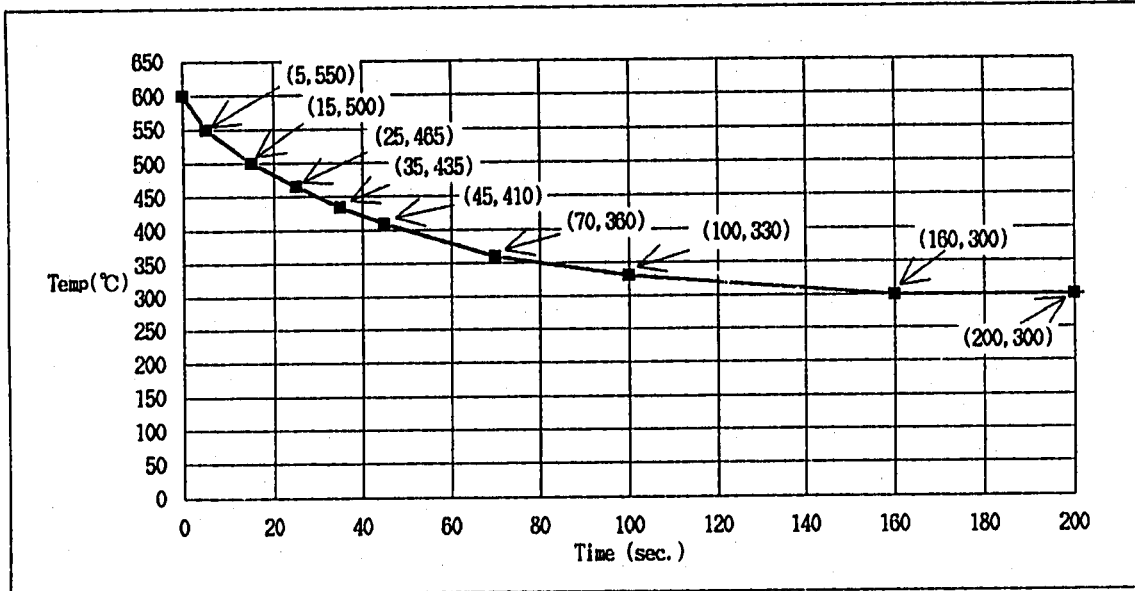


図4. 2 流体温度の時間変化特性 (コールドショック)

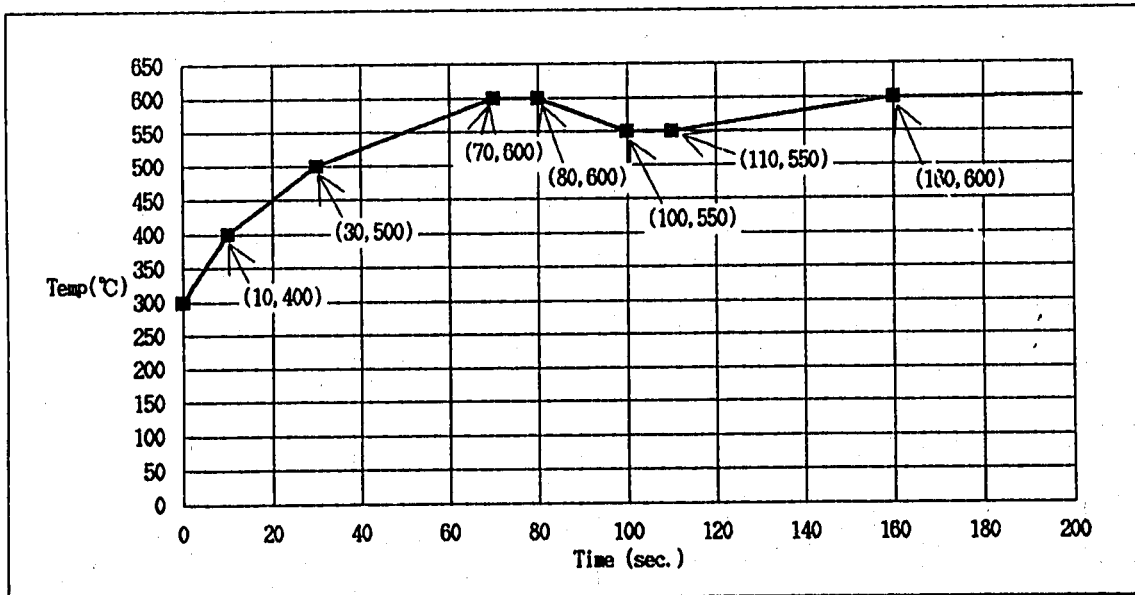


図4. 3 流体温度の時間変化特性 (ホットショック)

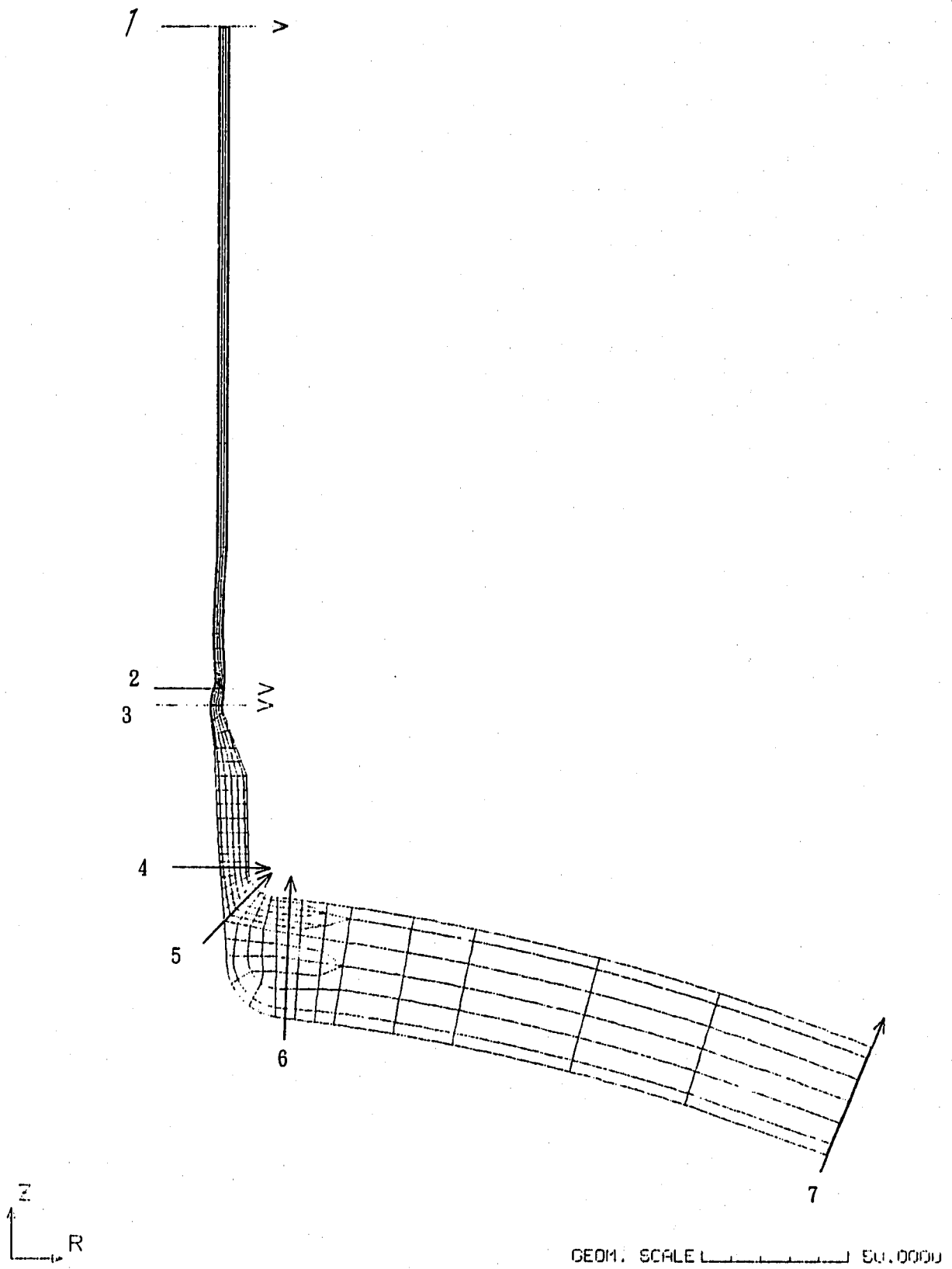
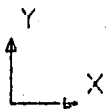
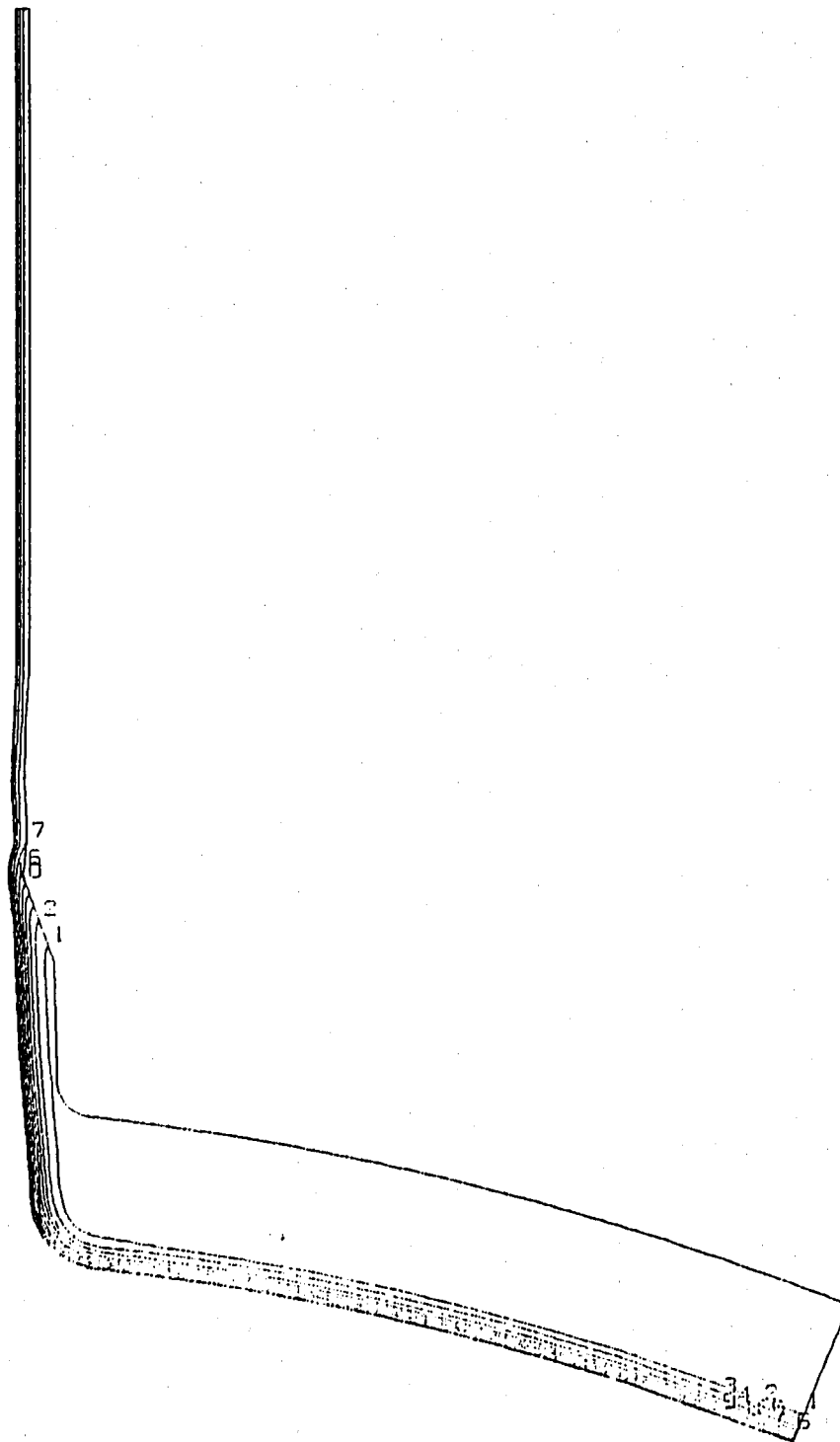


图5 评估断面图

FINAS
TEMPERATURE

CONTOUR VALUES

- 1 3.700-02
- 2 0.114000
- 3 0.191000
- 4 0.268000
- 5 0.345000
- 6 0.421999
- 7 0.498999
- 8 0.575999
- 9 0.652999
- 10 0.729999



GEOM. SCALE 50.0000

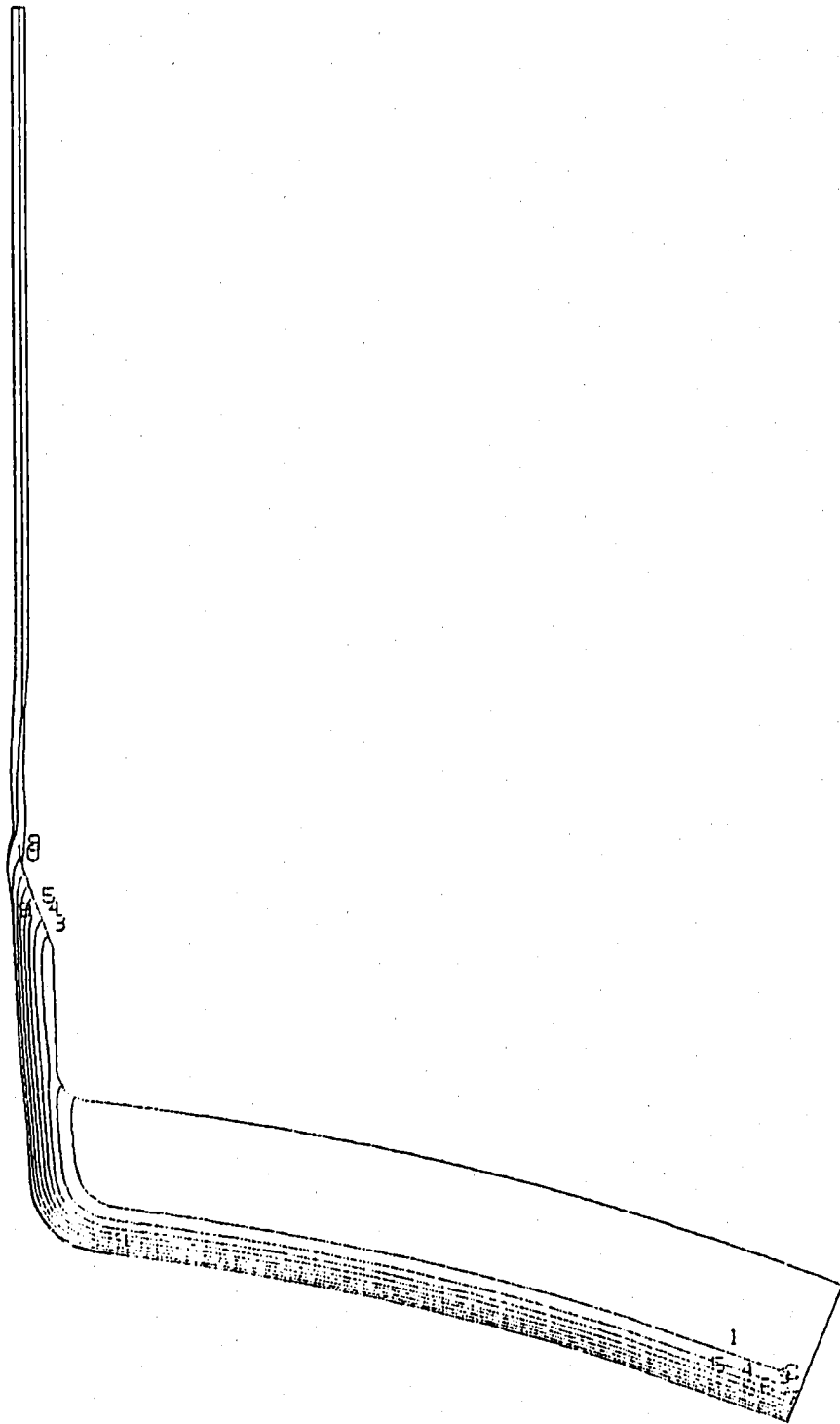
STEP NO. 18

図6. 1 温度コンター t=2 sec

FINAE
TEMPERATURE

CONTOUR VALUES

- 1 4.700-02
- 2 0.141000
- 3 0.235000
- 4 0.329000
- 5 0.423000
- 6 0.517000
- 7 0.610999
- 8 0.704999
- 9 0.798999
- 10 0.892999



GEOM. SCALE 1 50.0000

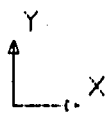
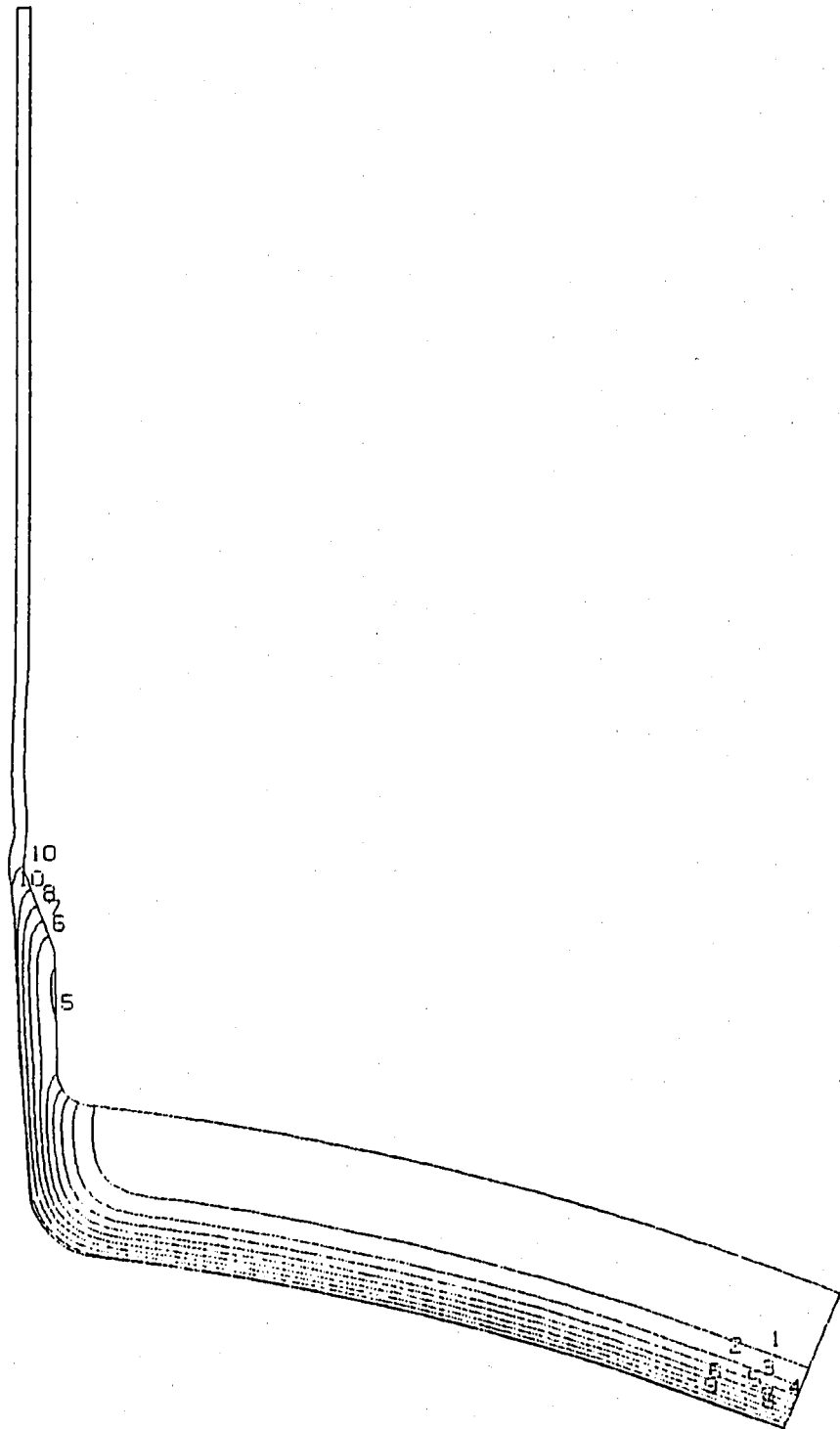
STEP (NO.) 33

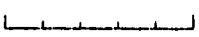
図6. 2 温度コンター t = 5 sec

FINAS
TEMPERATURE

CONTOUR VALUES

- 1 5.000-02
- 2 0.149000
- 3 0.248000
- 4 0.347000
- 5 0.446000
- 6 0.545000
- 7 0.643999
- 8 0.742999
- 9 0.841999
- 10 0.940999



GEOM. SCALE  50.0000

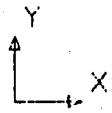
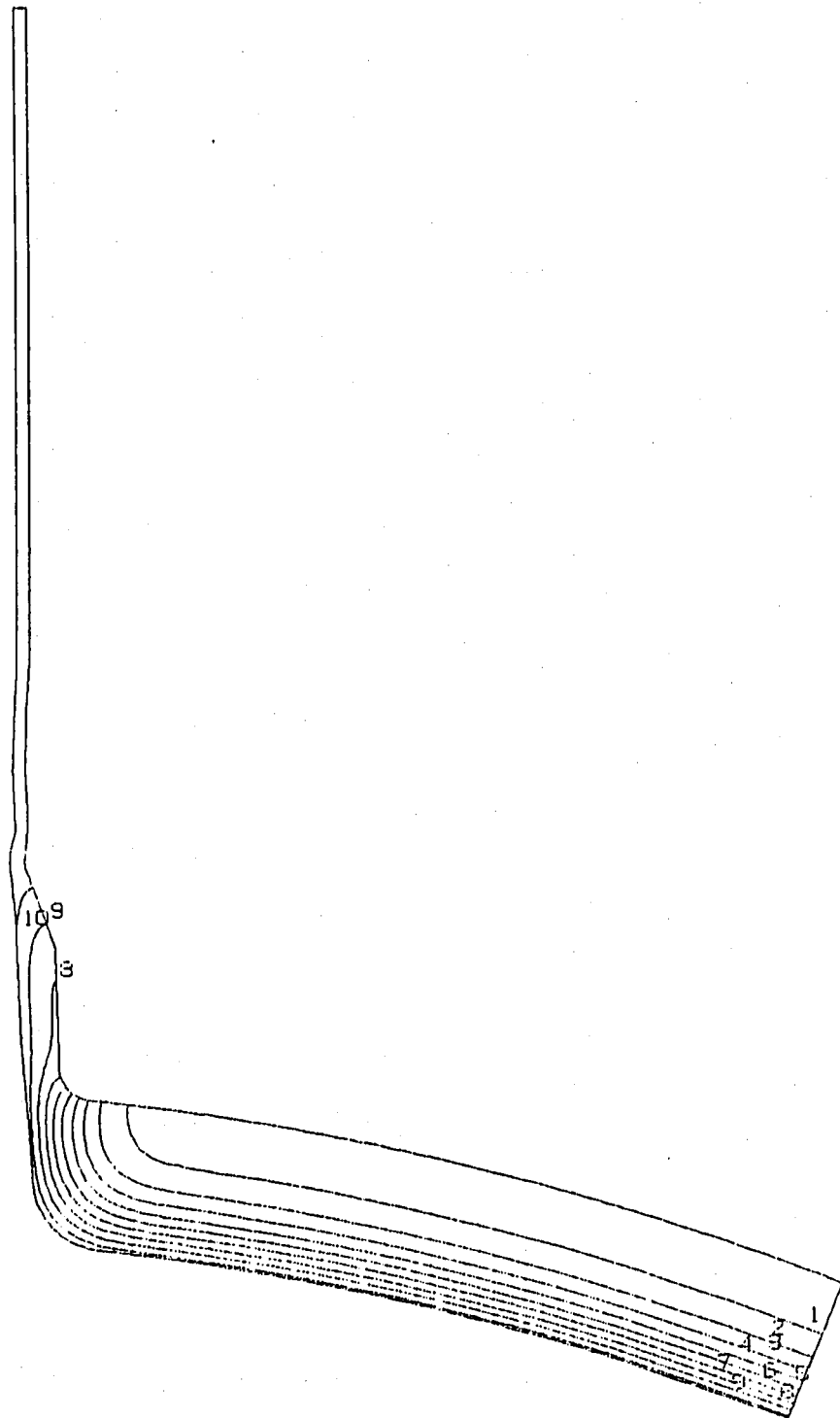
STEP NO. 43

図6. 3 温度コンター t = 10 sec

FINAS
TEMPERATURE

CONTOUR VALUES

- 1 5.600-02
- 2 0.156000
- 3 0.256000
- 4 0.356000
- 5 0.456000
- 6 0.555999
- 7 0.655999
- 8 0.755999
- 9 0.855999
- 10 0.955999



STEP NO. 53

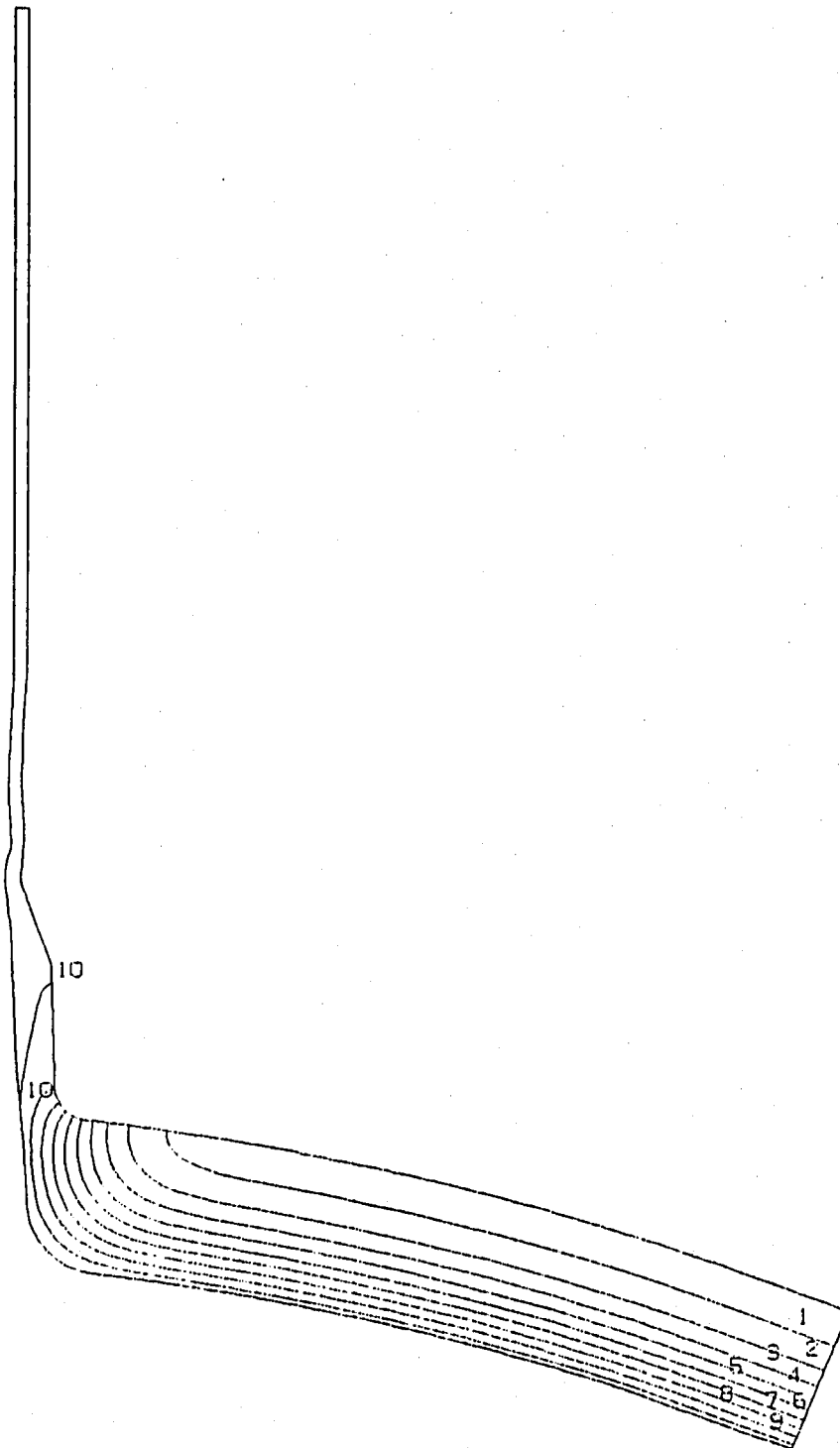
GEOM. SCALE 1 _____ 50.0000

図6. 4 温度コンター t=20 sec

FINAS
TEMPERATURE

CONTOUR VALUES

- 1 0.112000
- 2 0.206000
- 3 0.300000
- 4 0.394000
- 5 0.488000
- 6 0.581999
- 7 0.675999
- 8 0.769999
- 9 0.863999
- 10 0.957999



GEOM. SCALE 1 50.0000

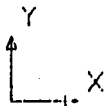
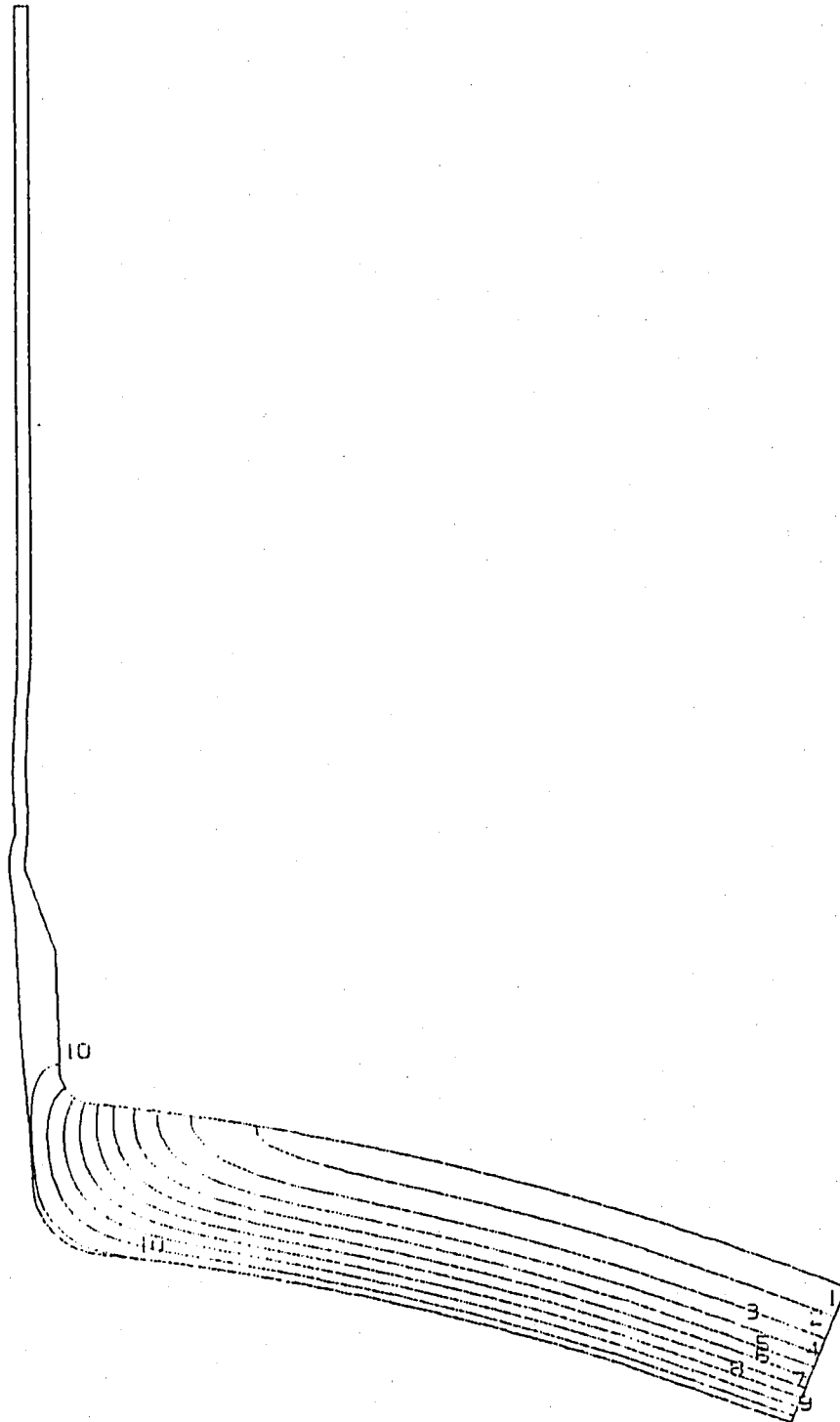
STEP NO. 63

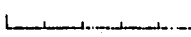
図6. 5 温度コンター t = 40 sec

FINAS
TEMPERATURE

CONTOUR VALUES

- 1 0.379000
- 2 0.444000
- 3 0.509000
- 4 0.573999
- 5 0.638999
- 6 0.703999
- 7 0.768999
- 8 0.833999
- 9 0.898999
- 10 0.963999



GEOM. SCALE  50.0000

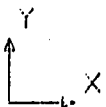
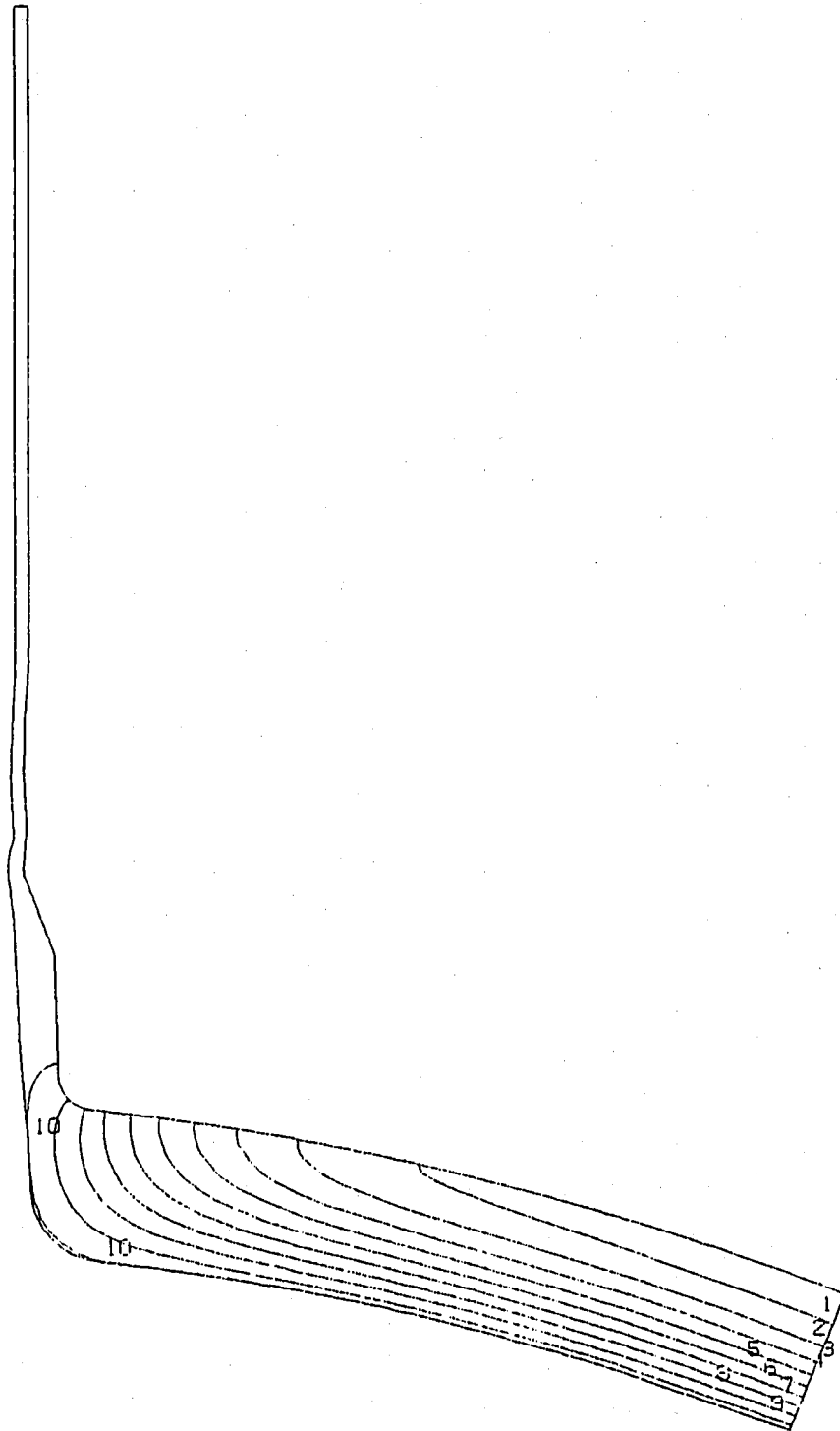
STEP NO. 75

図6. 6 温度コンター t = 100 sec

FINAS
TEMPERATURE

CONTOUR VALUES

- 1 0.832999
- 2 0.850999
- 3 0.868999
- 4 0.886999
- 5 0.904999
- 6 0.922999
- 7 0.940999
- 8 0.958999
- 9 0.976999
- 10 0.994999



GEOM. SCALE 50.0000

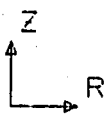
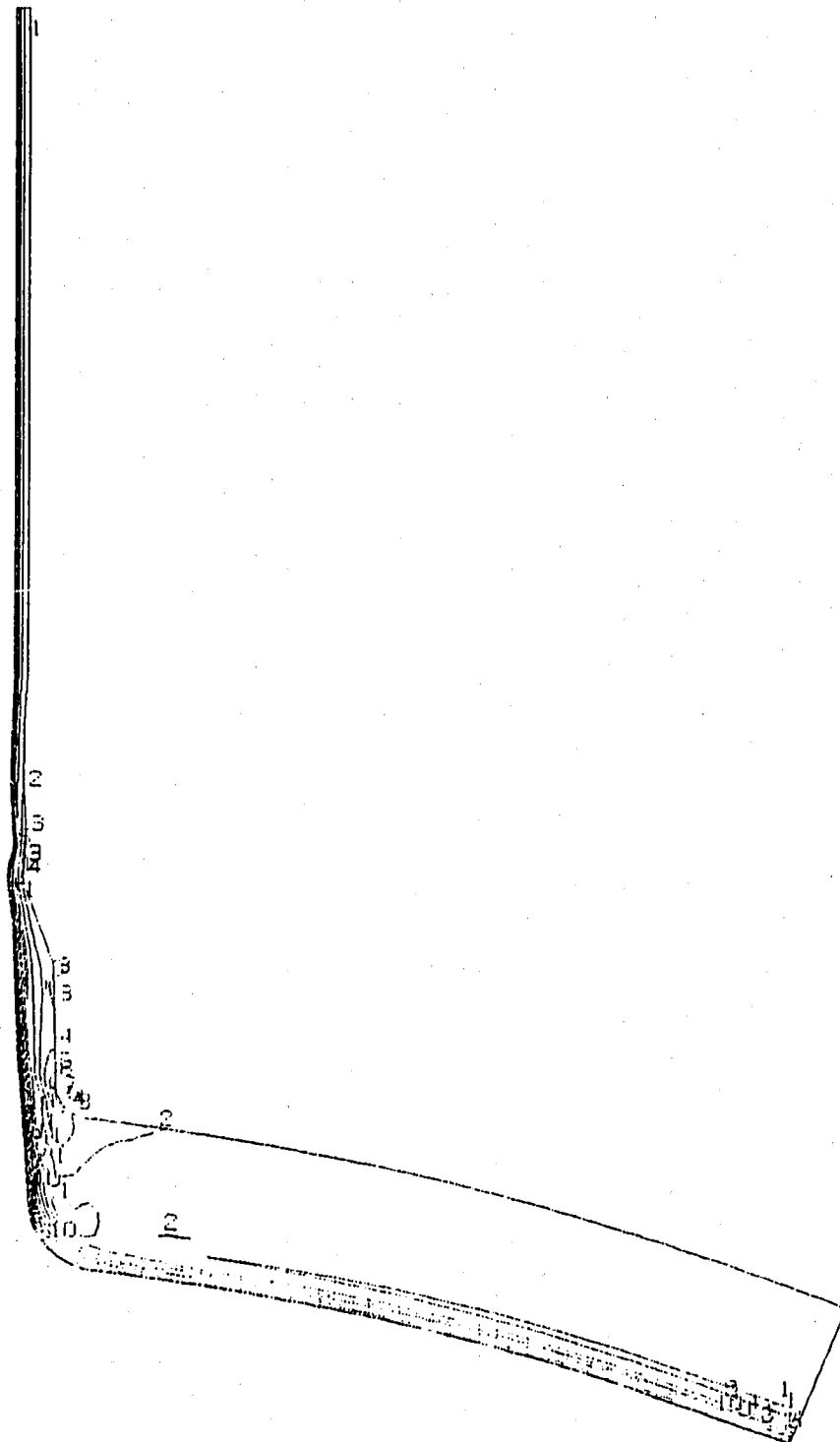
STEP NO. 90

図6. 7 温度コンター t=300 sec

FINAS
VON MISES STRESS

CONTOUR VALUES

- 1 1.500-02
- 2 4.300-02
- 3 7.100-02
- 4 9.900-02
- 5 0.127000
- 6 0.155000
- 7 0.183000
- 8 0.211000
- 9 0.239000
- 10 0.266999



GEOM. SCALE _____ 50.0000

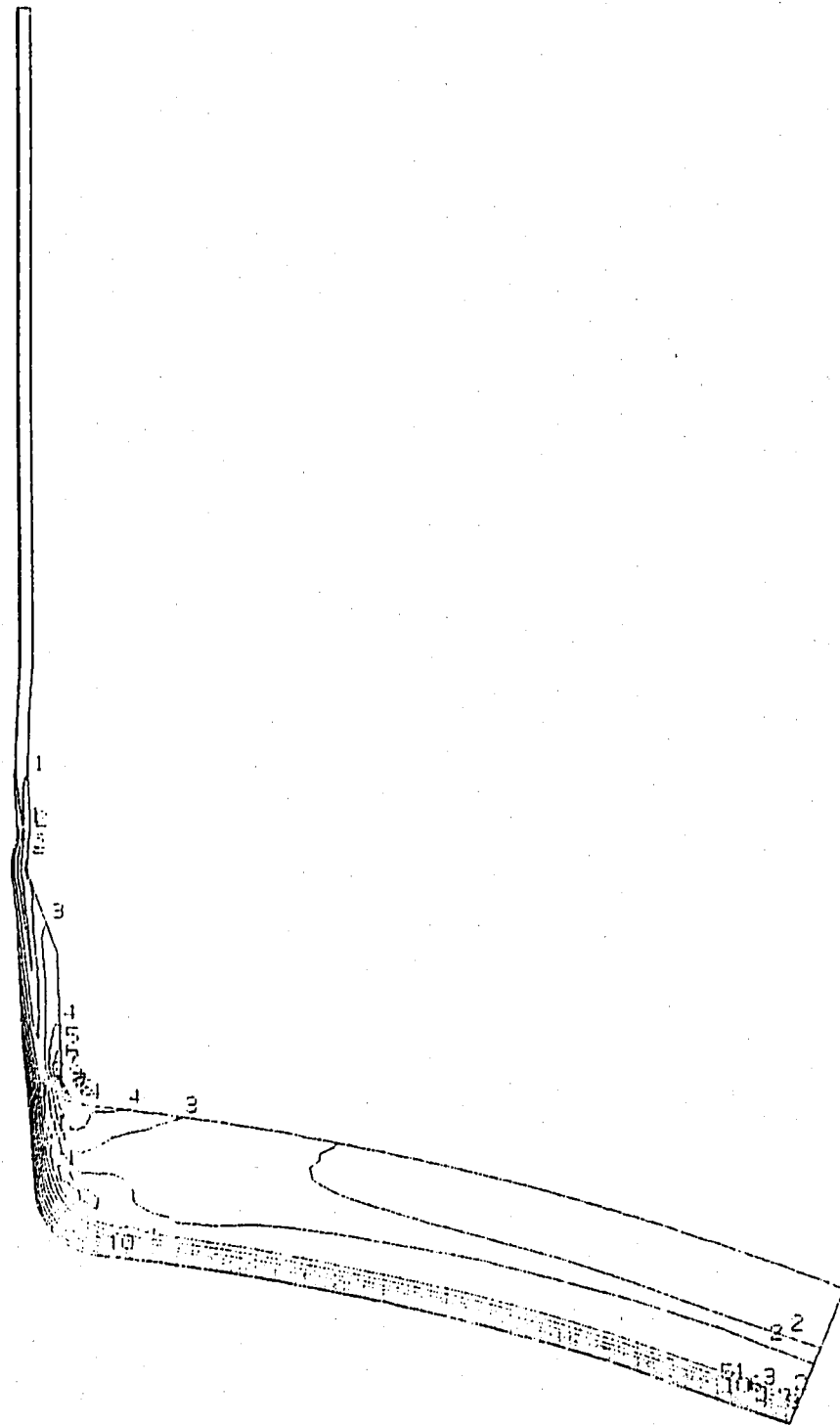
STEP NO. 19

図7. 1 ミーゼスの等価応力コンター t=2 sec

FINAS
VON MISES STRESS

CONTOUR VALUES

- 1 1.400-02
- 2 4.500-02
- 3 7.600-02
- 4 0.107000
- 5 0.138000
- 6 0.169000
- 7 0.200000
- 8 0.231000
- 9 0.262000
- 10 0.293000



GEOM. SCALE _____ 50.0000

STEP NO. 34

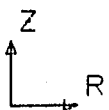
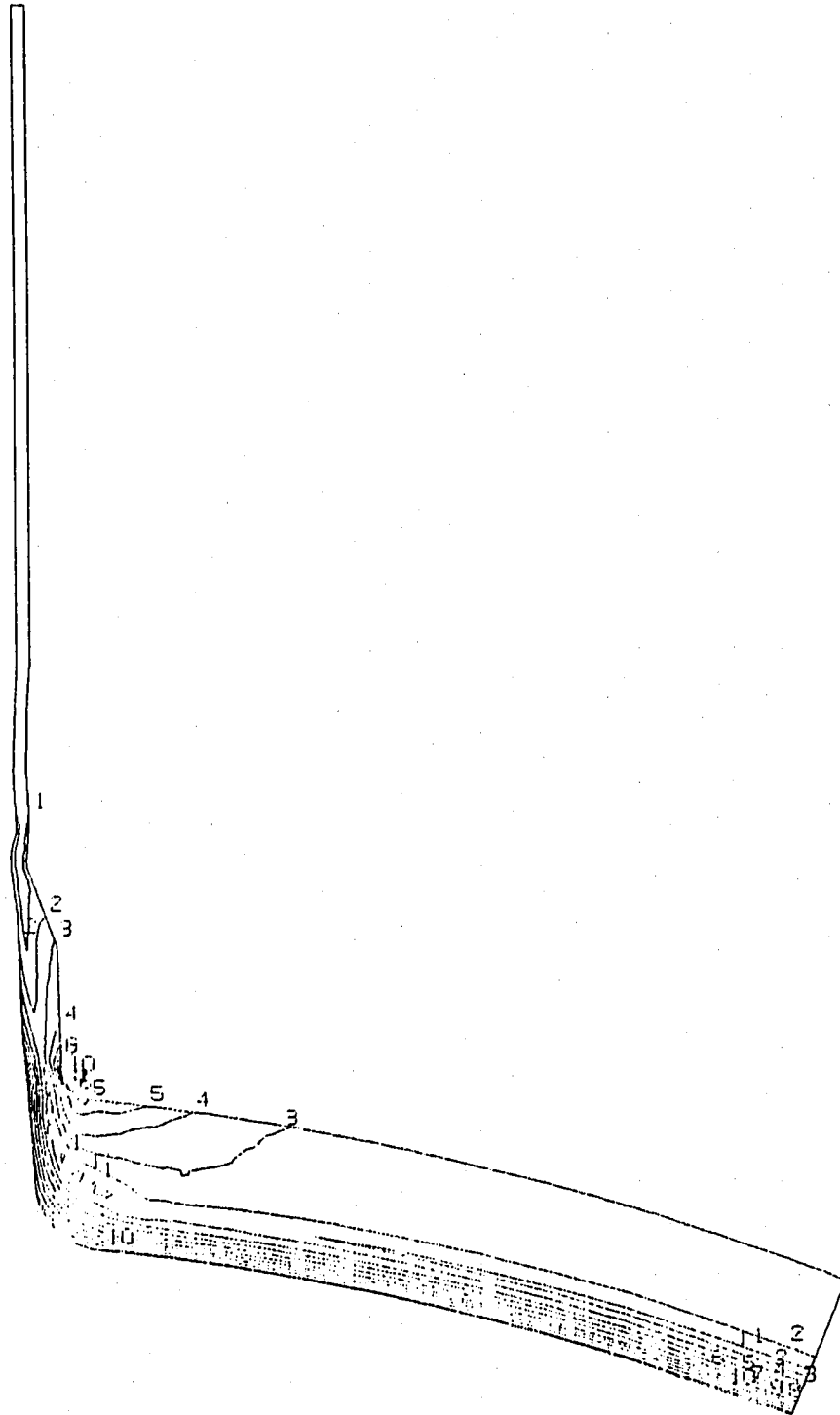
図7. 2 ミーゼスの等価応力コンター t = 5 sec

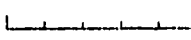
FINAS

VON MISES STRESS

CONTOUR VALUES

- 1 1.600-02
- 2 4.700-02
- 3 7.800-02
- 4 0.109000
- 5 0.140000
- 6 0.171000
- 7 0.202000
- 8 0.233000
- 9 0.264000
- 10 0.295000



GEOM. SCALE  50.0000

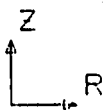
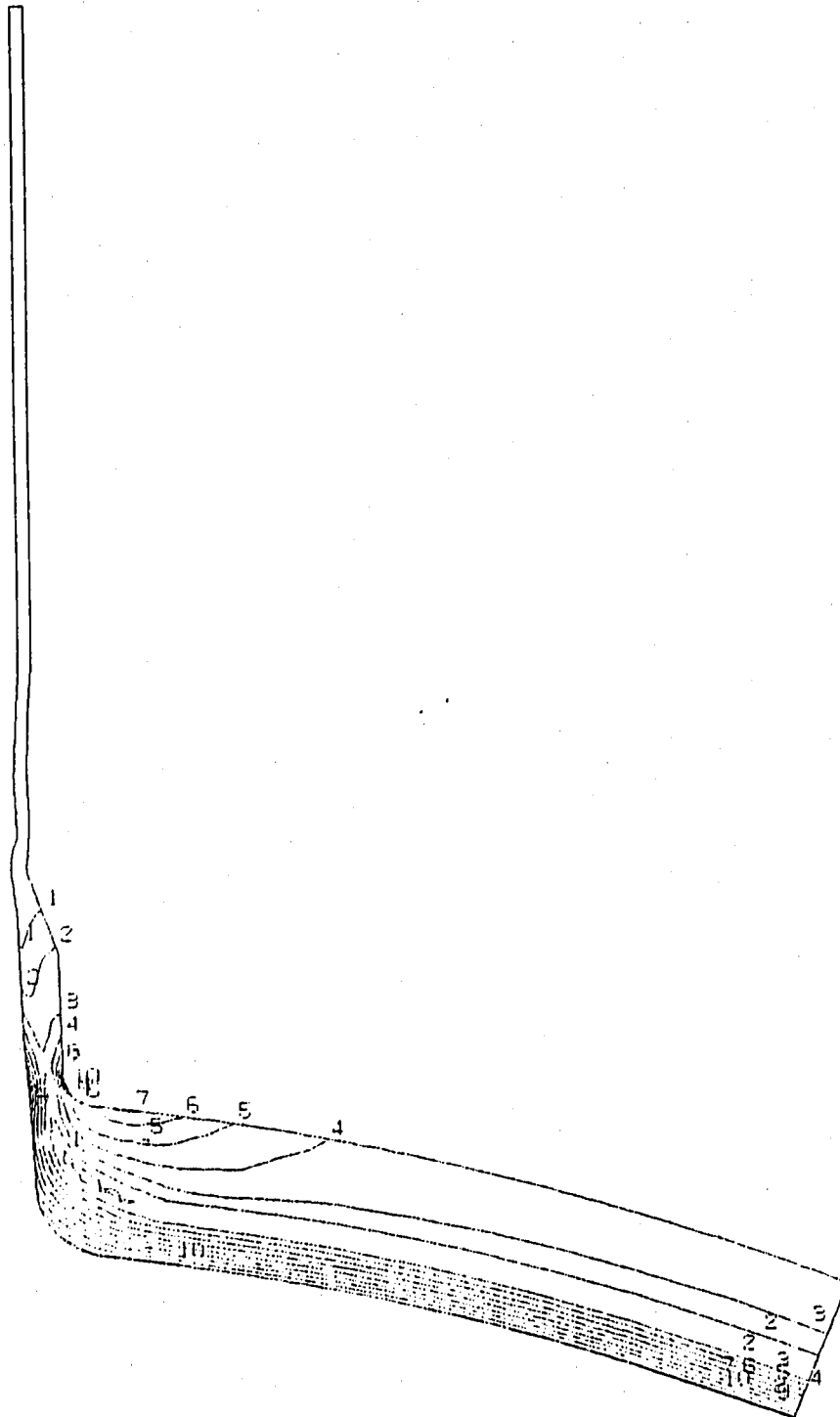
STEP NO. 44

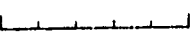
図7.3 ミーゼスの等価応力コンター t = 10 sec

FINAS
VON MISES STRESS

CONTOUR VALUES

- 1 1.500-02
- 2 4.500-02
- 3 7.500-02
- 4 0.105000
- 5 0.135000
- 6 0.165000
- 7 0.195000
- 8 0.225000
- 9 0.255000
- 10 0.285000



GEOM. SCALE  50.0000

STEP NO. 54

図7. 4 ミーゼスの等価応力コンター t=20 sec

FINAS
VON MISES STRESS

CONTOUR VALUES

- 1 1.400-02
- 2 4.200-02
- 3 7.000-02
- 4 9.800-02
- 5 0.126000
- 6 0.154000
- 7 0.182000
- 8 0.210000
- 9 0.238000
- 10 0.265999

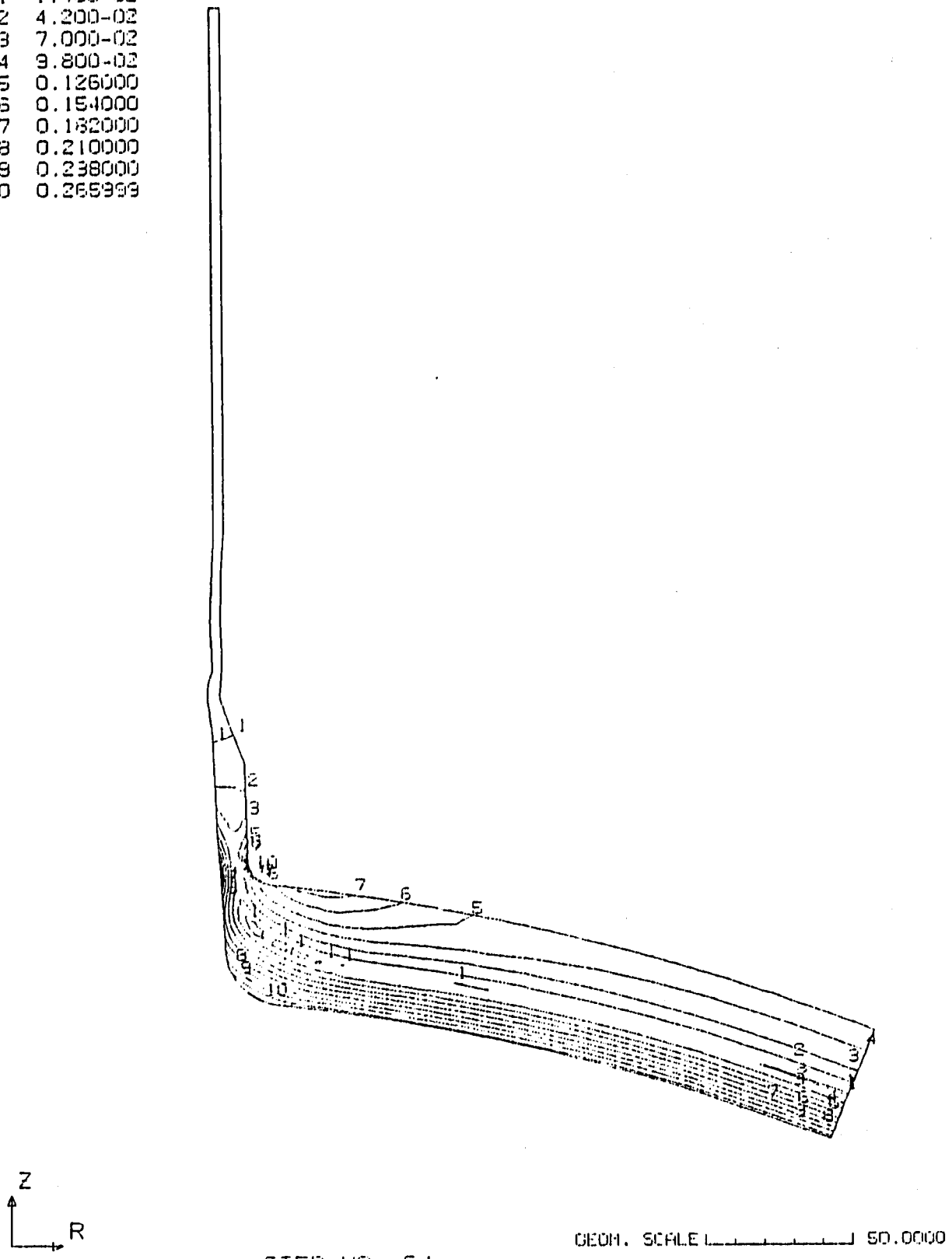
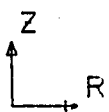
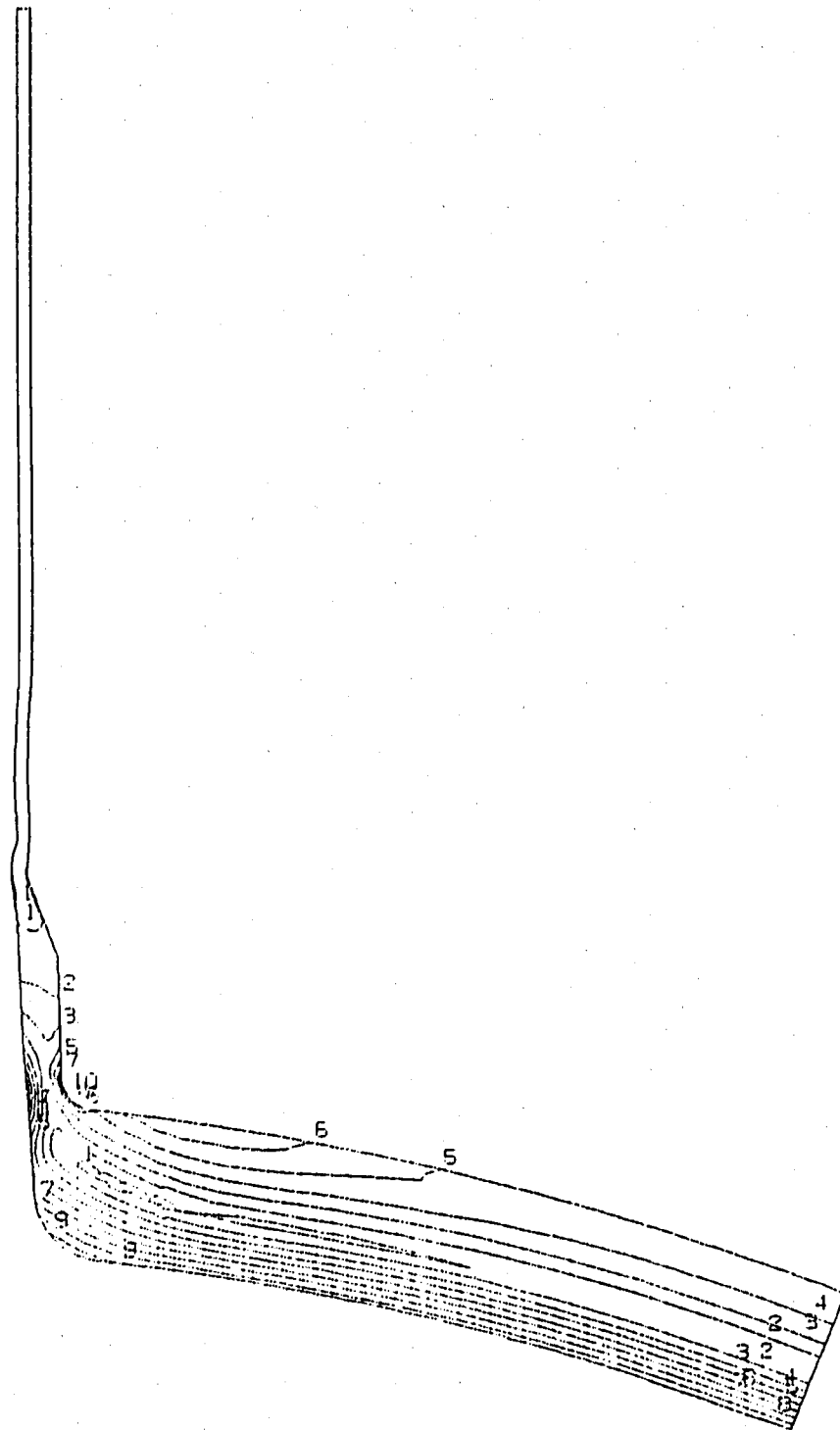



図7.5 ミーゼスの等価応力コンター t = 40 sec

FINAS
VON MISES STRESS

CONTOUR VALUES

- 1 1.000-02
- 2 3.000-02
- 3 5.000-02
- 4 7.000-02
- 5 9.000-02
- 6 0.110000
- 7 0.130000
- 8 0.150000
- 9 0.170000
- 10 0.190000



GEOM. SCALE  50.0000

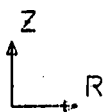
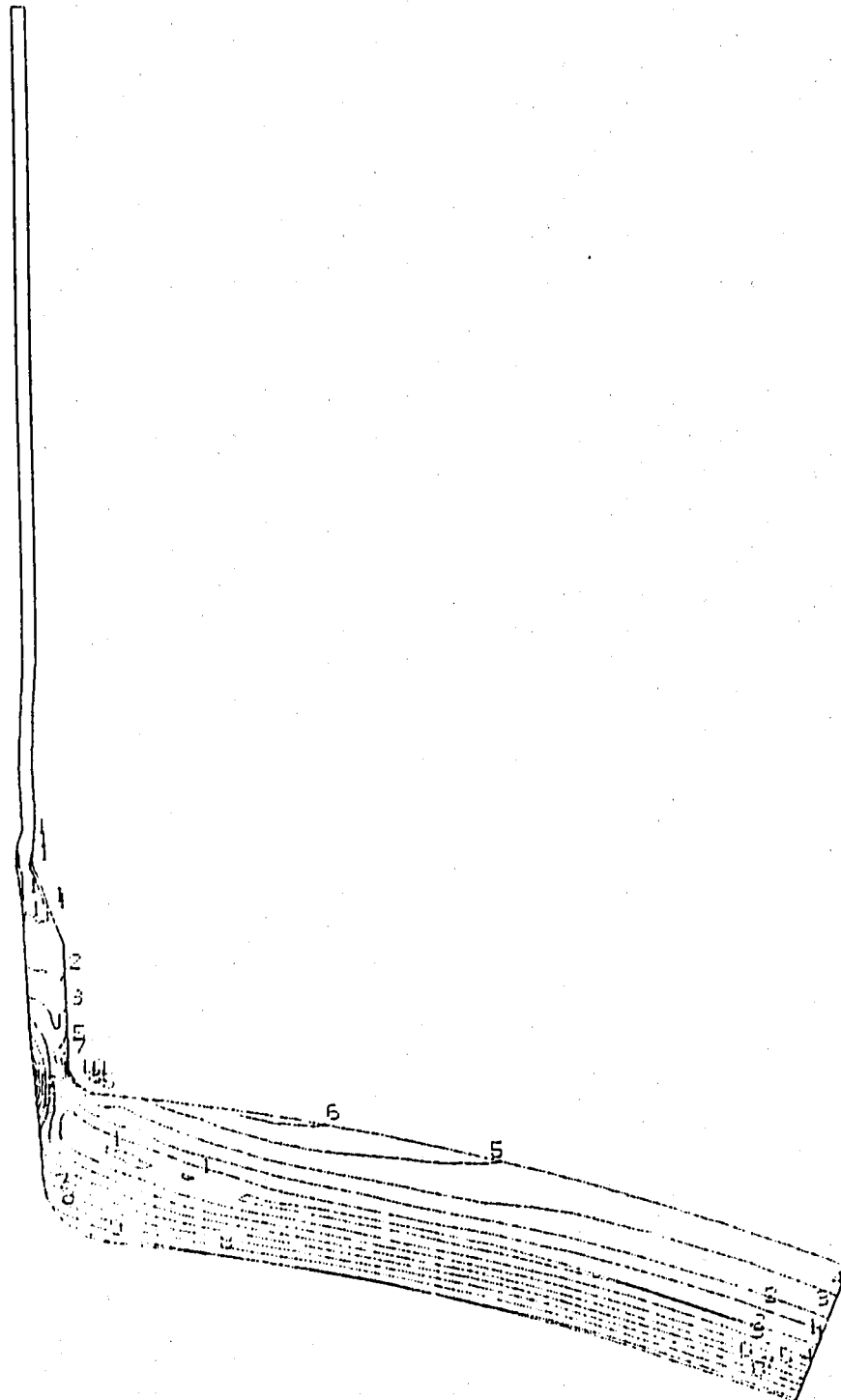
STEP NO. 76

図7.6 ミーゼスの等価応力コンター t = 100 sec

FINAS
VOII MISES STRESS

CONTOUR VALUES

| | |
|----|----------|
| 1 | 2.600-03 |
| 2 | 8.000-03 |
| 3 | 1.340-02 |
| 4 | 1.830-02 |
| 5 | 2.420-02 |
| 6 | 2.960-02 |
| 7 | 3.500-02 |
| 8 | 4.040-02 |
| 9 | 4.580-02 |
| 10 | 5.120-02 |



GEOM. SCALE 1:50,000

STEP NO. 91

図7.7 ミーゼスの等価応力コンター t=300 sec

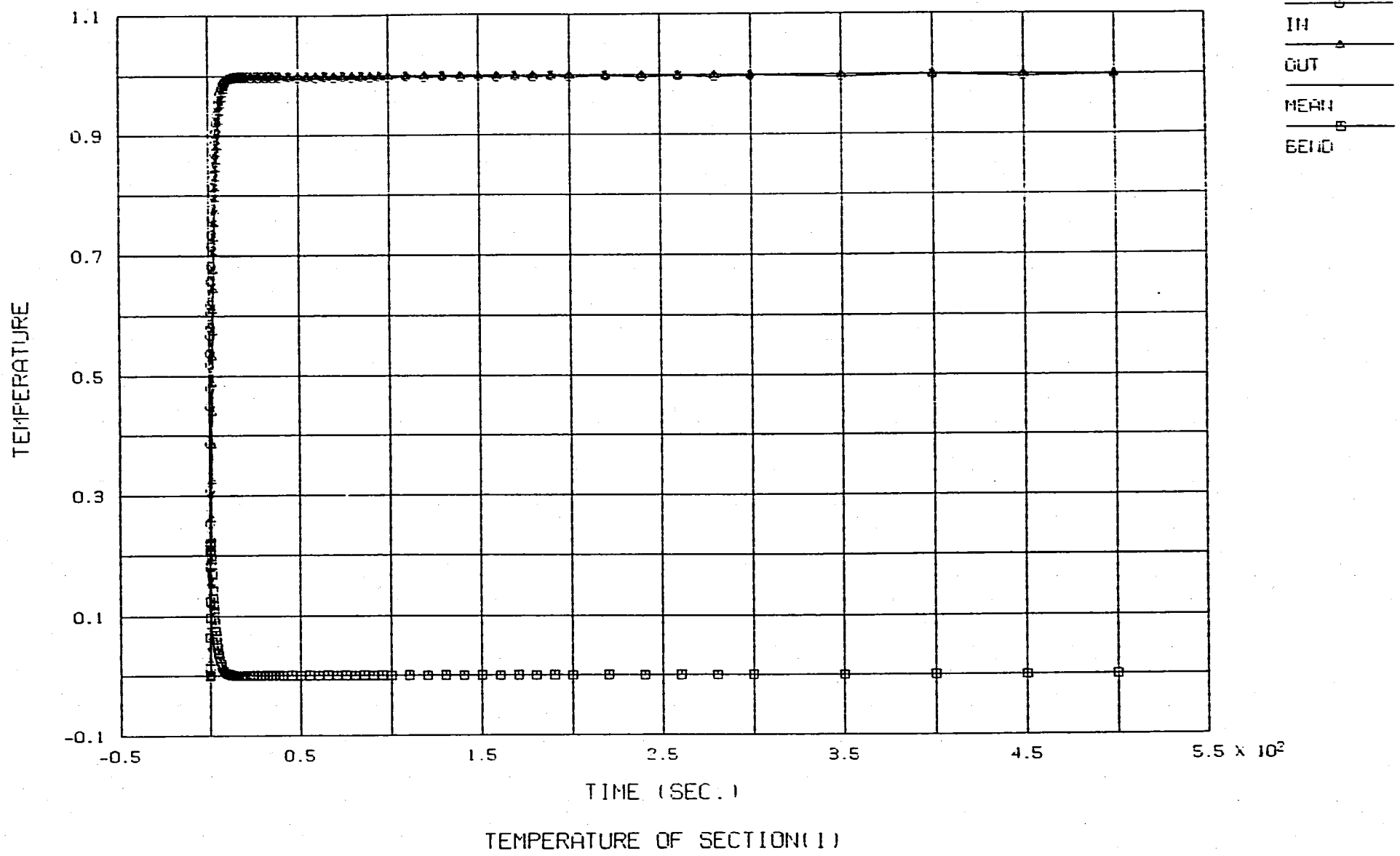


図8.1 評価断面1の温度

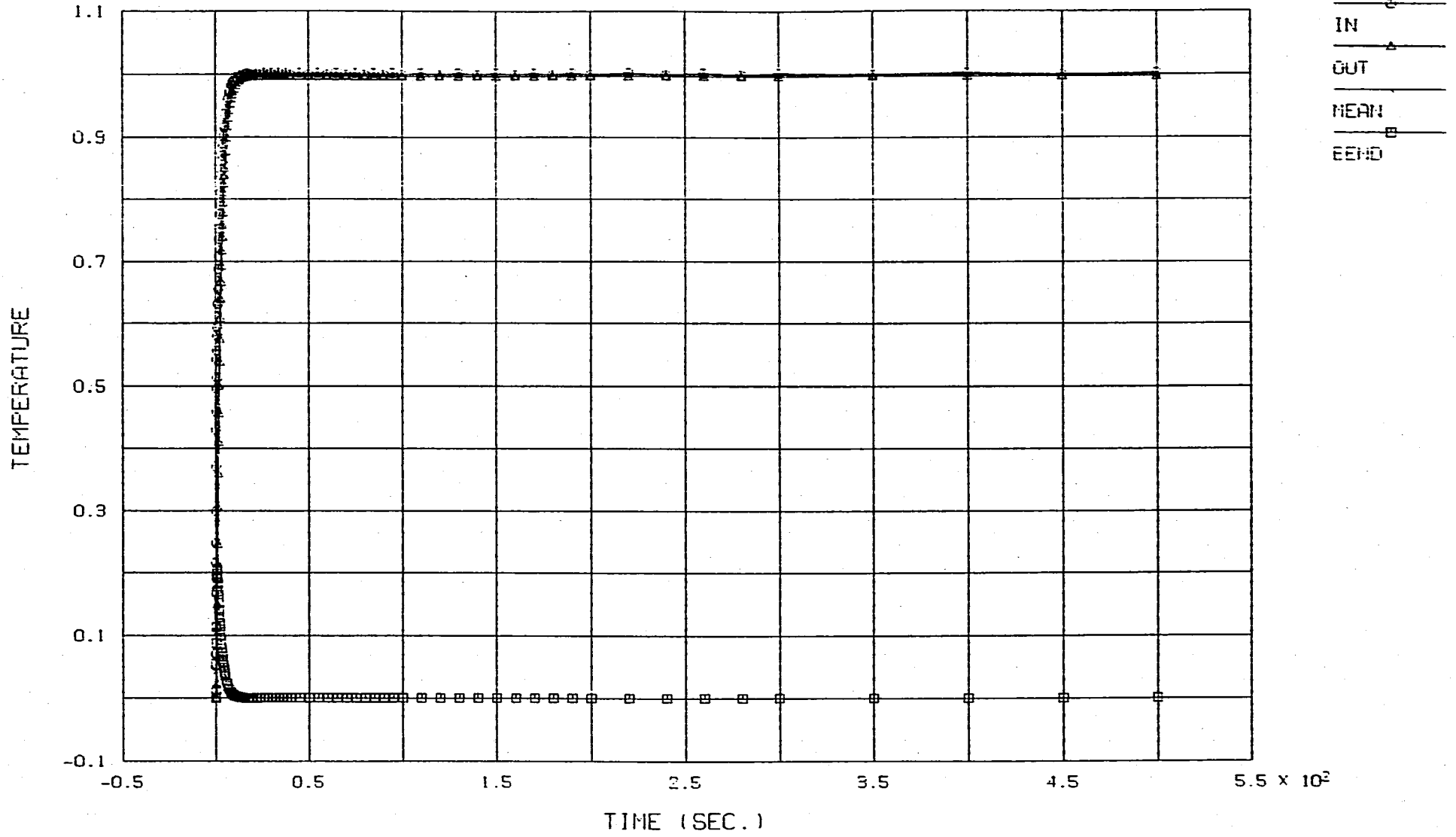
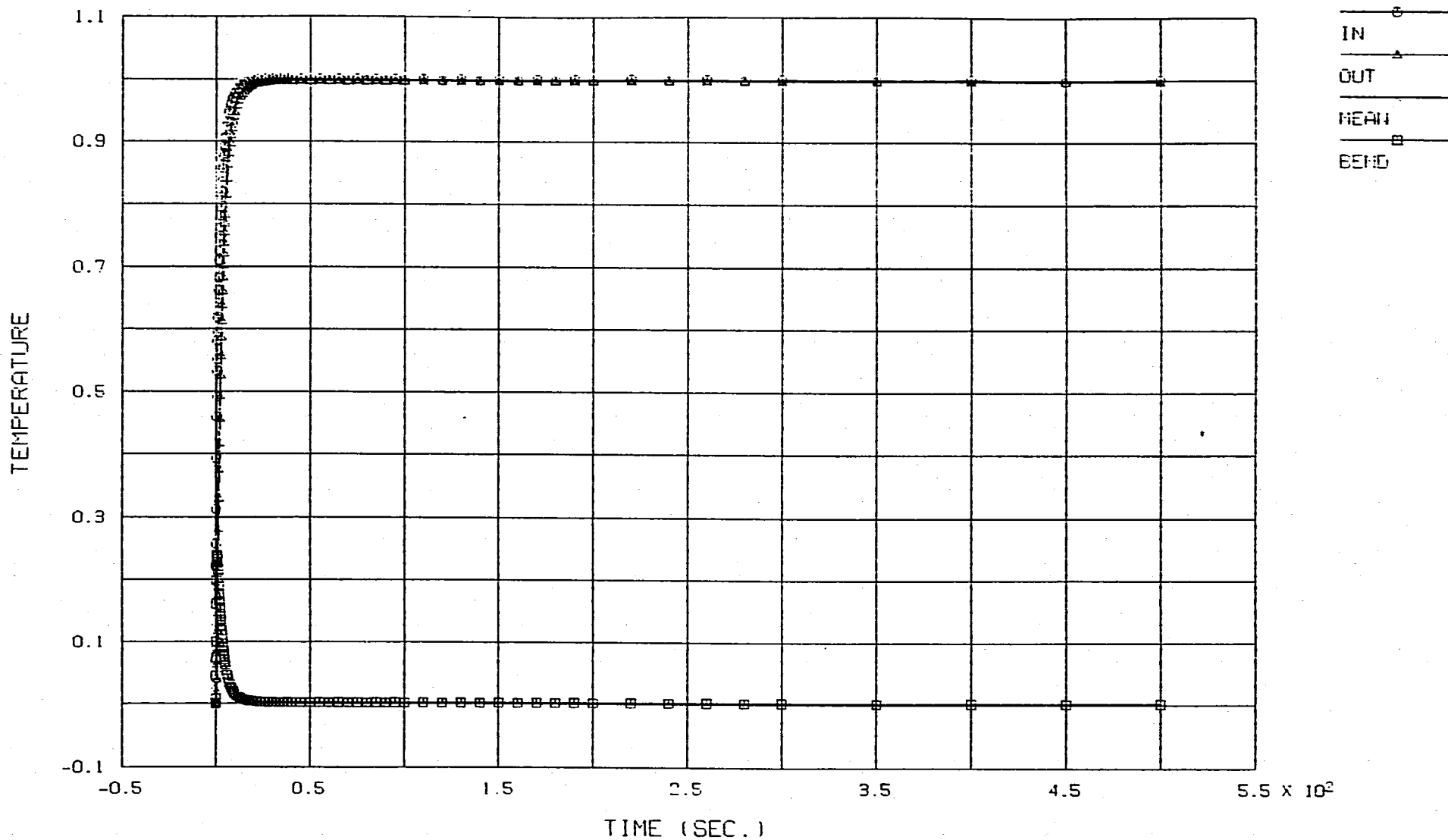


図8. 2 評価断面2の温度

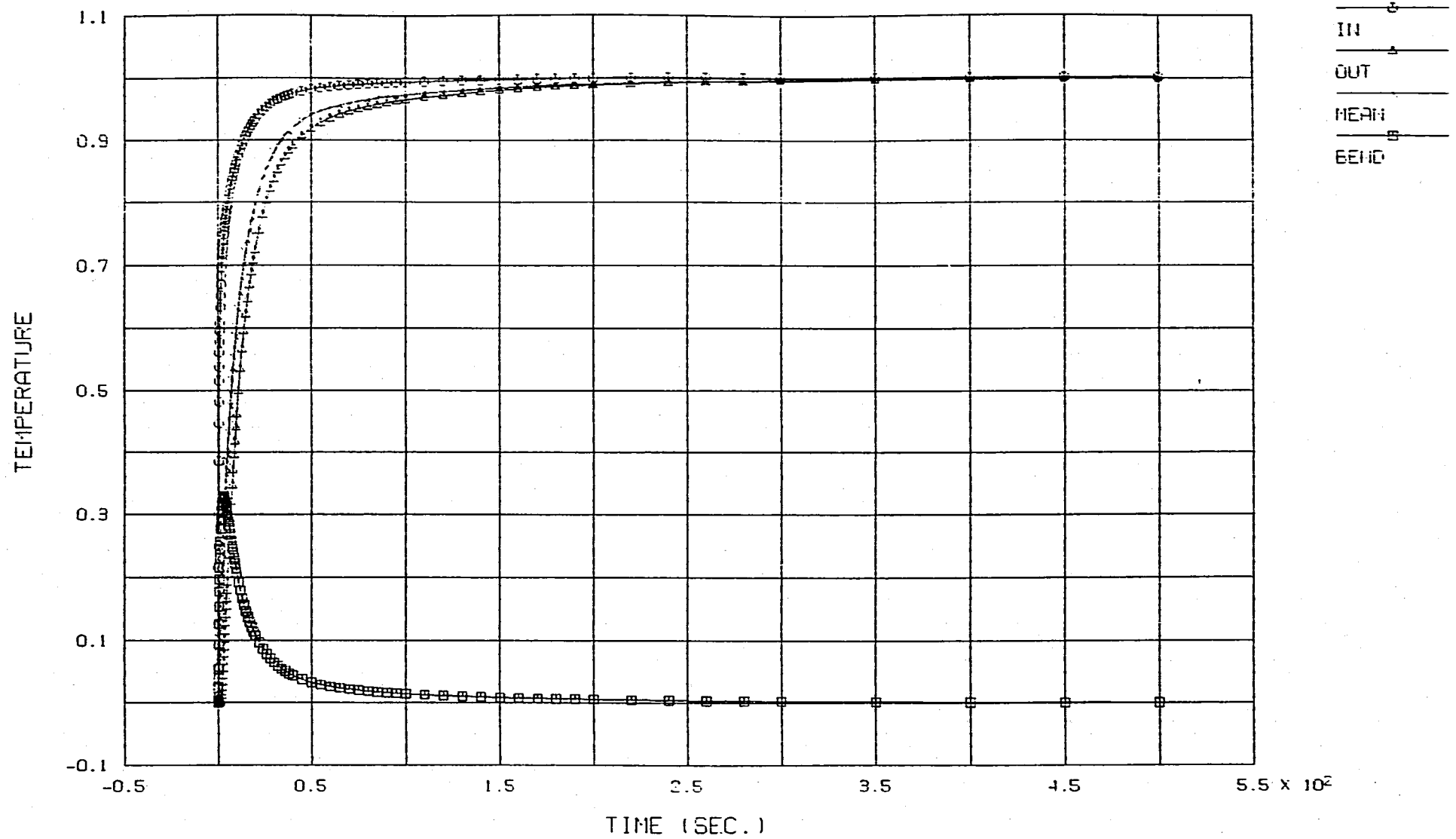
FINAS



TEMPERATURE OF SECTION(3)

図8.3 評価断面3の温度

FINAS



TEMPERATURE OF SECTION(4)

図8. 4 評価断面4の温度

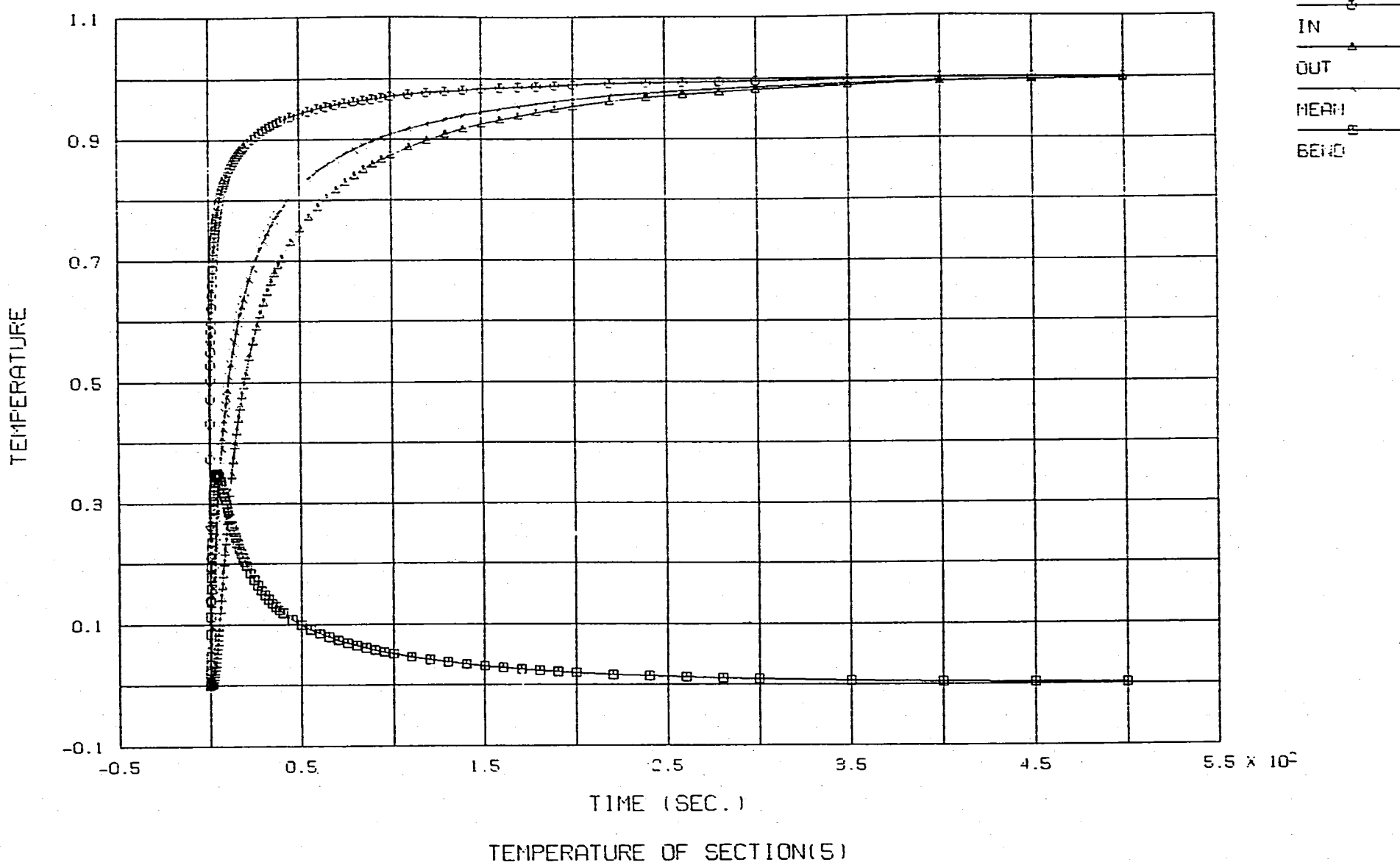
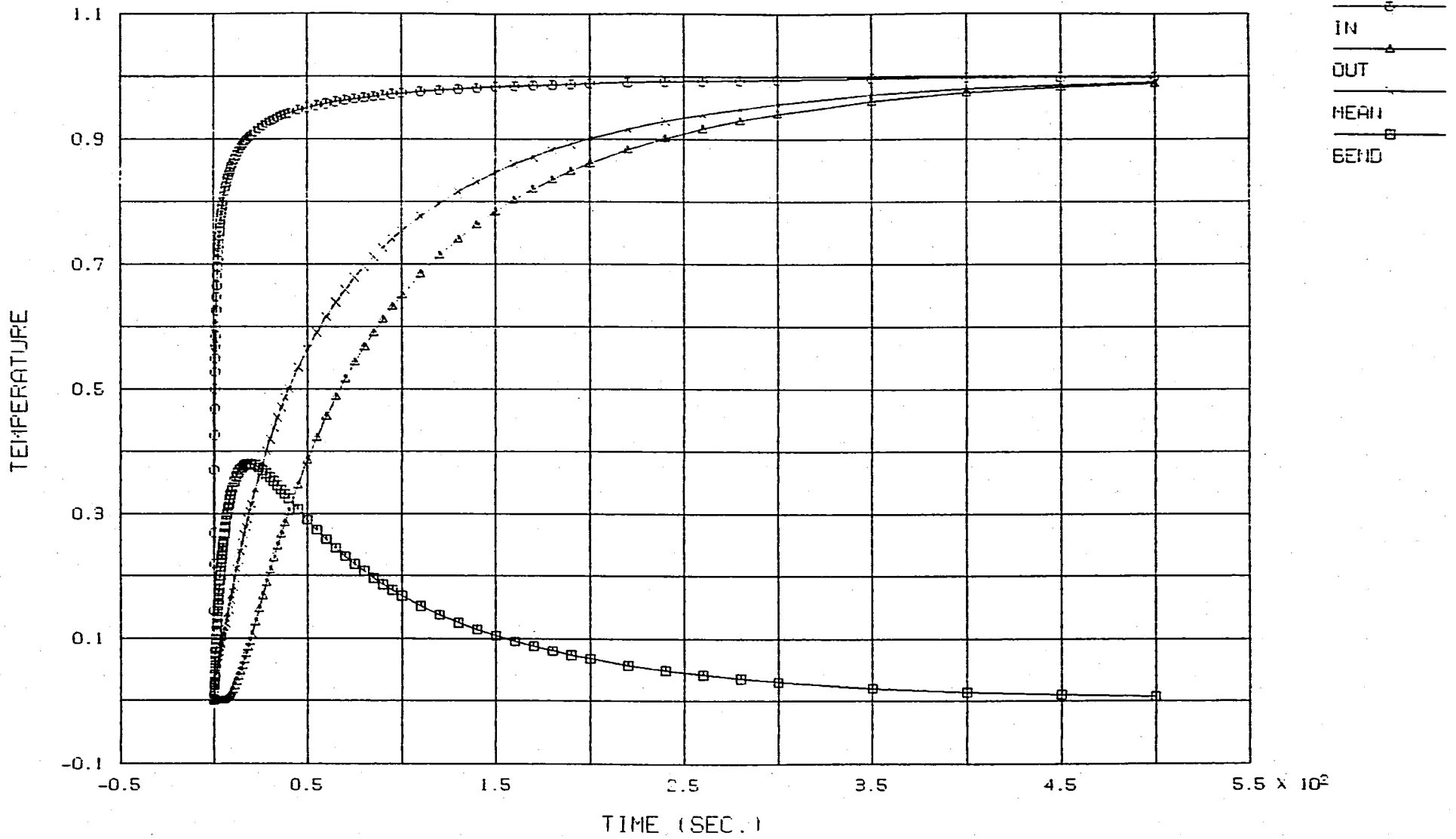
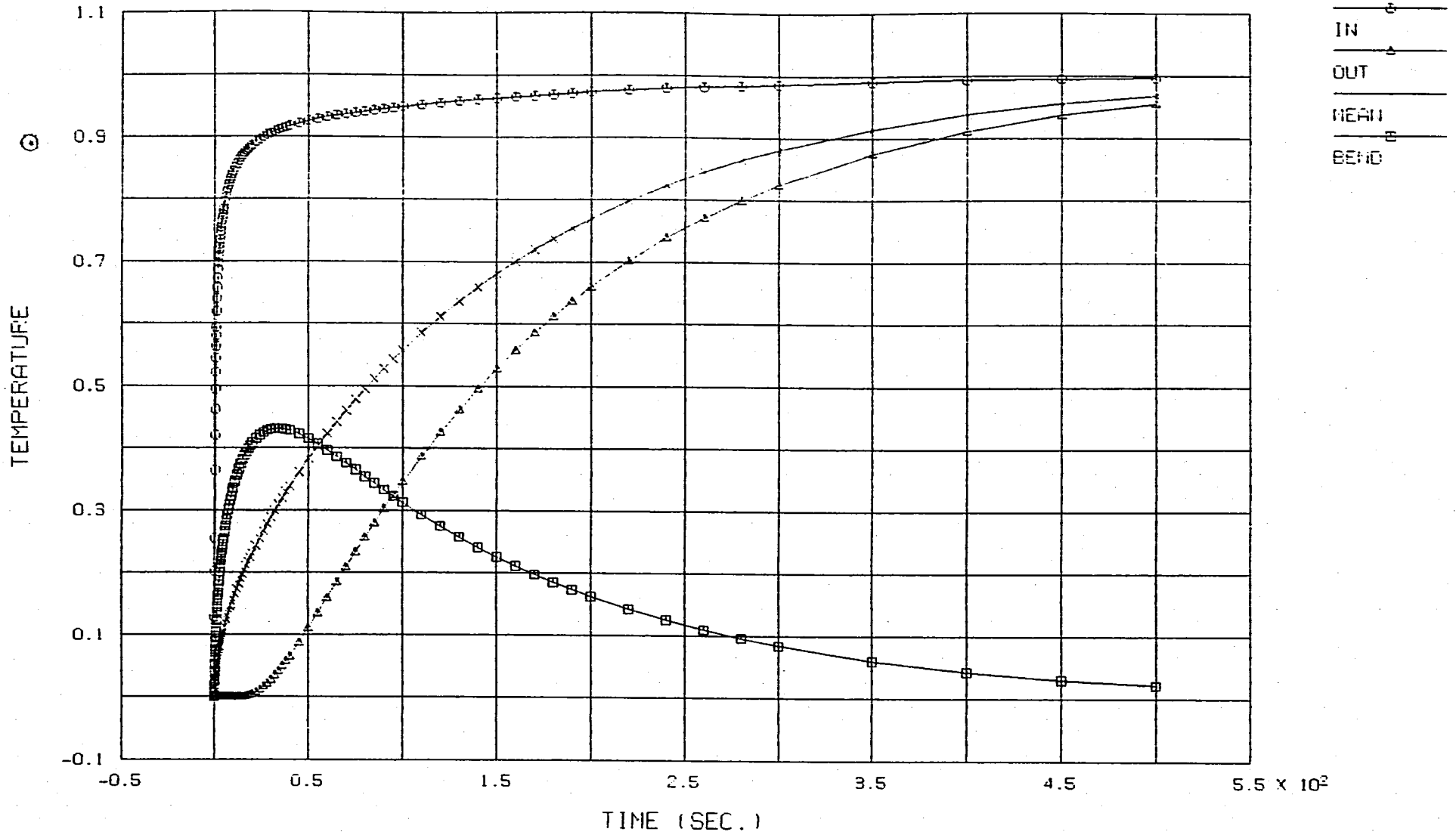


図8.5 評価断面5の温度



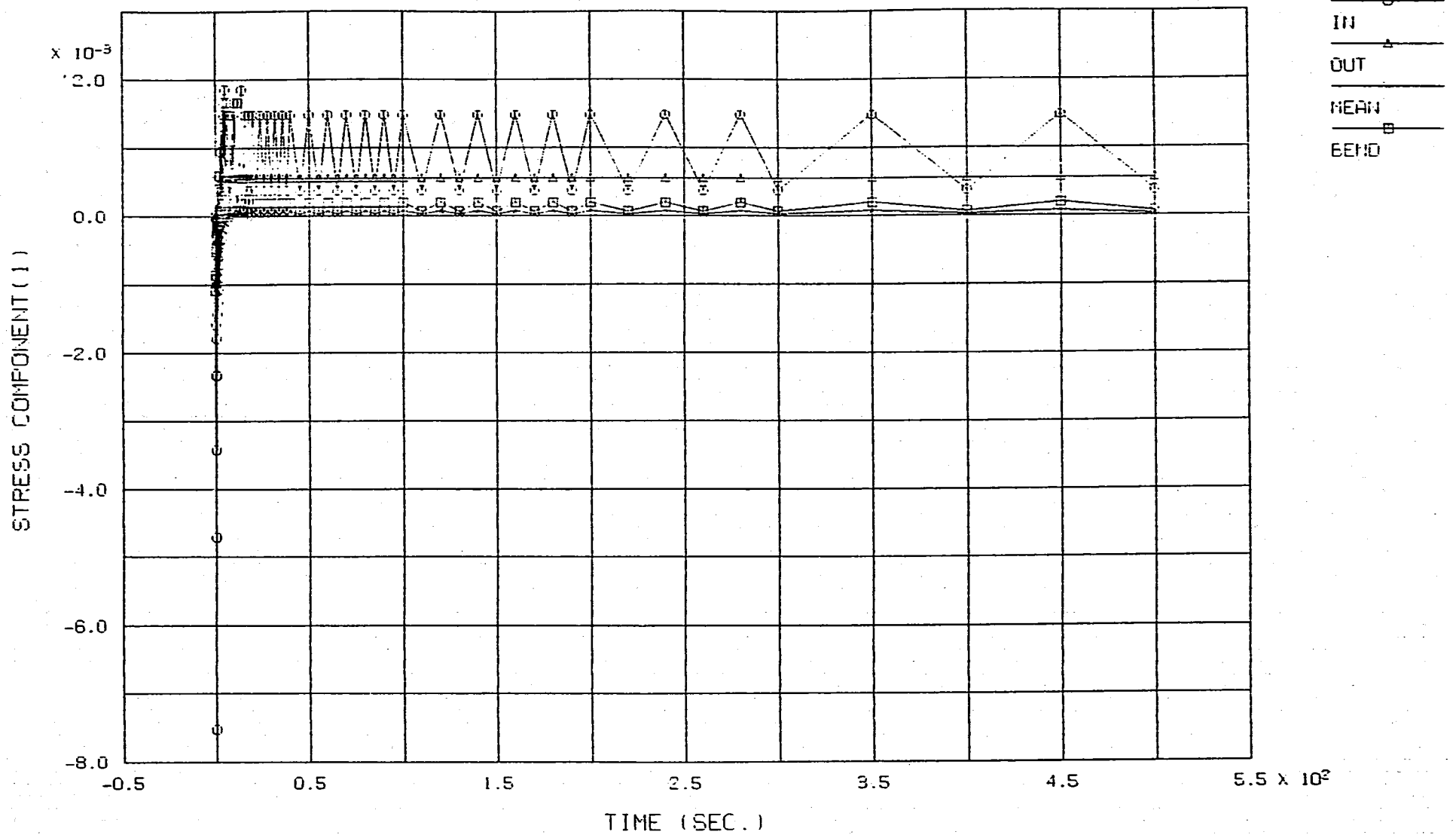
TEMPERATURE OF SECTION(6)

図8. 6 評価断面6の温度



TEMPERATURE OF SECTION(7)

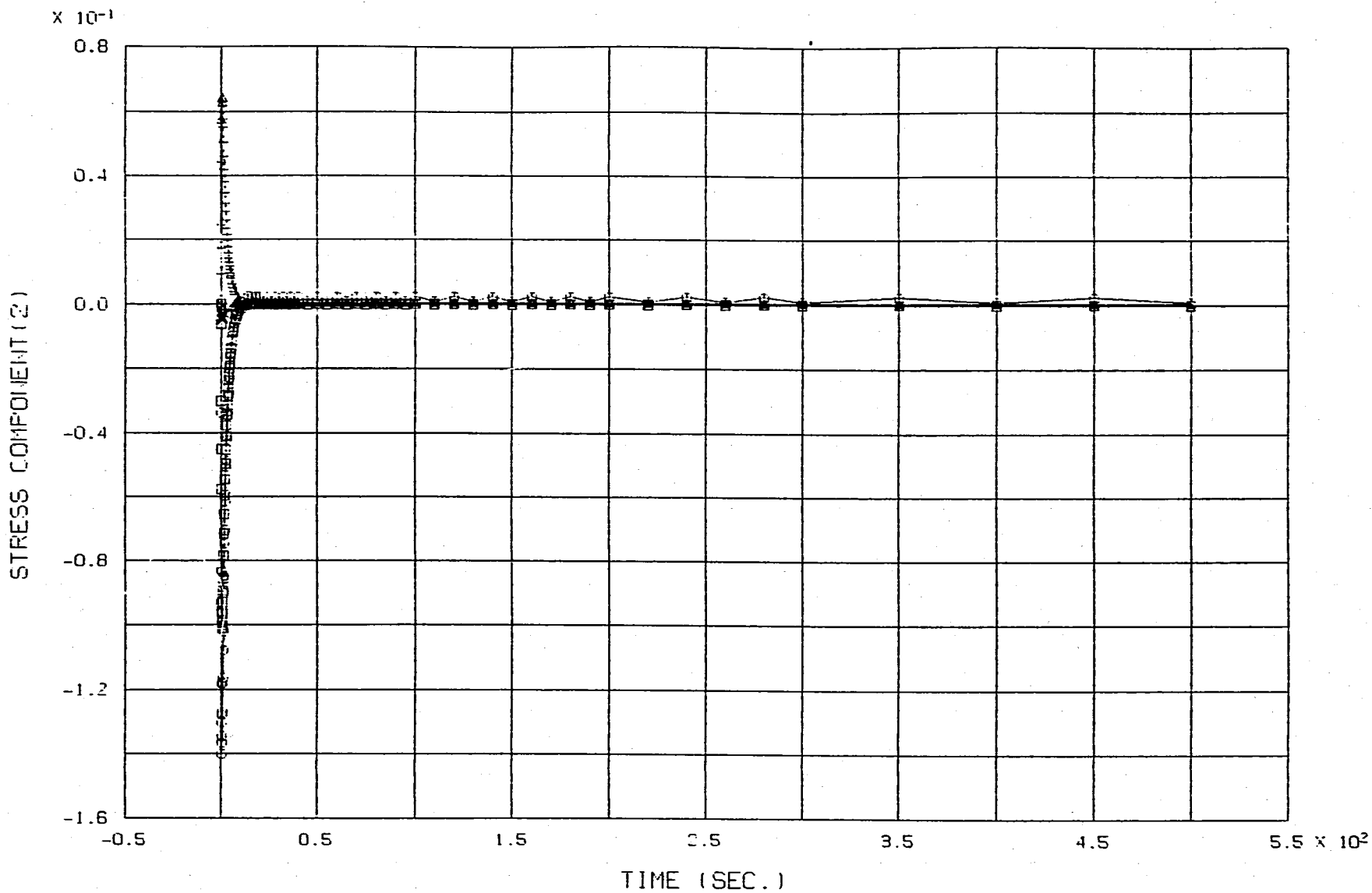
図8.7 評価断面7の温度



STRESS COMPONENT (1) OF SECTION (1)

図9. 1 (1) 評価断面1の応力テンソル成分1

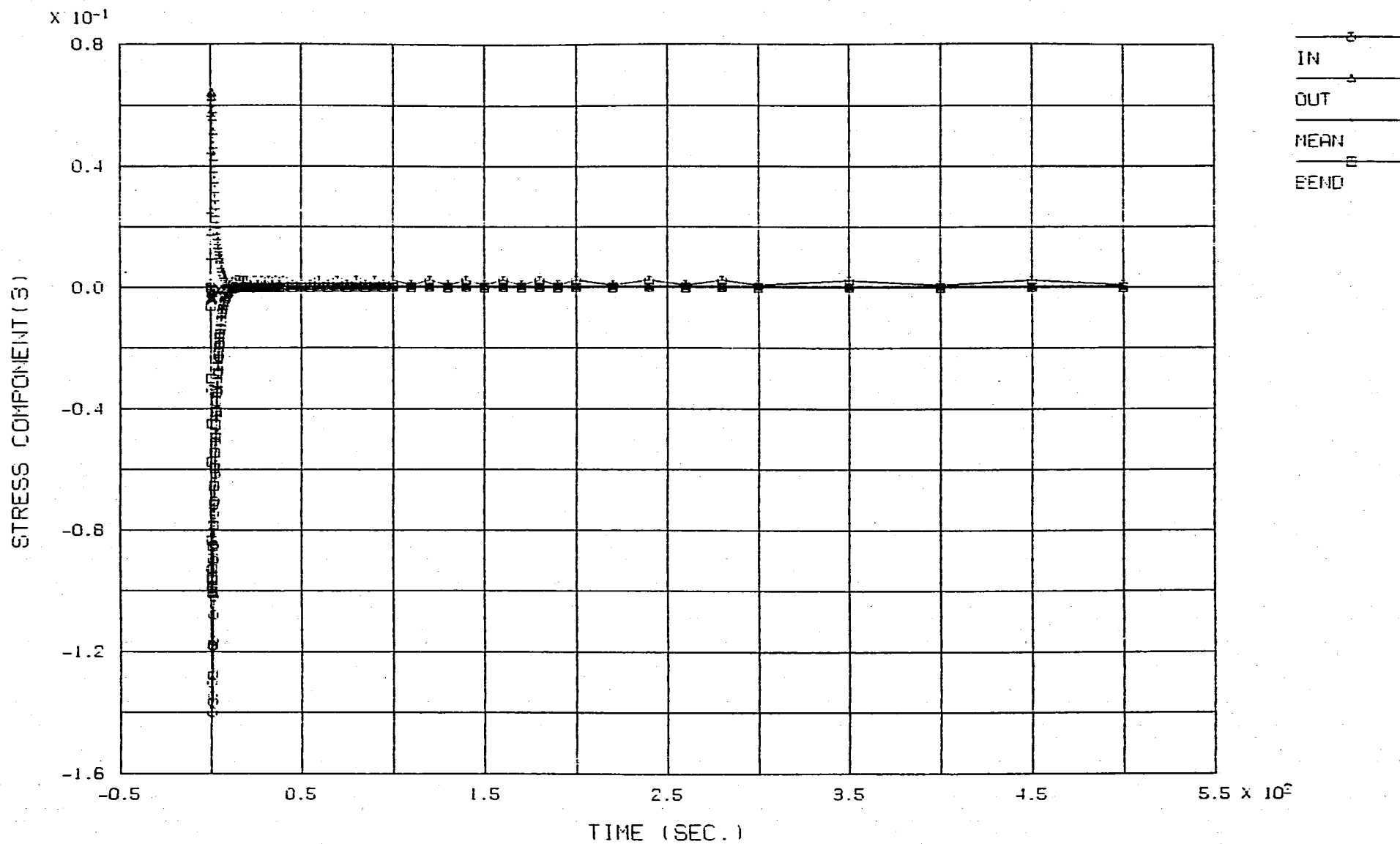
FINAS



STRESS COMPONENT (2) OF SECTION (1)

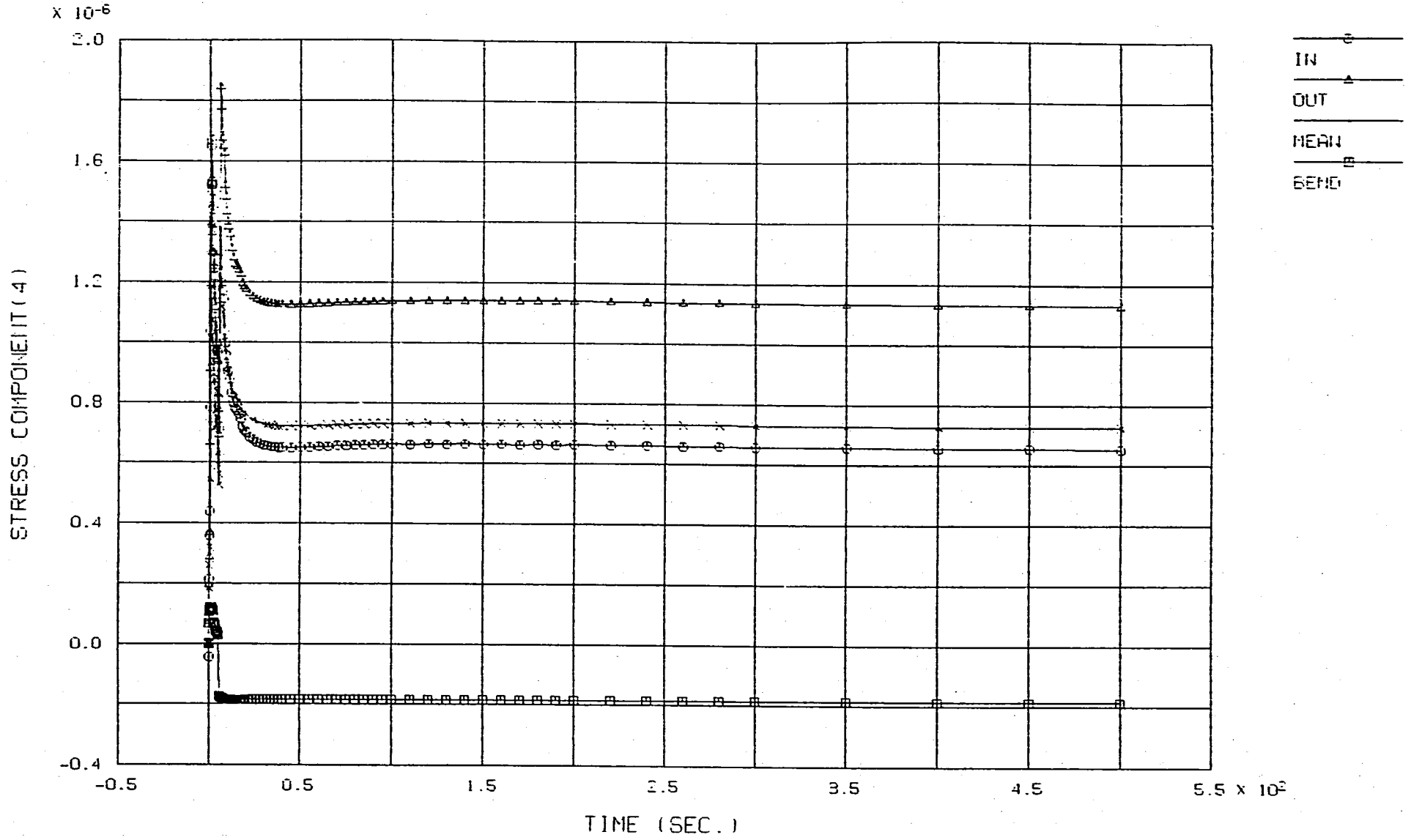
図9. 1 (2) 評価断面1の応力テンソル成分2

FINAS



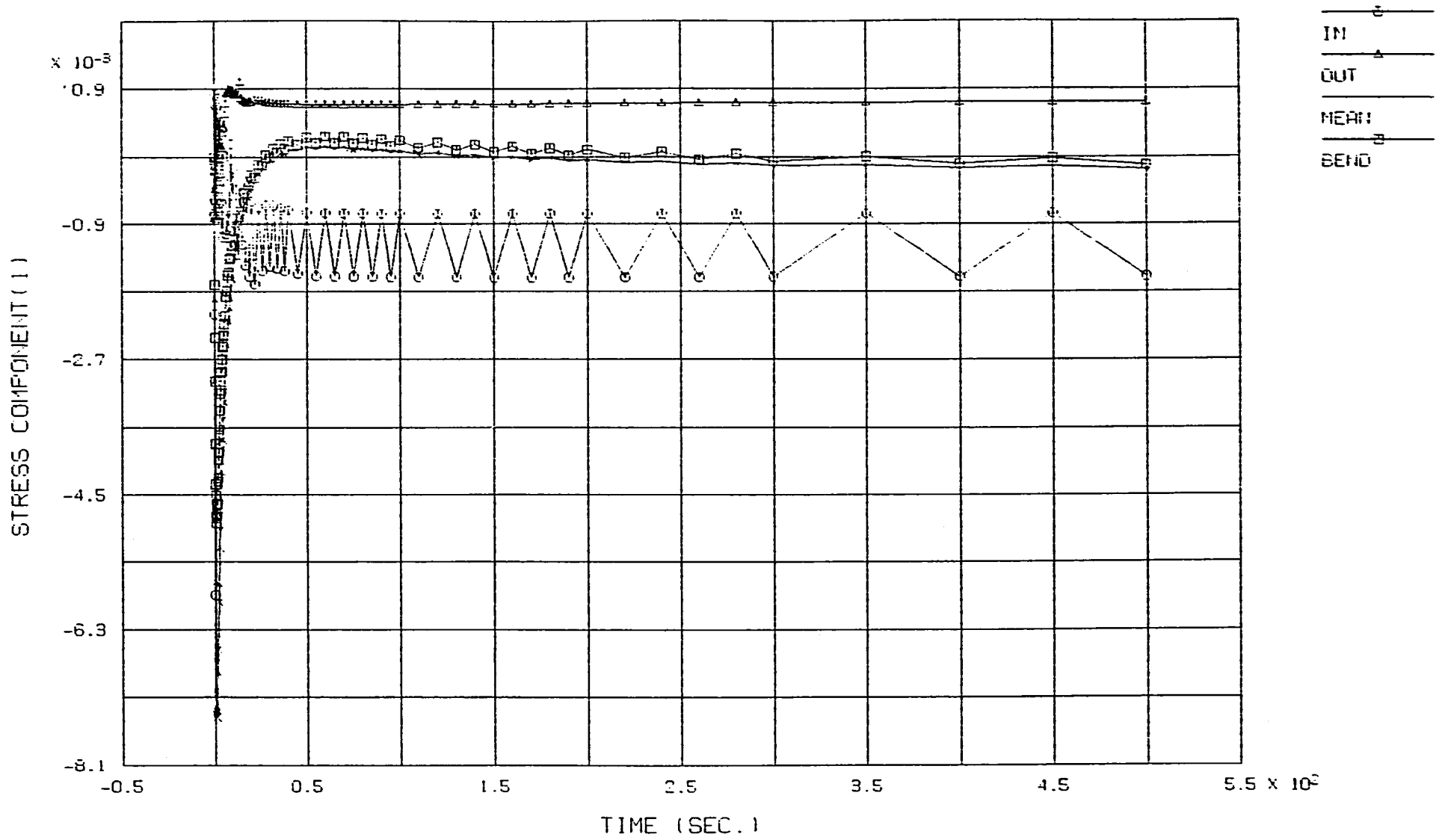
STRESS COMPONENT(3) OF SECTION(1)

図9. 1(3) 評価断面1の応力テンソル成分3



STRESS COMPONENT (4) OF SECTION (1)

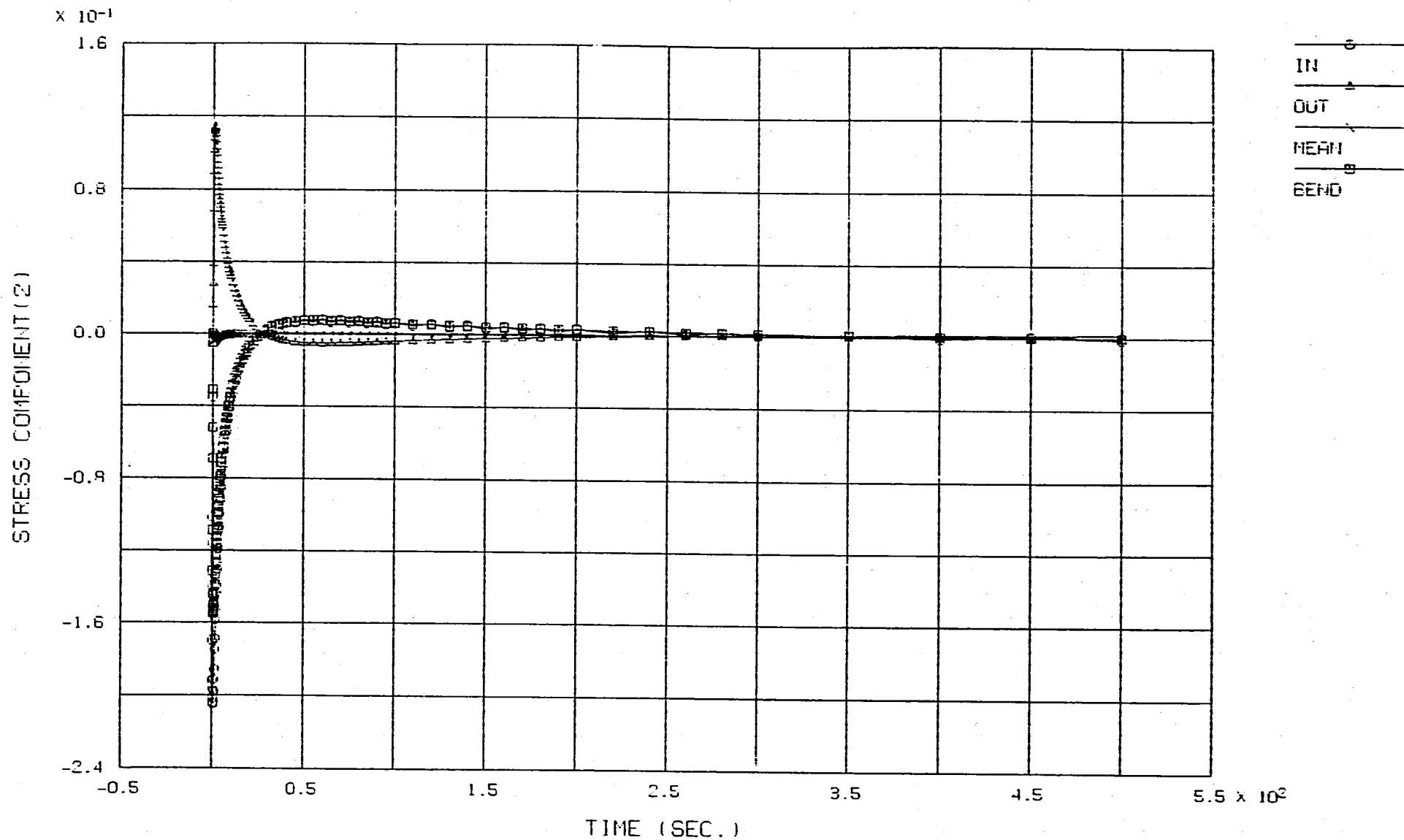
図9. 1 (4) 評価断面1の応力テンソル成分4



STRESS COMPONENT (1) OF SECTION (2)

図9. 2 (1) 評価断面2の応力テンソル成分1

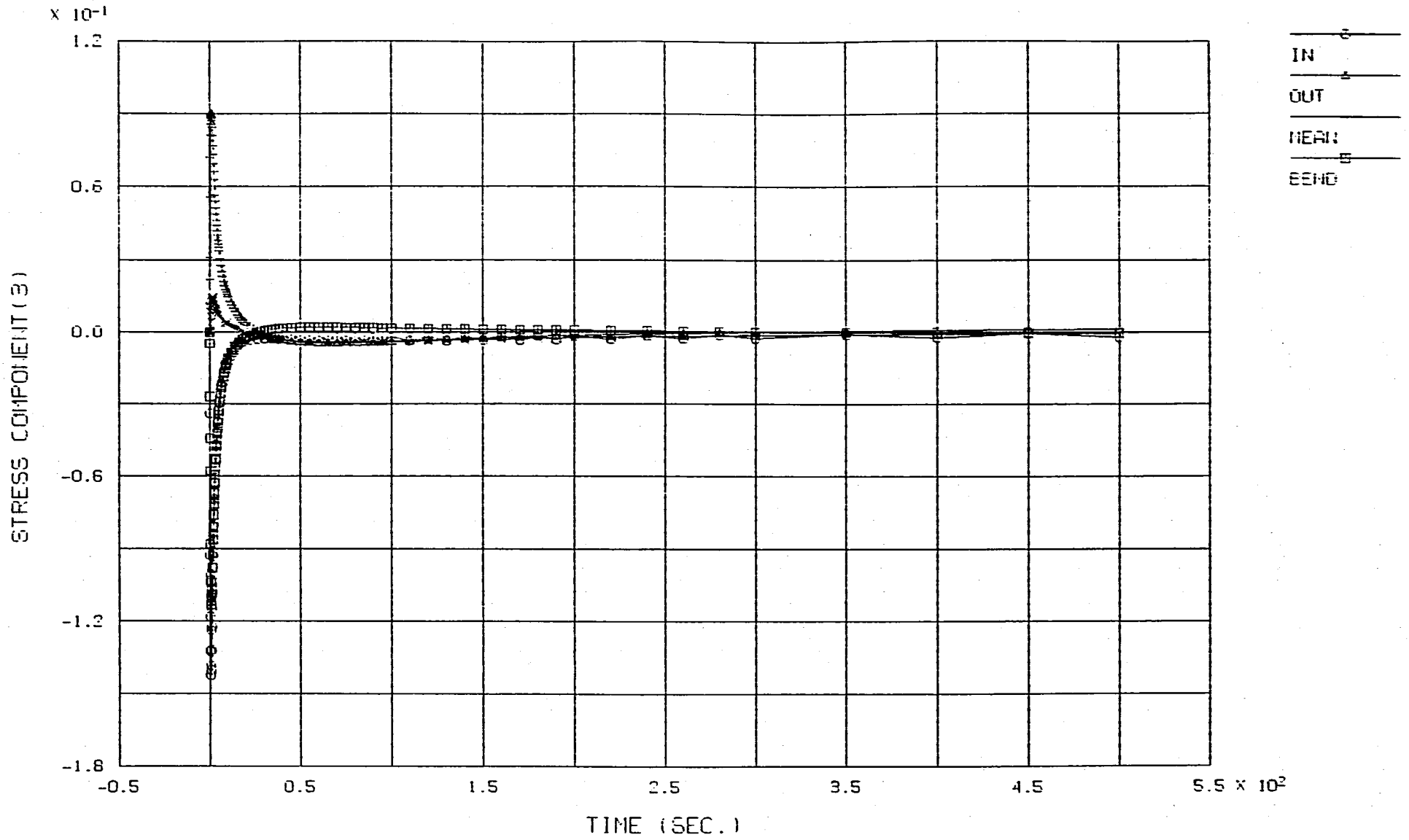
FINAS



STRESS COMPONENT (2) OF SECTION (2)

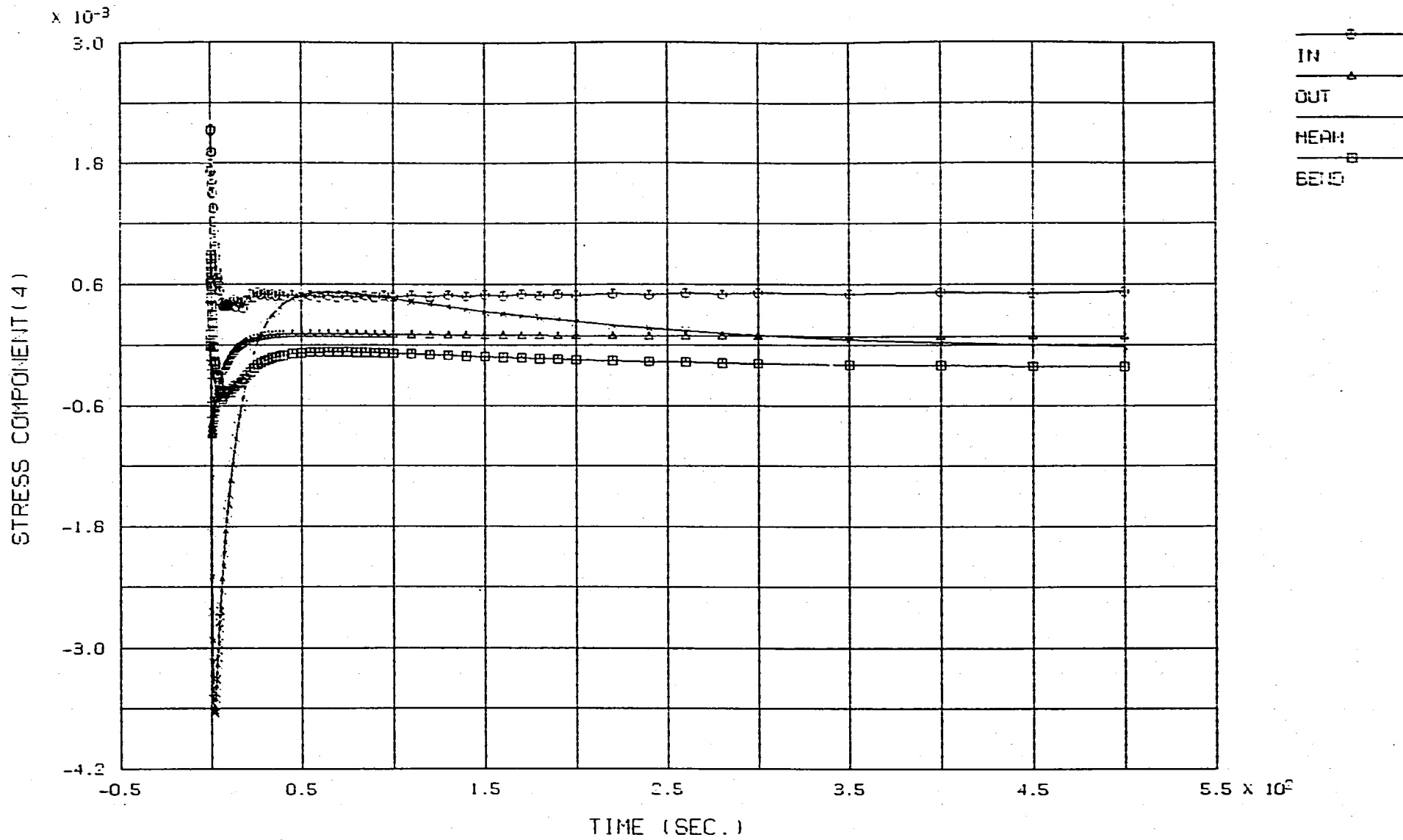
図9. 2 (2) 評価断面2の応力テンソル成分2

FINAS



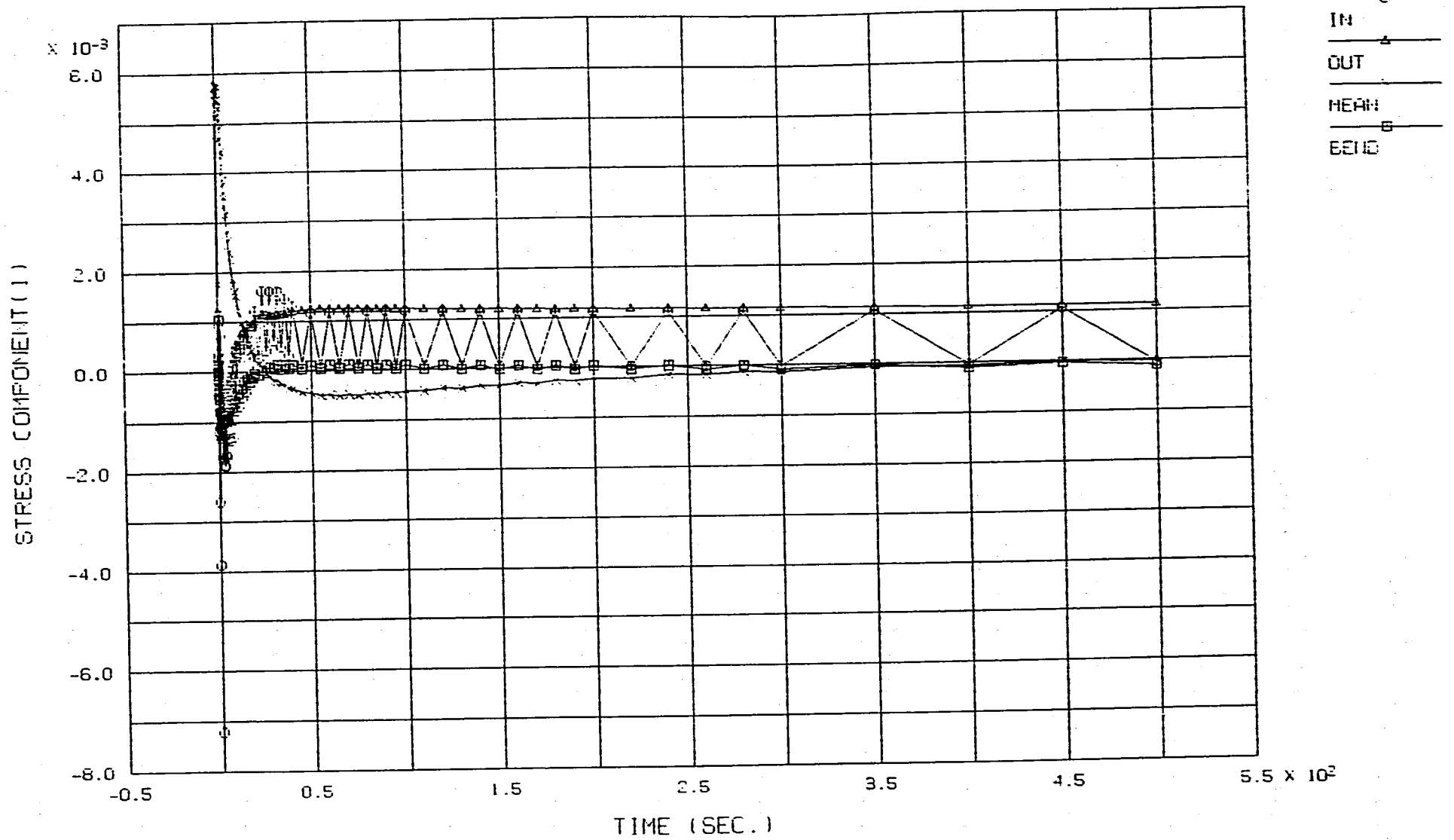
STRESS COMPONENT (3) OF SECTION (2)

図9. 2 (3) 評価断面2の応力テンソル成分3



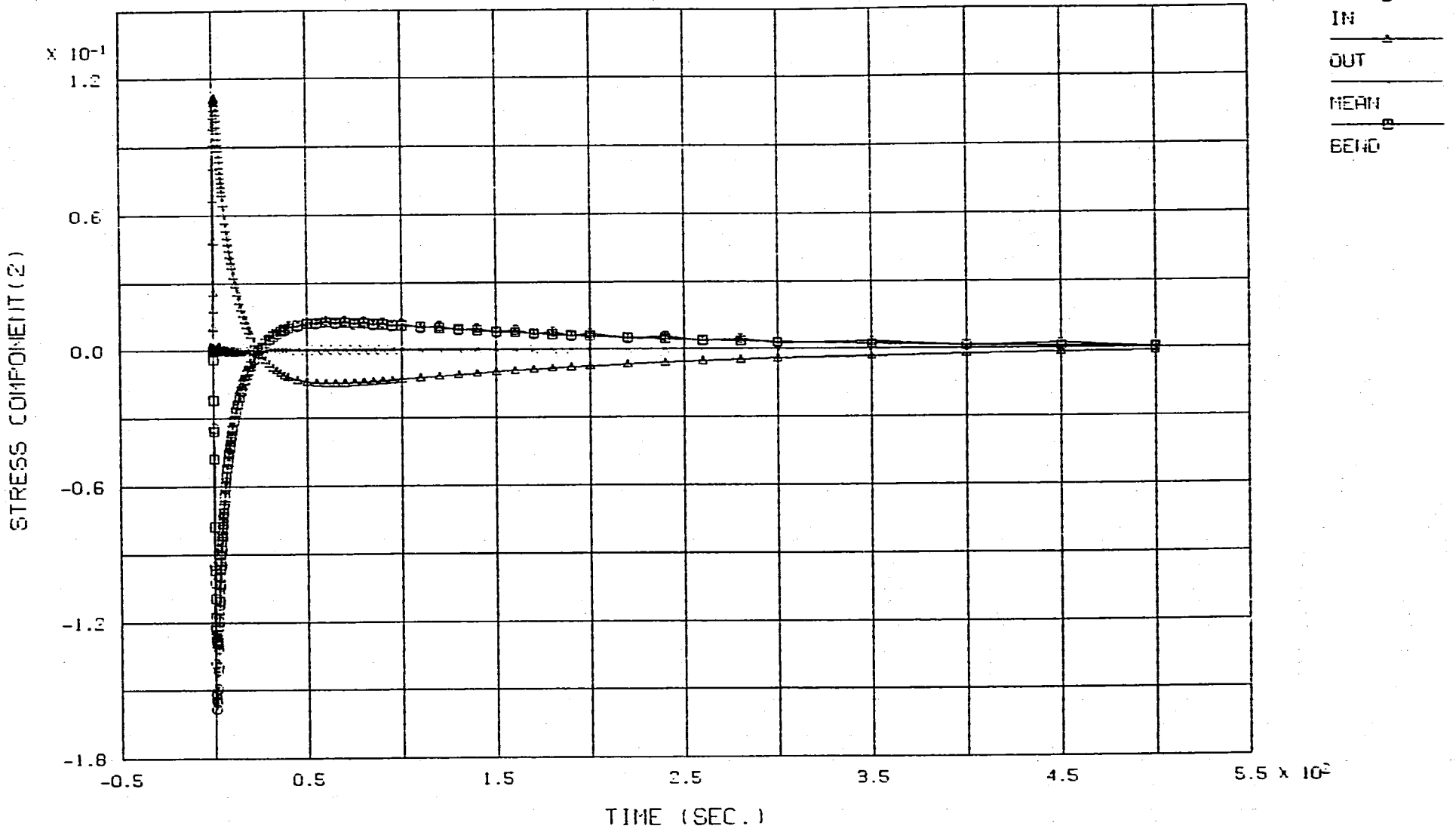
STRESS COMPONENT (4) OF SECTION (2)

図9. 2 (4) 評価断面2の応力テンソル成分4



STRESS COMPONENT (1) OF SECTION (3)

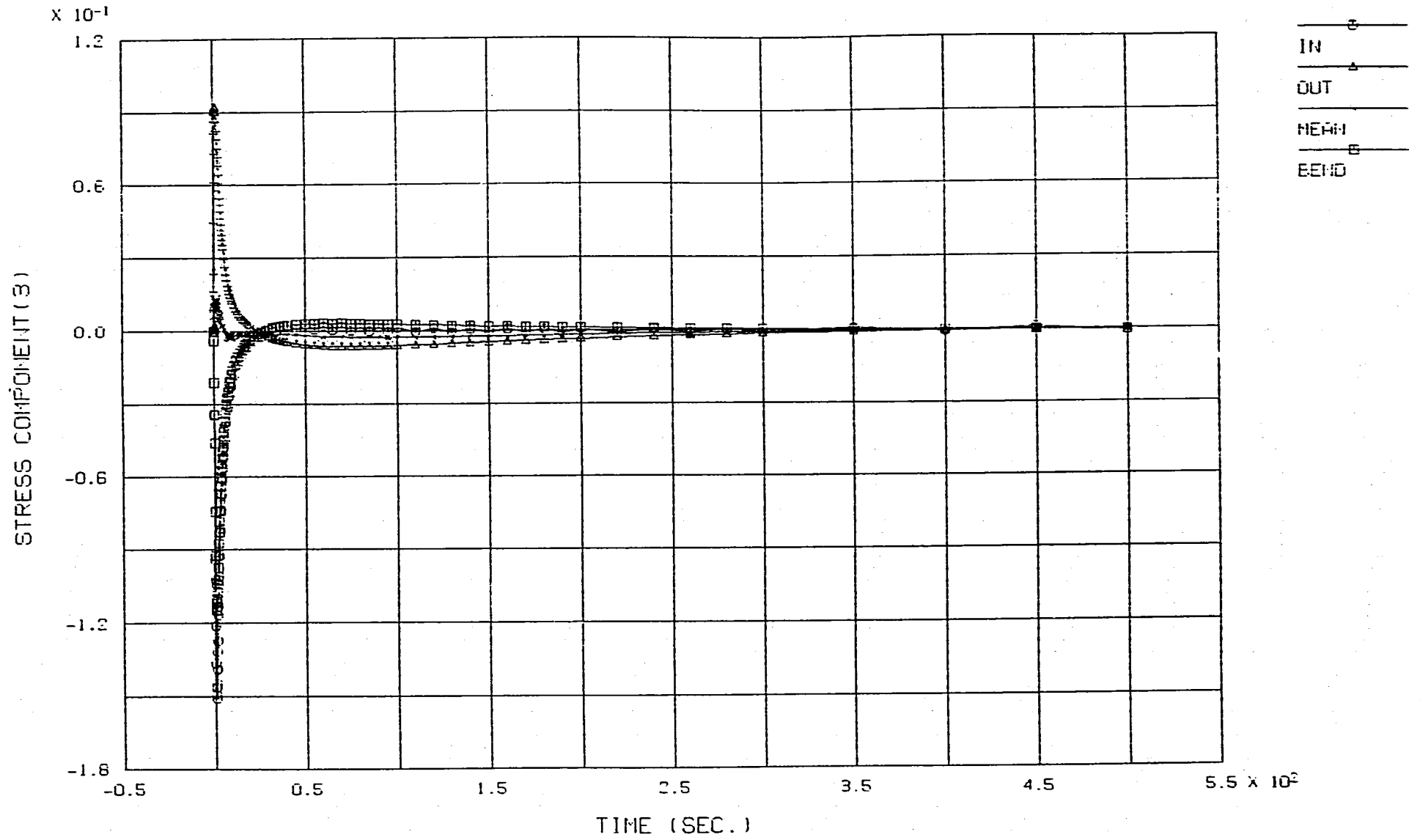
図9. 3 (1) 評価断面3の応力テンソル成分1



STRESS COMPONENT (2) OF SECTION (3)

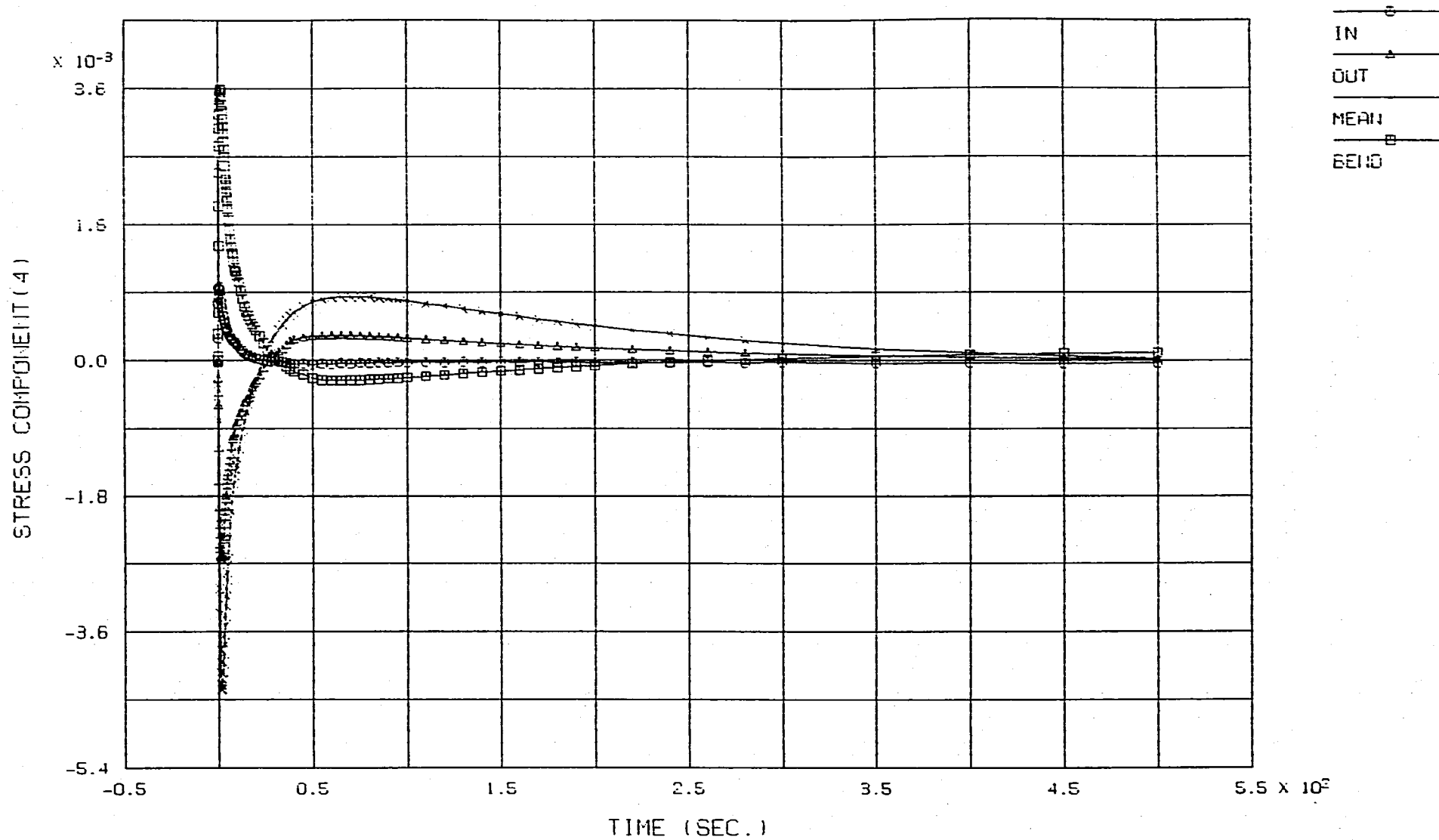
図9. 3 (2) 評価断面3の応力テンソル成分2

FINAS



STRESS COMPONENT (3) OF SECTION (3)

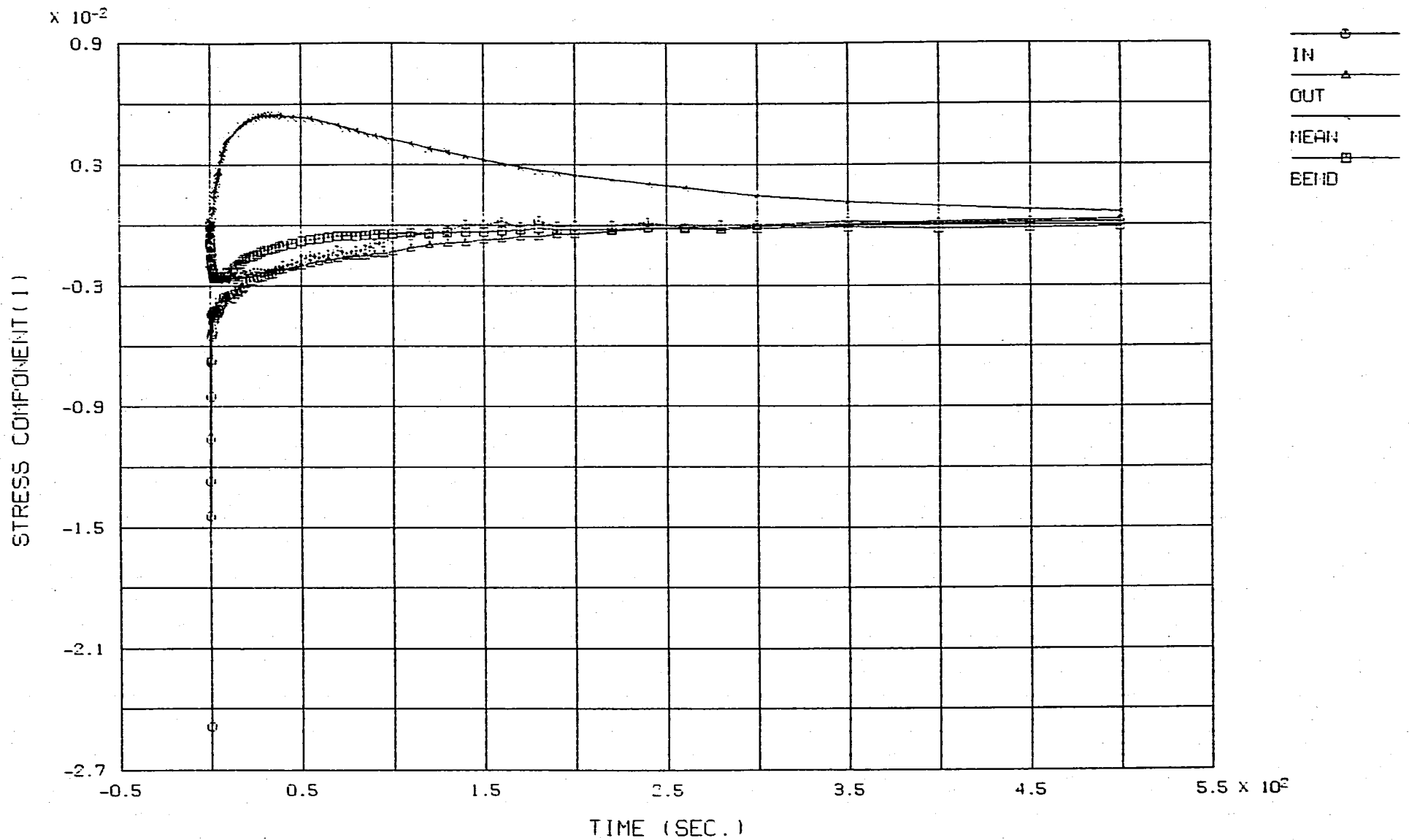
図9. 3 (3) 評価断面3の応力テンソル成分3



STRESS COMPONENT (4) OF SECTION (3)

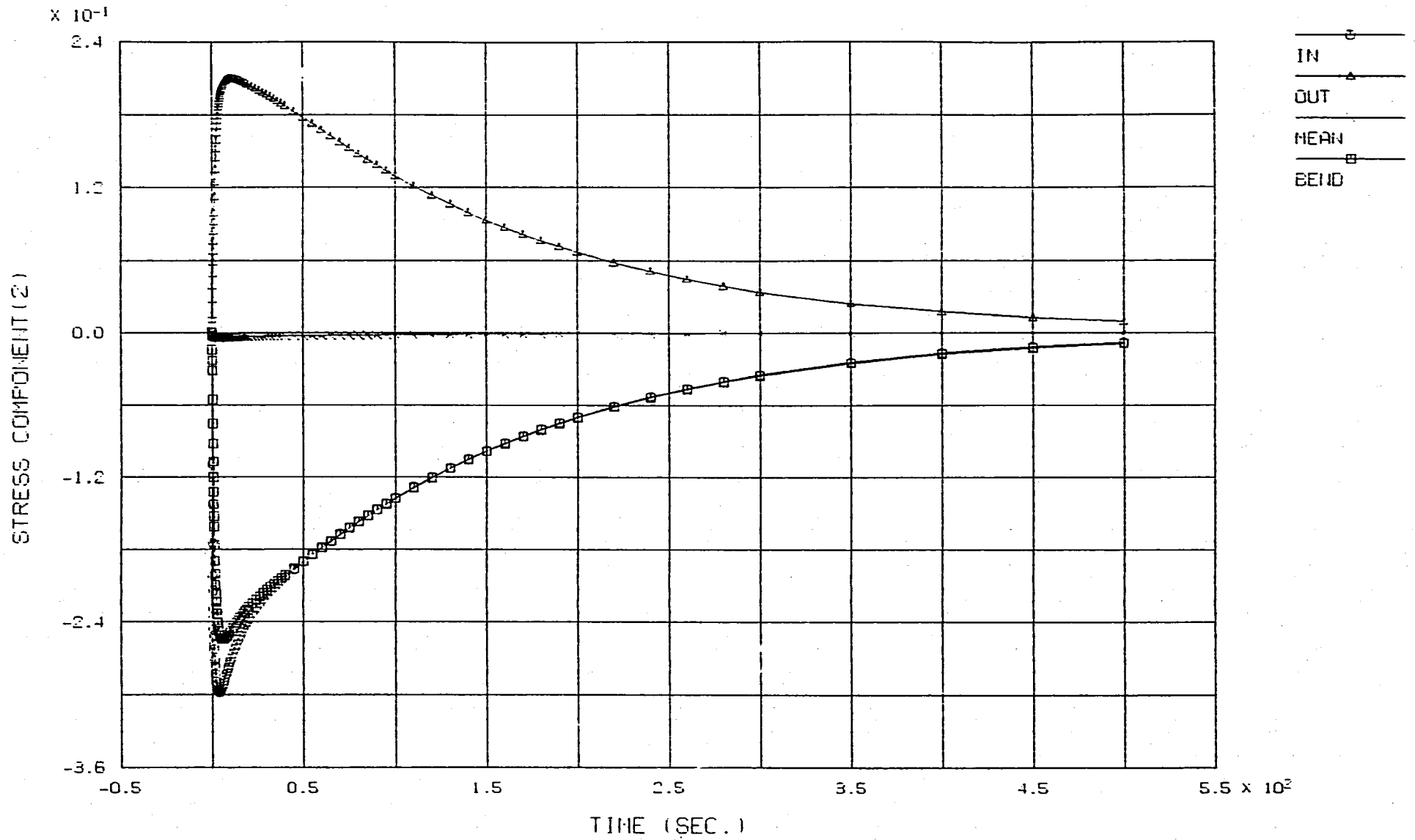
図9. 3 (4) 評価断面3の応力テンソル成分4

FINAS



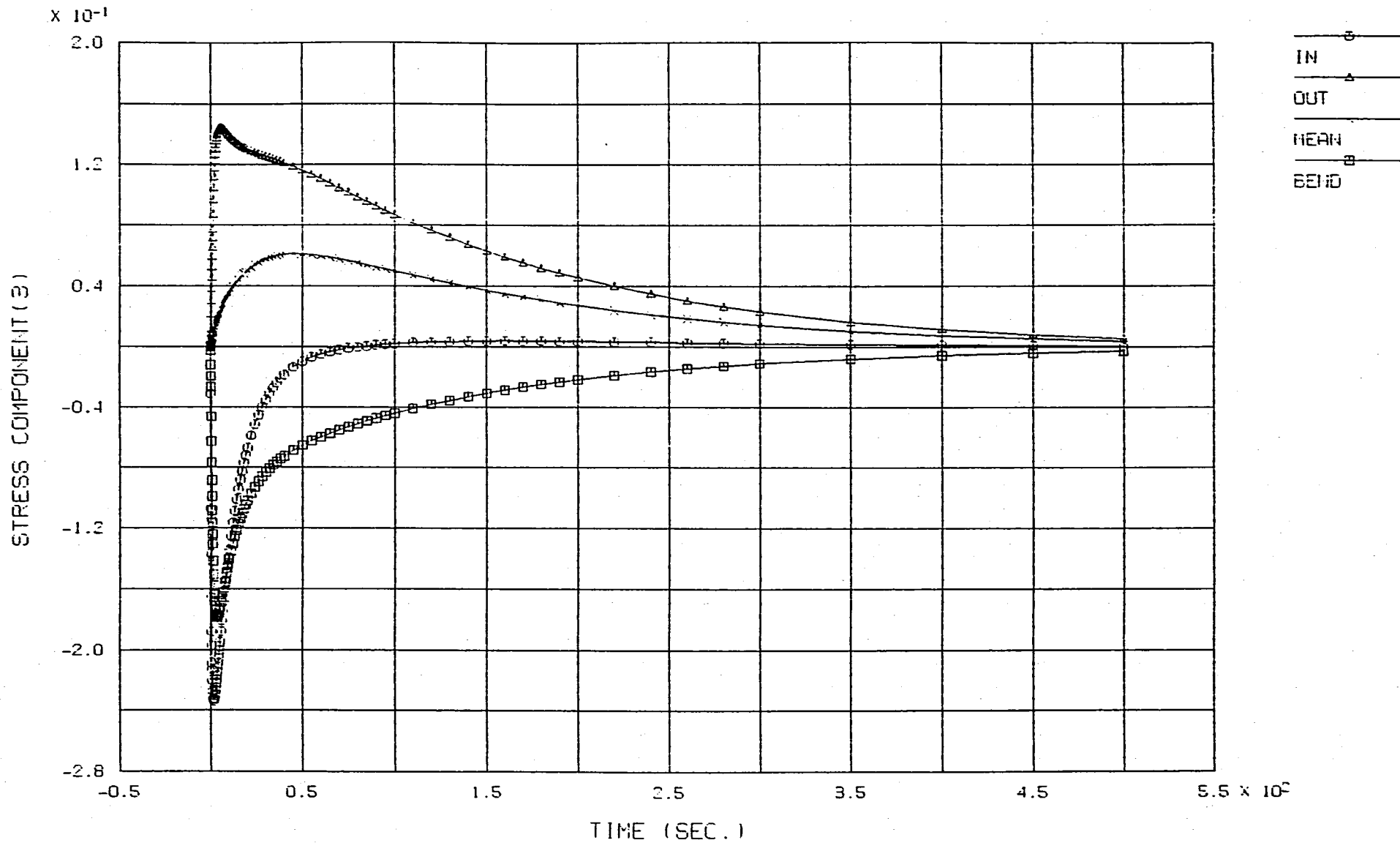
STRESS COMPONENT (1) OF SECTION (4)

図9. 4 (1) 評価断面4の応力テンソル成分1



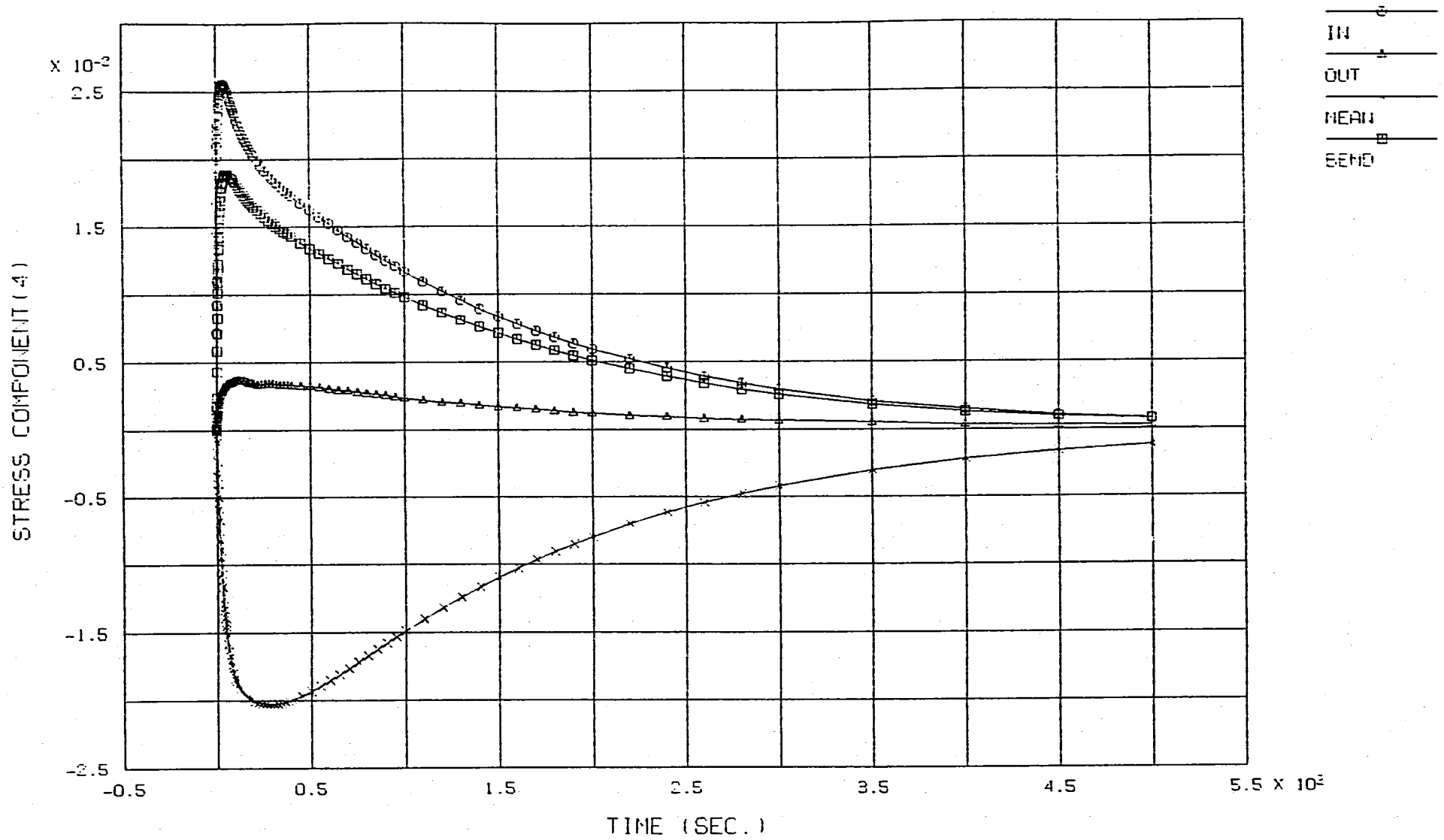
STRESS COMPONENT (2) OF SECTION (4)

図9. 4 (2) 評価断面4の応力テンソル成分2



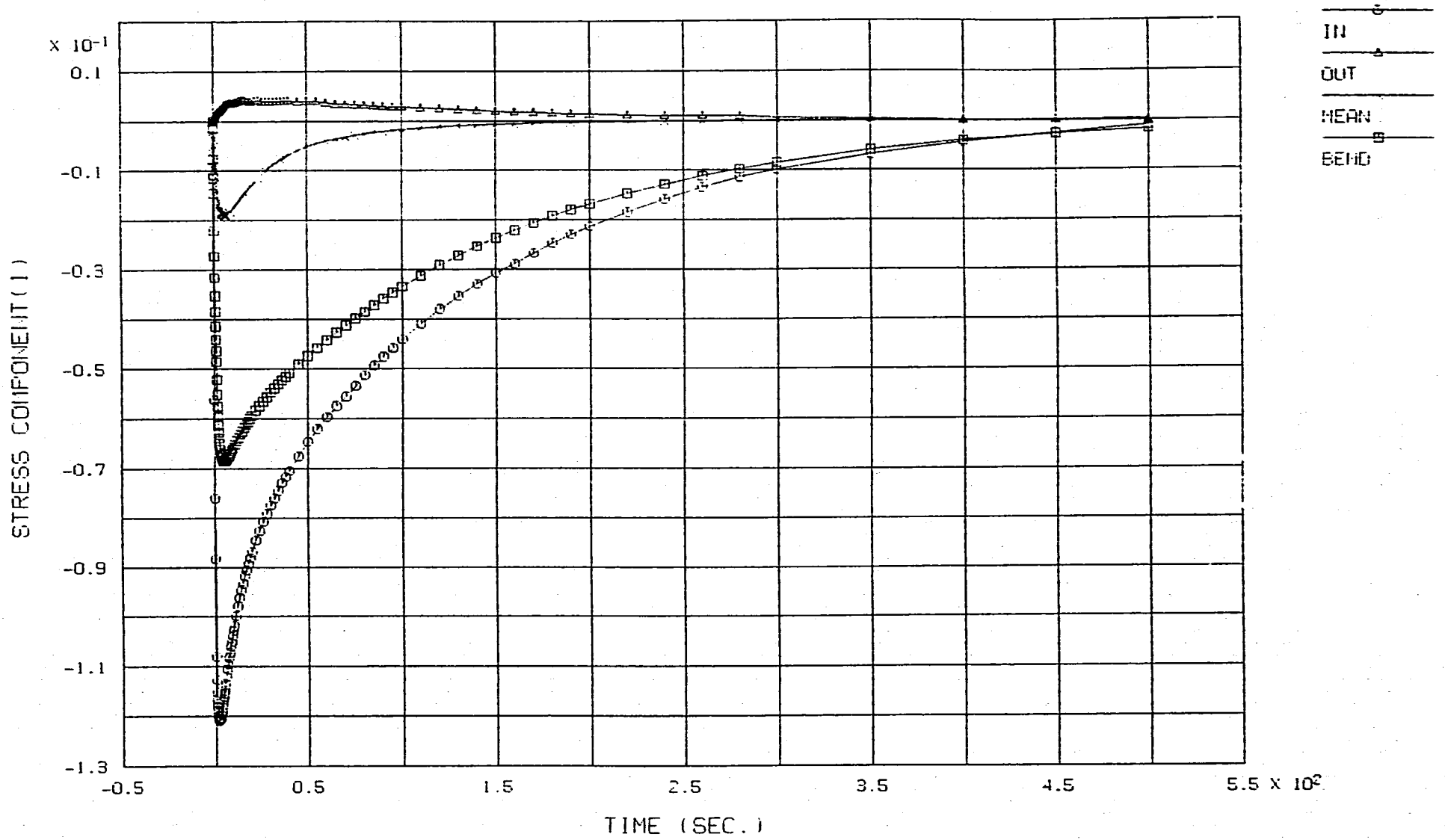
STRESS COMPONENT (3) OF SECTION (4)

図9. 4 (3) 評価断面4の応力テンソル成分3



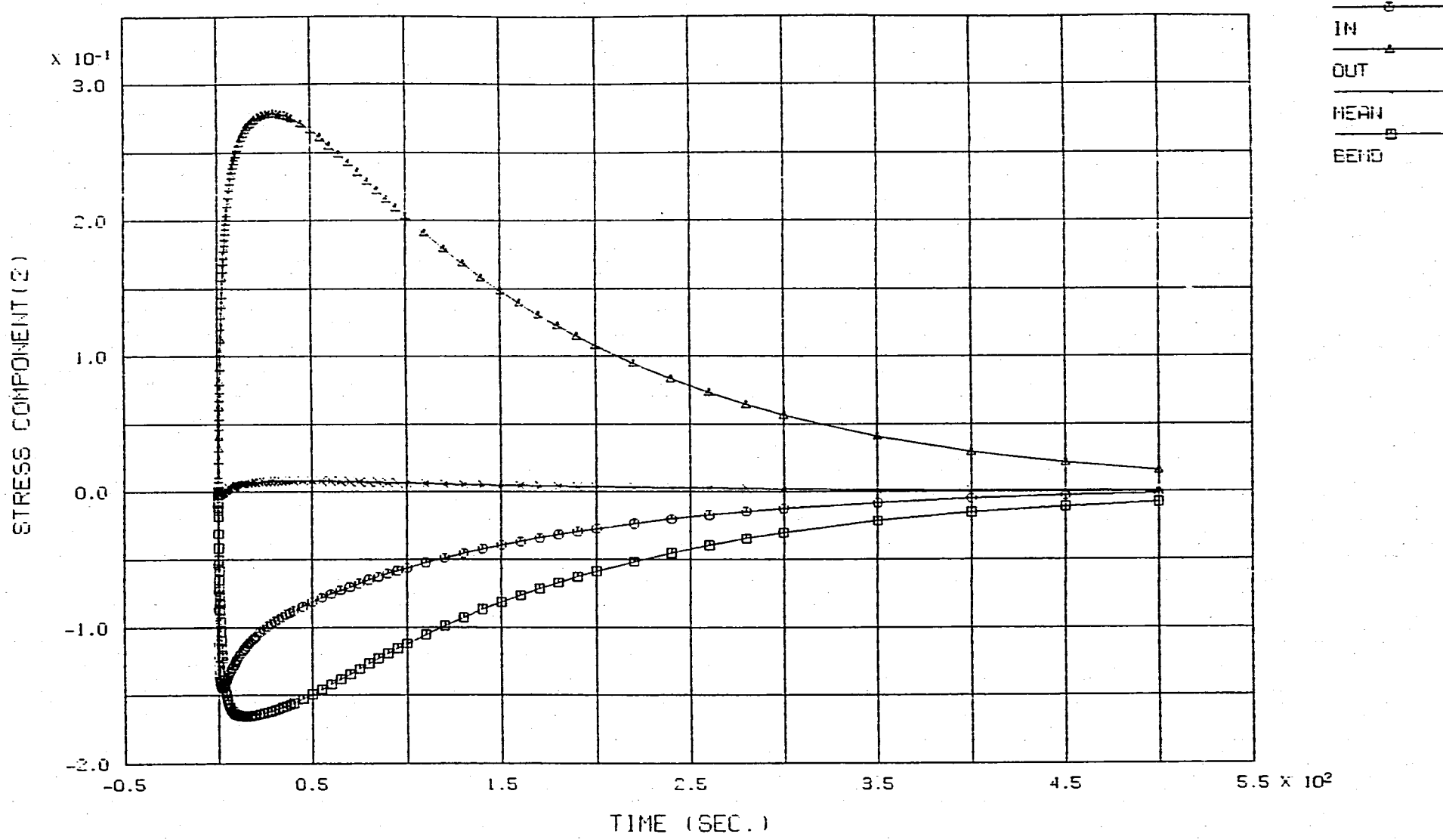
STRESS COMPONENT (4) OF SECTION (4)

図9. 4 (4) 評価断面4の応力テンソル成分4



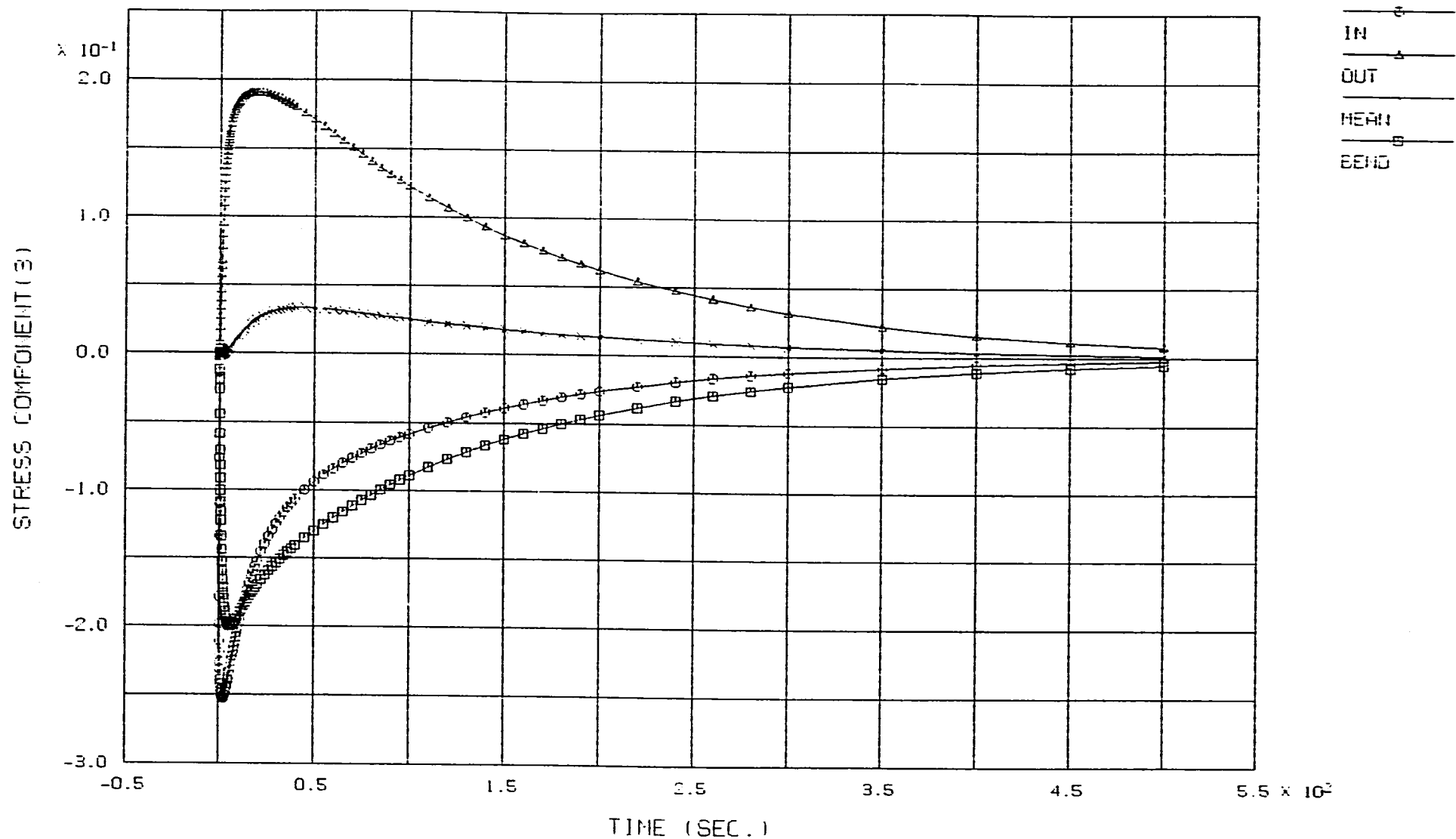
STRESS COMPONENT (1) OF SECTION (5)

図9. 5 (1) 評価断面5の応力テンソル成分1



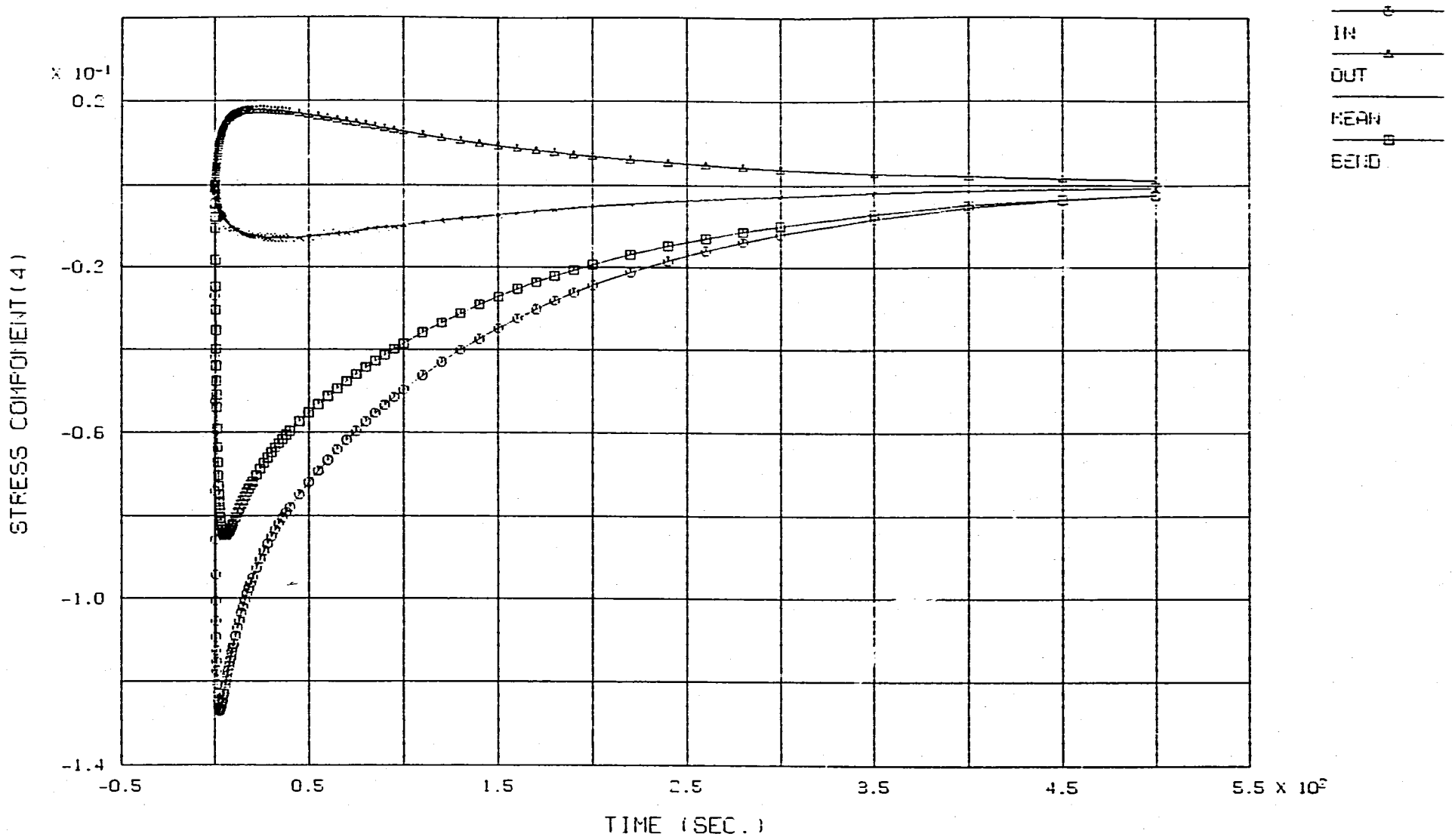
STRESS COMPONENT (2) OF SECTION (5)

図9. 5 (2) 評価断面5の応力テンソル成分2



STRESS COMPONENT(3) OF SECTION(5)

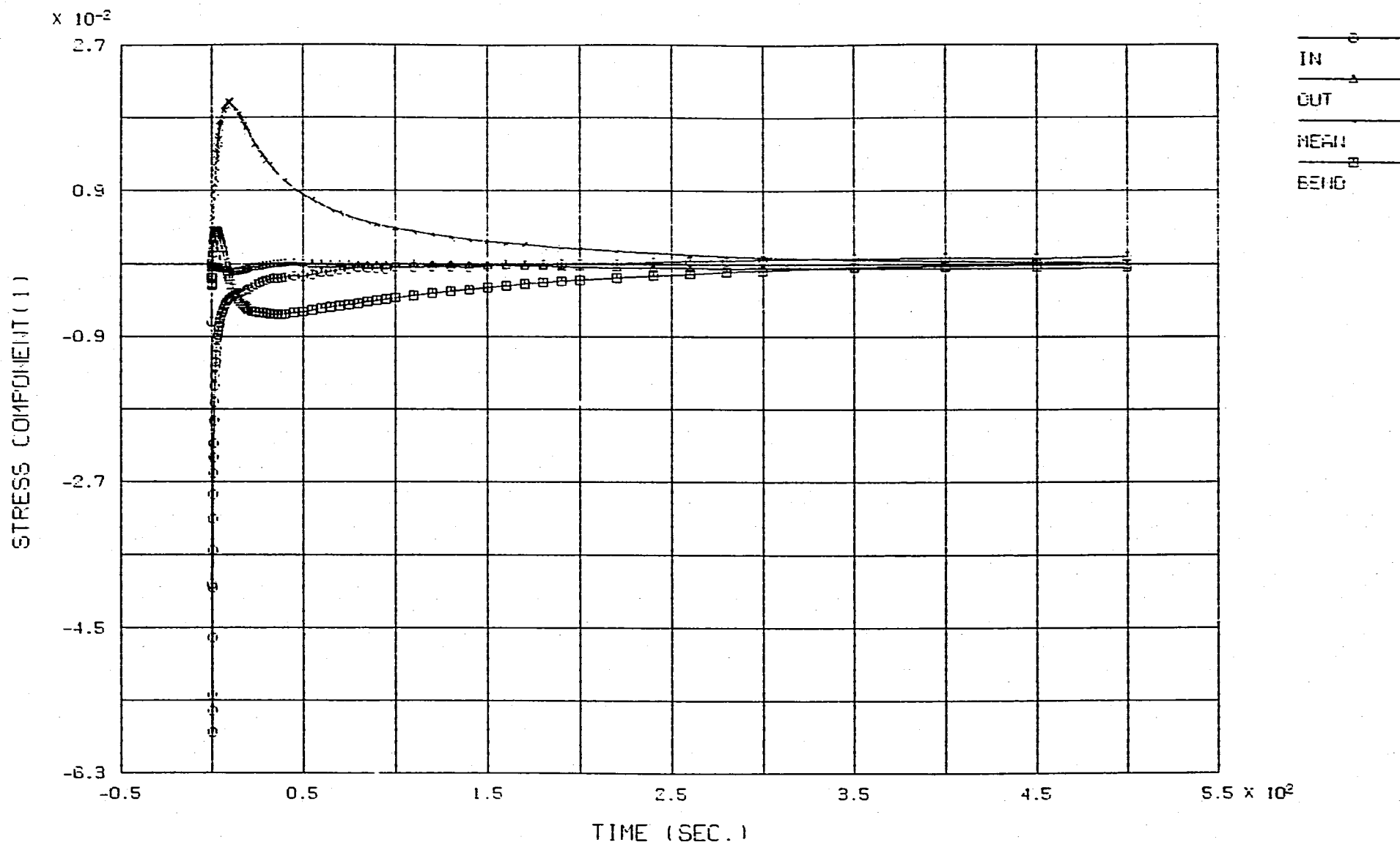
図9. 5 (3) 評価断面5の応力テンソル成分3



STRESS COMPONENT (4) OF SECTION (5)

図9. 5 (4) 評価断面5の応力テンソル成分4

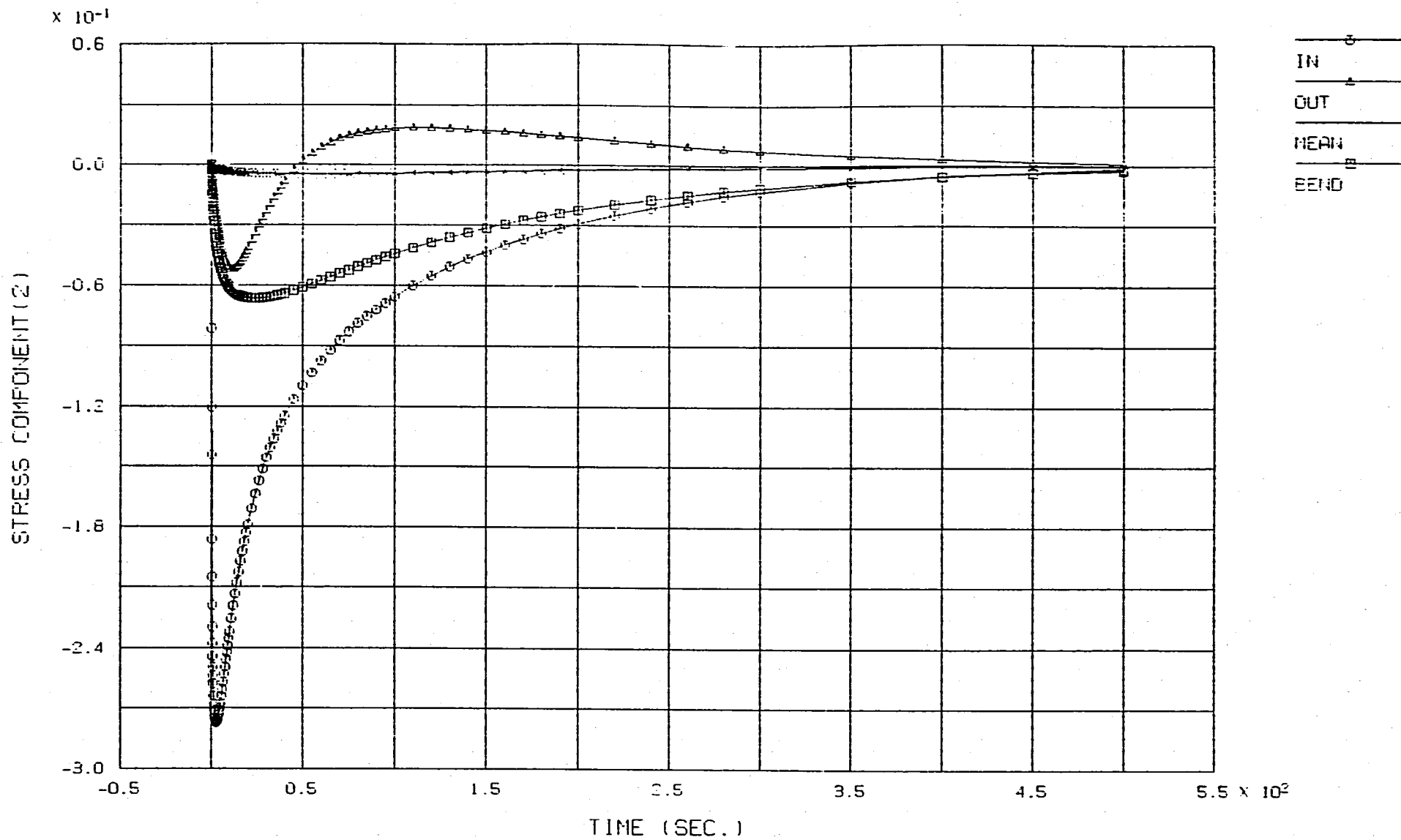
FINAS



STRESS COMPONENT (1) OF SECTION (6)

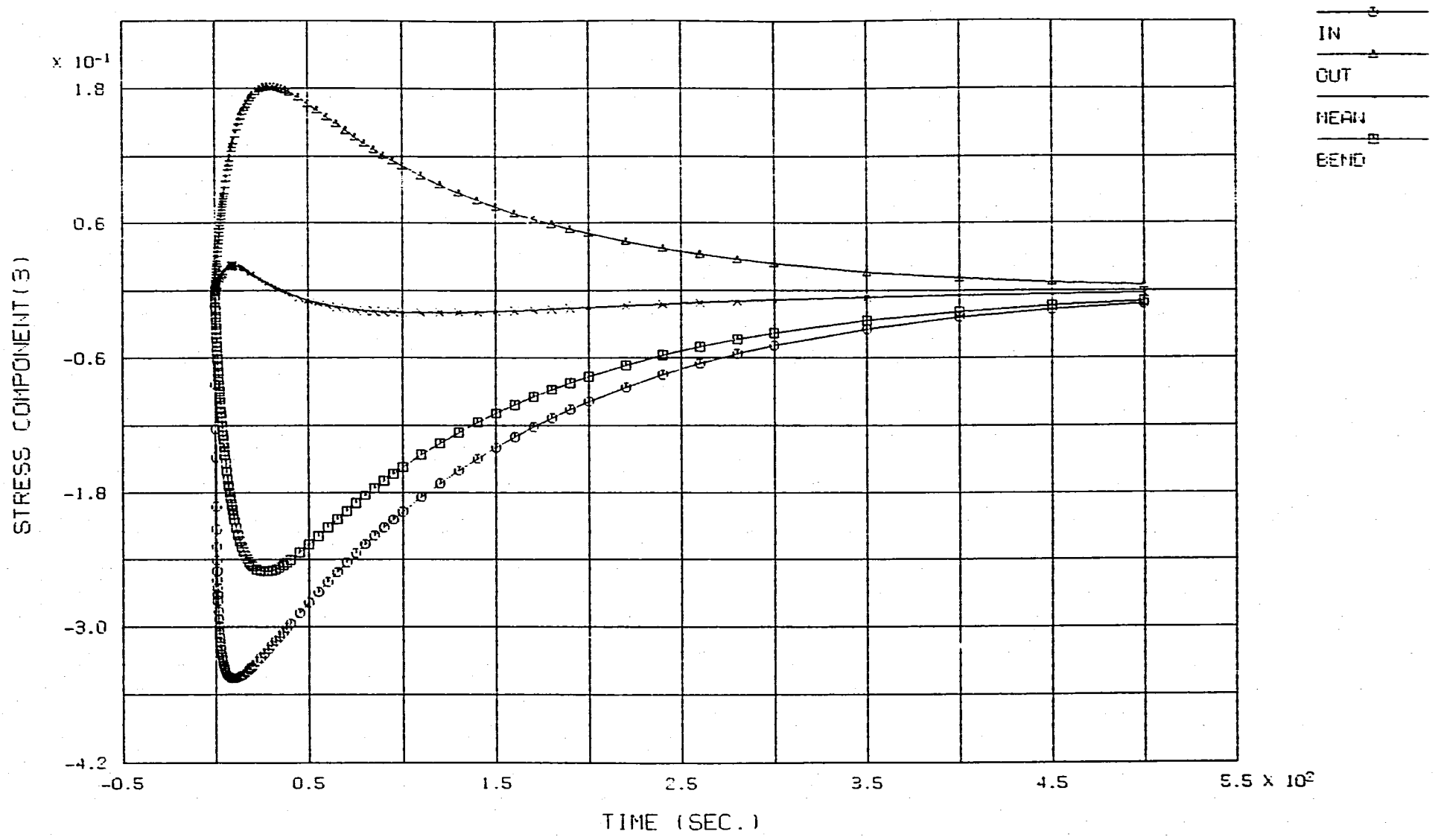
図9. 6 (1) 評価断面6の応力テンソル成分1

FINAS



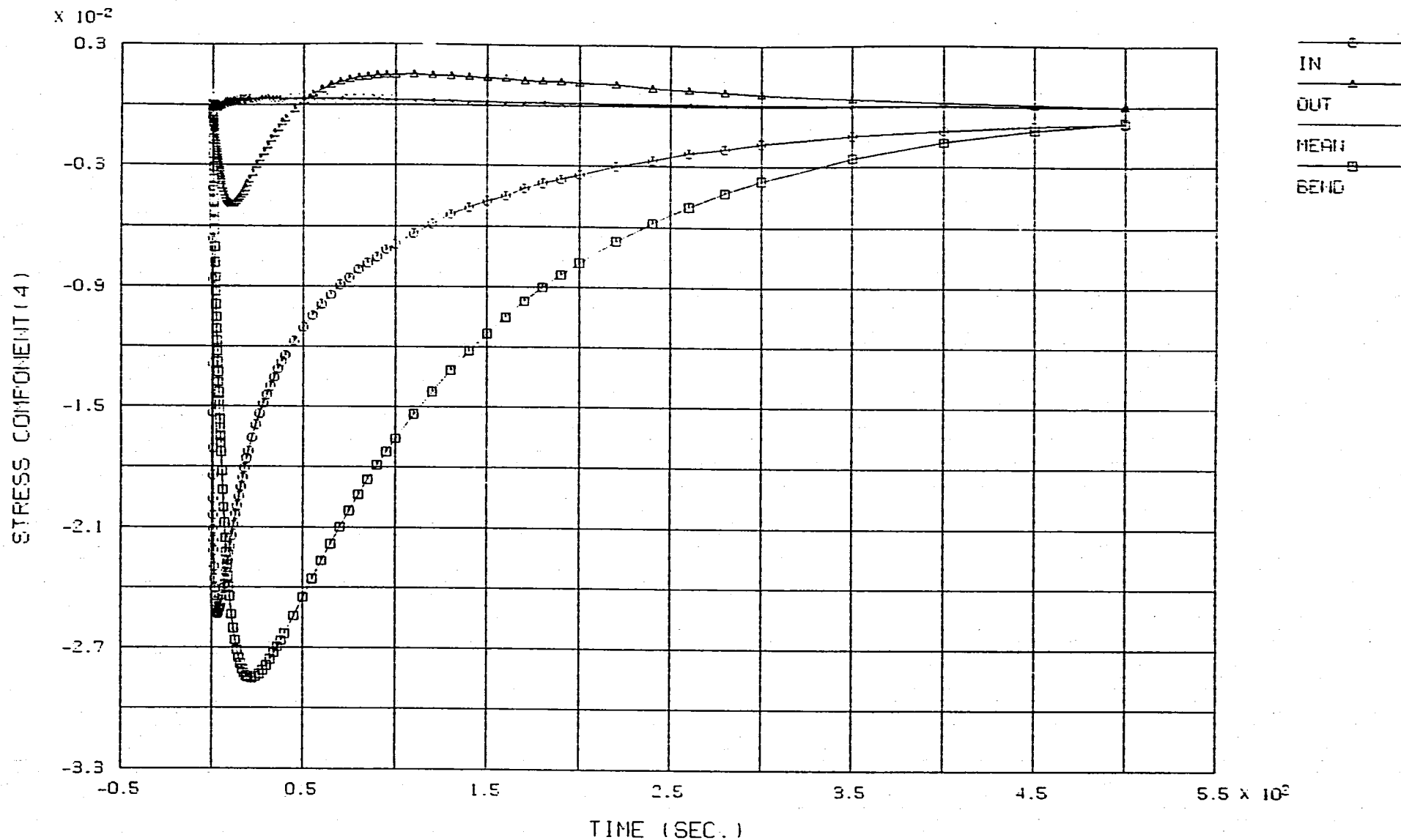
STRESS COMPONENT (2) OF SECTION (6)

図9. 6 (2) 評価断面6の応力テンソル成分2



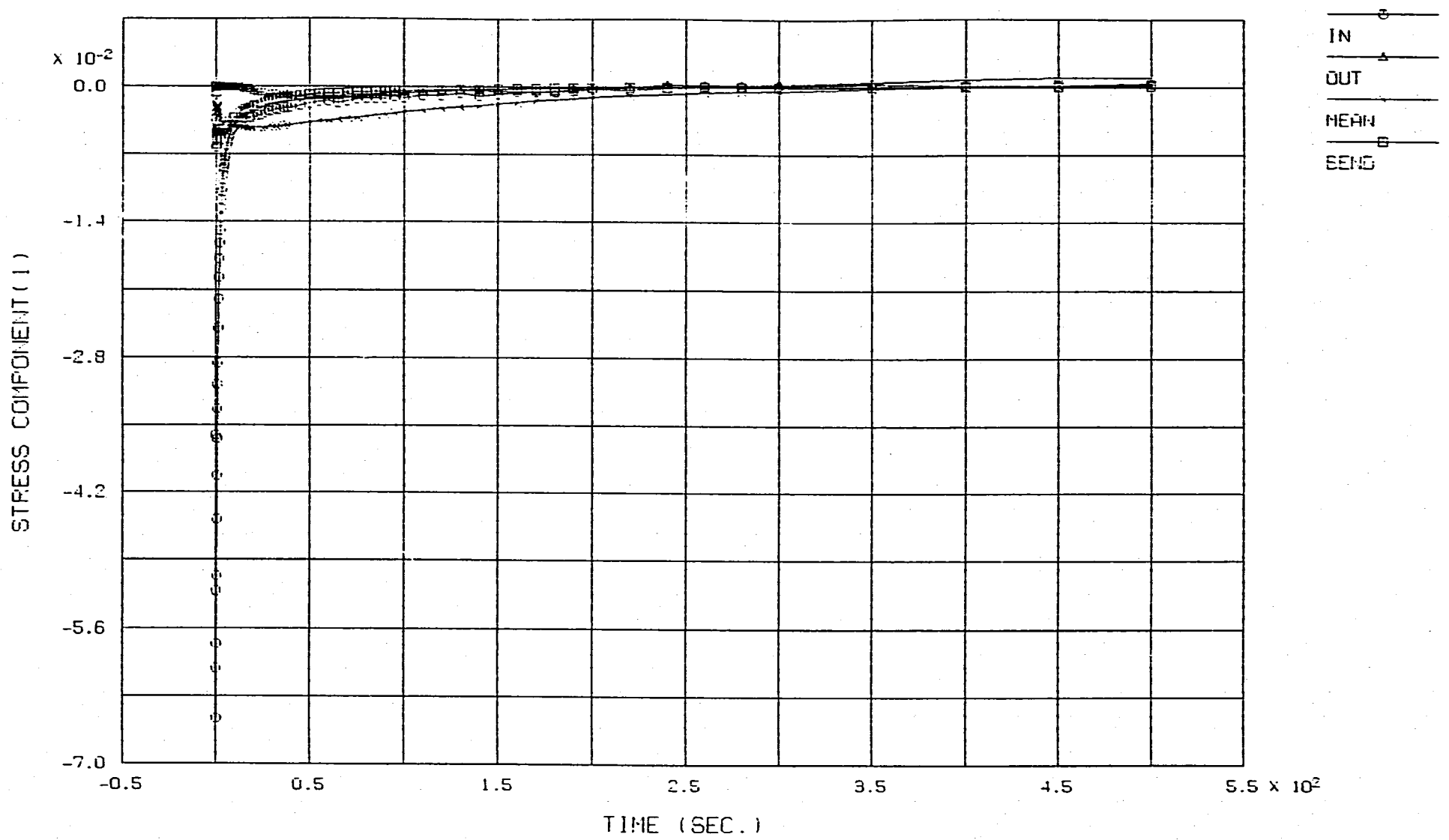
STRESS COMPONENT (3) OF SECTION (6)

図9. 6 (3) 評価断面6の応力テンソル成分3



STRESS COMPONENT (4) OF SECTION (6)

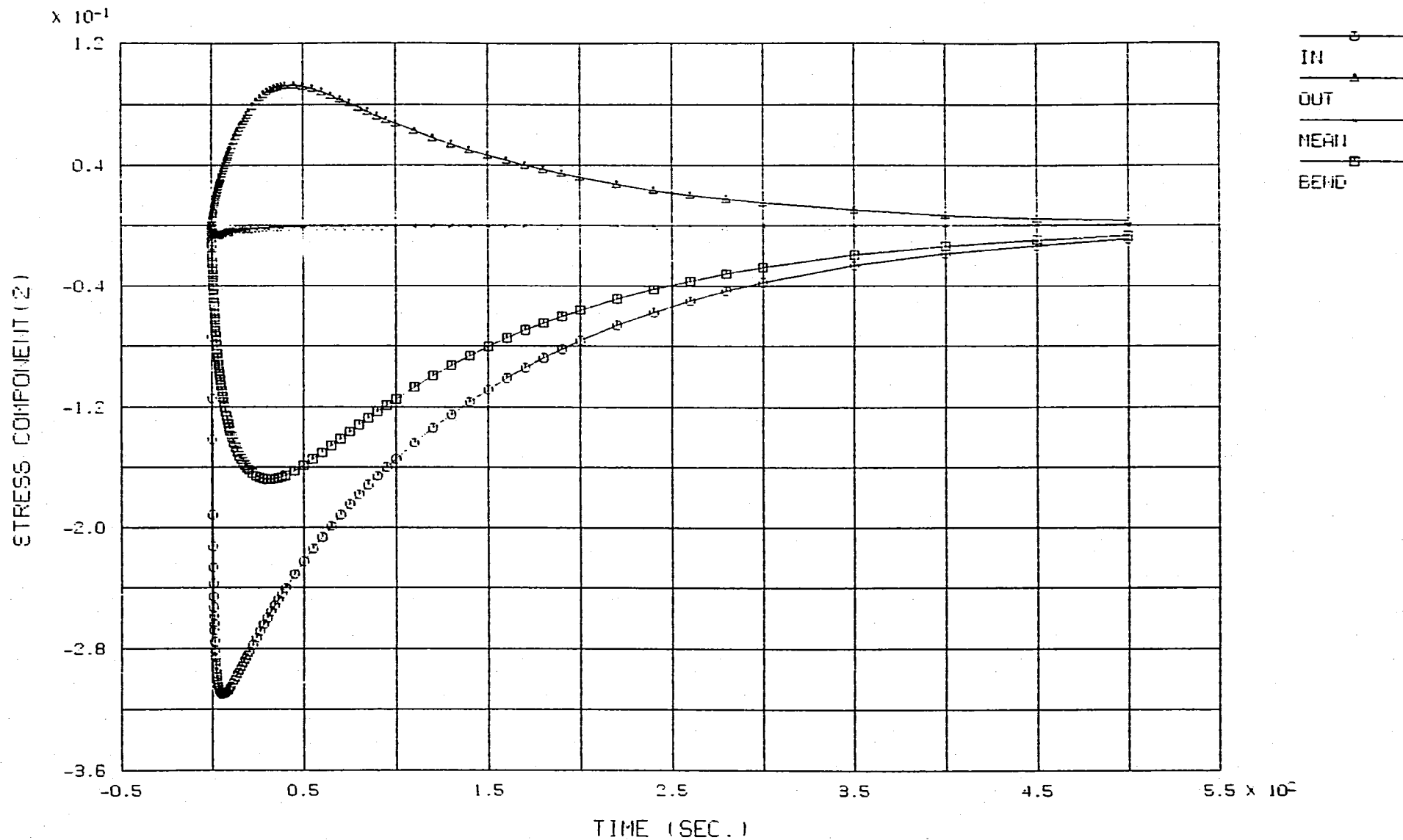
図9. 6 (4) 評価断面6の応力テンソル成分4



STRESS COMPONENT (1) OF SECTION(7)

図9. 7 (1) 評価断面7の応力テンソル成分1

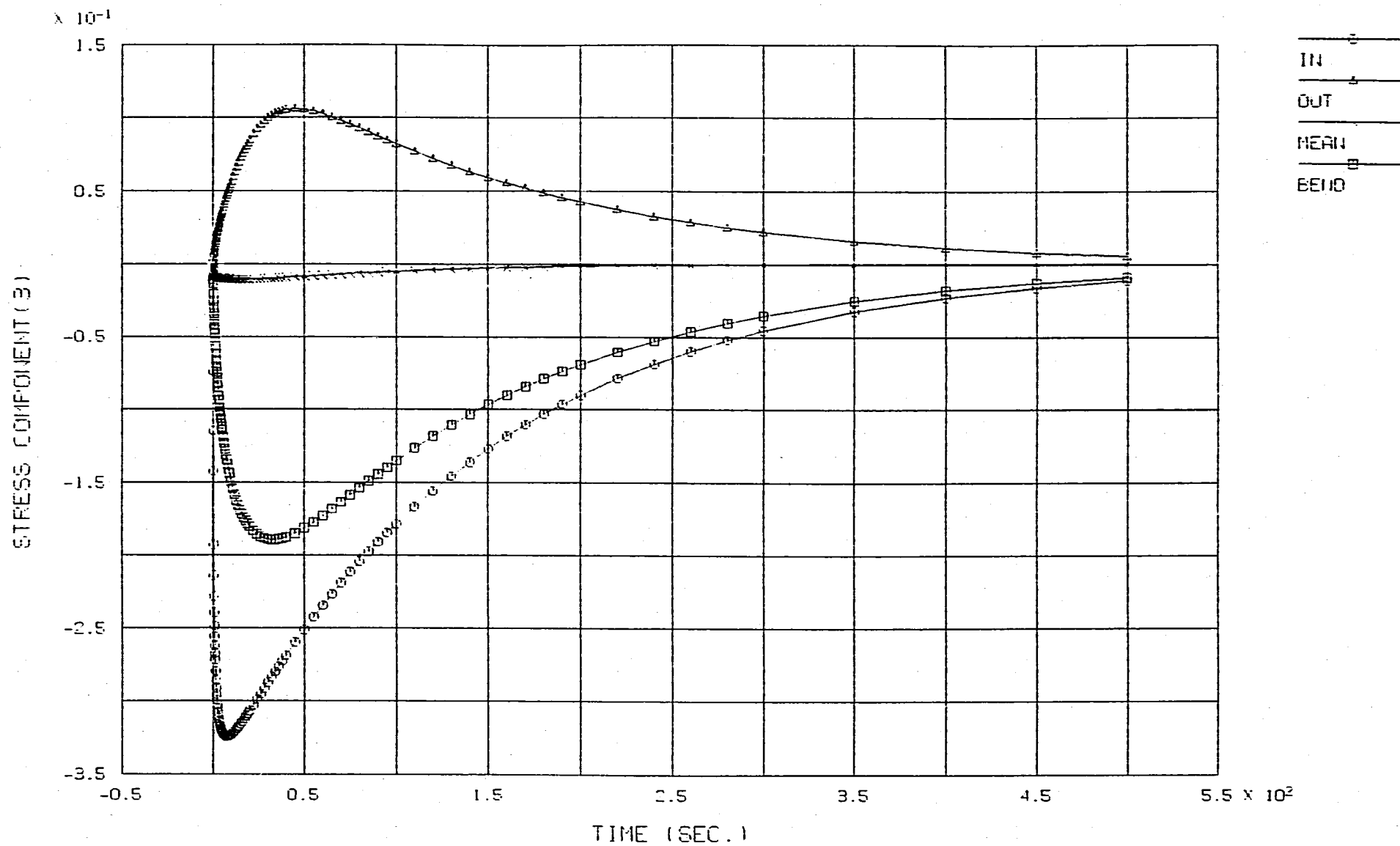
- 69 -



- 70 -

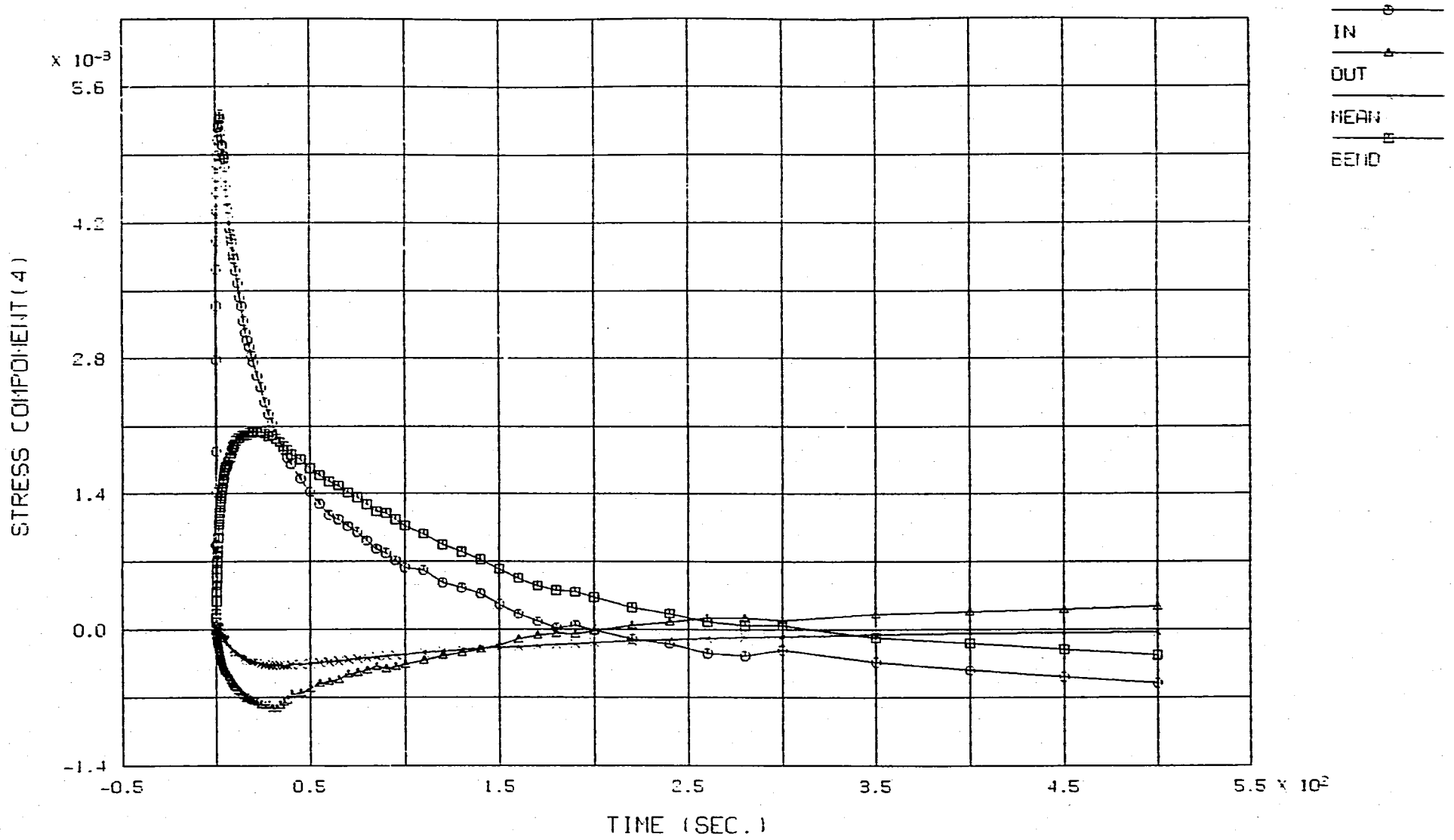
STRESS COMPONENT (2) OF SECTION (7)

図9. 7 (2) 評価断面7の応力テンソル成分2



STRESS COMPONENT (3) OF SECTION (7)

図9. 7 (3) 評価断面7の応力テンソル成分3



STRESS COMPONENT(4) OF SECTION(7)

図9. 7 (4) 評価断面7の応力テンソル成分4

ステップ温度変化の基本解 表 1. 1 評価断面1の温度

断面1の温度

| ステップ | 時間(S) | FINAS解 | | | |
|------|-------|--------|------|------|------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.01 | 0.07 | 0.00 | 0.00 | 0.01 |
| 3 | 0.04 | 0.22 | 0.00 | 0.03 | 0.06 |
| 4 | 0.07 | 0.25 | 0.00 | 0.05 | 0.10 |
| 5 | 0.10 | 0.31 | 0.00 | 0.06 | 0.12 |
| 6 | 0.20 | 0.39 | 0.01 | 0.11 | 0.18 |
| 7 | 0.30 | 0.45 | 0.02 | 0.16 | 0.21 |
| 8 | 0.40 | 0.48 | 0.05 | 0.20 | 0.22 |
| 9 | 0.50 | 0.52 | 0.08 | 0.23 | 0.22 |
| 10 | 0.60 | 0.54 | 0.12 | 0.27 | 0.22 |
| 11 | 0.70 | 0.57 | 0.16 | 0.30 | 0.21 |
| 12 | 0.80 | 0.58 | 0.19 | 0.33 | 0.20 |
| 13 | 0.90 | 0.61 | 0.23 | 0.36 | 0.19 |
| 14 | 1.00 | 0.62 | 0.26 | 0.39 | 0.19 |
| 15 | 1.20 | 0.66 | 0.33 | 0.45 | 0.17 |
| 16 | 1.40 | 0.68 | 0.38 | 0.49 | 0.16 |
| 17 | 1.60 | 0.72 | 0.44 | 0.54 | 0.14 |
| 18 | 1.80 | 0.74 | 0.49 | 0.58 | 0.13 |
| 19 | 2.00 | 0.76 | 0.53 | 0.62 | 0.12 |
| 20 | 2.20 | 0.78 | 0.57 | 0.65 | 0.11 |
| 21 | 2.40 | 0.80 | 0.61 | 0.68 | 0.10 |
| 22 | 2.60 | 0.81 | 0.65 | 0.71 | 0.09 |
| 23 | 2.80 | 0.83 | 0.68 | 0.73 | 0.08 |
| 24 | 3.00 | 0.85 | 0.70 | 0.76 | 0.07 |
| 25 | 3.20 | 0.86 | 0.73 | 0.78 | 0.07 |
| 26 | 3.40 | 0.87 | 0.75 | 0.80 | 0.06 |
| 27 | 3.60 | 0.88 | 0.78 | 0.81 | 0.06 |
| 28 | 3.80 | 0.89 | 0.80 | 0.83 | 0.05 |
| 29 | 4.00 | 0.90 | 0.81 | 0.85 | 0.05 |
| 30 | 4.20 | 0.91 | 0.83 | 0.86 | 0.04 |
| 31 | 4.40 | 0.92 | 0.85 | 0.87 | 0.04 |
| 32 | 4.60 | 0.92 | 0.86 | 0.88 | 0.04 |
| 33 | 4.80 | 0.93 | 0.87 | 0.89 | 0.03 |
| 34 | 5.00 | 0.94 | 0.88 | 0.90 | 0.03 |
| 35 | 5.50 | 0.95 | 0.91 | 0.92 | 0.02 |
| 36 | 6.00 | 0.96 | 0.93 | 0.94 | 0.02 |
| 37 | 6.50 | 0.97 | 0.94 | 0.95 | 0.02 |
| 38 | 7.00 | 0.97 | 0.95 | 0.96 | 0.01 |
| 39 | 7.50 | 0.98 | 0.96 | 0.97 | 0.01 |
| 40 | 8.00 | 0.98 | 0.97 | 0.98 | 0.01 |
| 41 | 8.50 | 0.99 | 0.98 | 0.98 | 0.01 |
| 42 | 9.00 | 0.99 | 0.98 | 0.98 | 0.00 |
| 43 | 9.50 | 0.99 | 0.99 | 0.99 | 0.00 |
| 44 | 10.00 | 0.99 | 0.99 | 0.99 | 0.00 |
| 45 | 11.00 | 1.00 | 0.99 | 0.99 | 0.00 |
| 46 | 12.00 | 0.99 | 1.00 | 1.00 | 0.00 |
| 47 | 13.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 48 | 14.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 49 | 15.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 50 | 16.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 51 | 17.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 52 | 18.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 53 | 19.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 54 | 20.00 | 1.00 | 1.00 | 1.00 | 0.00 |

| | | | | | |
|----|--------|------|------|------|------|
| 55 | 22.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 56 | 24.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 57 | 26.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 58 | 28.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 59 | 30.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 60 | 32.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 61 | 34.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 62 | 36.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 63 | 38.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 64 | 40.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 65 | 45.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 66 | 50.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 67 | 55.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 68 | 60.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 69 | 65.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 70 | 70.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 71 | 75.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 72 | 80.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 73 | 85.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 74 | 90.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 75 | 95.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 76 | 100.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 77 | 110.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 78 | 120.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 79 | 130.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 80 | 140.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 81 | 150.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 82 | 160.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 83 | 170.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 84 | 180.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 85 | 190.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 86 | 200.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 87 | 220.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 88 | 240.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 89 | 260.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 90 | 280.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 91 | 300.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 92 | 350.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 93 | 400.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 94 | 450.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 95 | 500.00 | 1.00 | 1.00 | 1.00 | 0.00 |

ステップ温度変化の基本解 表1. 2 評価断面2の温度

断面2の温度

| ステップ | 時間(S) | FINAS解 | | | |
|------|-------|--------|------|------|------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.01 | 0.07 | 0.00 | 0.00 | 0.01 |
| 3 | 0.04 | 0.22 | 0.00 | 0.02 | 0.05 |
| 4 | 0.07 | 0.25 | 0.00 | 0.04 | 0.09 |
| 5 | 0.10 | 0.30 | 0.00 | 0.06 | 0.11 |
| 6 | 0.20 | 0.37 | 0.01 | 0.11 | 0.17 |
| 7 | 0.30 | 0.43 | 0.02 | 0.15 | 0.19 |
| 8 | 0.40 | 0.46 | 0.05 | 0.18 | 0.20 |
| 9 | 0.50 | 0.50 | 0.08 | 0.22 | 0.21 |
| 10 | 0.60 | 0.51 | 0.11 | 0.25 | 0.20 |
| 11 | 0.70 | 0.54 | 0.15 | 0.28 | 0.20 |
| 12 | 0.80 | 0.56 | 0.18 | 0.31 | 0.19 |
| 13 | 0.90 | 0.58 | 0.21 | 0.34 | 0.19 |
| 14 | 1.00 | 0.59 | 0.25 | 0.37 | 0.18 |
| 15 | 1.20 | 0.63 | 0.30 | 0.42 | 0.17 |
| 16 | 1.40 | 0.66 | 0.36 | 0.46 | 0.15 |
| 17 | 1.60 | 0.69 | 0.41 | 0.51 | 0.14 |
| 18 | 1.80 | 0.71 | 0.46 | 0.54 | 0.13 |
| 19 | 2.00 | 0.74 | 0.50 | 0.58 | 0.12 |
| 20 | 2.20 | 0.75 | 0.54 | 0.61 | 0.11 |
| 21 | 2.40 | 0.78 | 0.57 | 0.64 | 0.10 |
| 22 | 2.60 | 0.79 | 0.61 | 0.67 | 0.09 |
| 23 | 2.80 | 0.81 | 0.64 | 0.70 | 0.09 |
| 24 | 3.00 | 0.82 | 0.67 | 0.72 | 0.08 |
| 25 | 3.20 | 0.84 | 0.69 | 0.74 | 0.07 |
| 26 | 3.40 | 0.85 | 0.72 | 0.76 | 0.07 |
| 27 | 3.60 | 0.86 | 0.74 | 0.78 | 0.06 |
| 28 | 3.80 | 0.87 | 0.76 | 0.80 | 0.06 |
| 29 | 4.00 | 0.88 | 0.78 | 0.81 | 0.05 |
| 30 | 4.20 | 0.89 | 0.79 | 0.83 | 0.05 |
| 31 | 4.40 | 0.90 | 0.81 | 0.84 | 0.04 |
| 32 | 4.60 | 0.91 | 0.82 | 0.85 | 0.04 |
| 33 | 4.80 | 0.92 | 0.84 | 0.87 | 0.04 |
| 34 | 5.00 | 0.92 | 0.85 | 0.88 | 0.04 |
| 35 | 5.50 | 0.94 | 0.88 | 0.90 | 0.03 |
| 36 | 6.00 | 0.95 | 0.90 | 0.92 | 0.02 |
| 37 | 6.50 | 0.96 | 0.92 | 0.93 | 0.02 |
| 38 | 7.00 | 0.96 | 0.93 | 0.94 | 0.02 |
| 39 | 7.50 | 0.97 | 0.94 | 0.95 | 0.01 |
| 40 | 8.00 | 0.97 | 0.95 | 0.96 | 0.01 |
| 41 | 8.50 | 0.98 | 0.96 | 0.97 | 0.01 |
| 42 | 9.00 | 0.98 | 0.97 | 0.97 | 0.01 |
| 43 | 9.50 | 0.99 | 0.97 | 0.98 | 0.01 |
| 44 | 10.00 | 0.99 | 0.98 | 0.98 | 0.00 |
| 45 | 11.00 | 0.99 | 0.98 | 0.99 | 0.00 |
| 46 | 12.00 | 0.99 | 0.99 | 0.99 | 0.00 |
| 47 | 13.00 | 1.00 | 0.99 | 0.99 | 0.00 |
| 48 | 14.00 | 1.00 | 0.99 | 1.00 | 0.00 |
| 49 | 15.00 | 1.00 | 0.99 | 1.00 | 0.00 |
| 50 | 16.00 | 1.00 | 0.99 | 1.00 | 0.00 |
| 51 | 17.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 52 | 18.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 53 | 19.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 54 | 20.00 | 1.00 | 1.00 | 1.00 | 0.00 |

| | | | | | |
|----|--------|------|------|------|------|
| 55 | 22.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 56 | 24.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 57 | 26.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 58 | 28.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 59 | 30.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 60 | 32.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 61 | 34.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 62 | 36.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 63 | 38.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 64 | 40.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 65 | 45.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 66 | 50.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 67 | 55.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 68 | 60.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 69 | 65.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 70 | 70.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 71 | 75.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 72 | 80.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 73 | 85.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 74 | 90.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 75 | 95.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 76 | 100.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 77 | 110.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 78 | 120.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 79 | 130.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 80 | 140.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 81 | 150.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 82 | 160.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 83 | 170.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 84 | 180.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 85 | 190.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 86 | 200.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 87 | 220.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 88 | 240.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 89 | 260.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 90 | 280.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 91 | 300.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 92 | 350.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 93 | 400.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 94 | 450.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 95 | 500.00 | 1.00 | 1.00 | 1.00 | 0.00 |

ステップ温度変化の基本解

表 1. 3 評価断面3の温度

断面3の温度

| ステップ | 時間(S) | FINAS解 | | | |
|------|-------|--------|------|------|------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.01 | 0.07 | 0.00 | 0.00 | 0.01 |
| 3 | 0.04 | 0.22 | 0.00 | 0.02 | 0.05 |
| 4 | 0.07 | 0.26 | 0.00 | 0.03 | 0.07 |
| 5 | 0.10 | 0.31 | 0.00 | 0.04 | 0.10 |
| 6 | 0.20 | 0.39 | 0.00 | 0.08 | 0.16 |
| 7 | 0.30 | 0.46 | 0.01 | 0.12 | 0.20 |
| 8 | 0.40 | 0.49 | 0.02 | 0.16 | 0.22 |
| 9 | 0.50 | 0.53 | 0.04 | 0.19 | 0.23 |
| 10 | 0.60 | 0.55 | 0.06 | 0.22 | 0.24 |
| 11 | 0.70 | 0.58 | 0.09 | 0.25 | 0.24 |
| 12 | 0.80 | 0.59 | 0.12 | 0.28 | 0.24 |
| 13 | 0.90 | 0.62 | 0.15 | 0.30 | 0.23 |
| 14 | 1.00 | 0.63 | 0.17 | 0.33 | 0.23 |
| 15 | 1.20 | 0.66 | 0.23 | 0.37 | 0.22 |
| 16 | 1.40 | 0.68 | 0.28 | 0.42 | 0.20 |
| 17 | 1.60 | 0.71 | 0.33 | 0.46 | 0.19 |
| 18 | 1.80 | 0.73 | 0.38 | 0.50 | 0.18 |
| 19 | 2.00 | 0.75 | 0.42 | 0.53 | 0.17 |
| 20 | 2.20 | 0.76 | 0.46 | 0.56 | 0.15 |
| 21 | 2.40 | 0.78 | 0.49 | 0.59 | 0.14 |
| 22 | 2.60 | 0.79 | 0.53 | 0.62 | 0.13 |
| 23 | 2.80 | 0.81 | 0.56 | 0.64 | 0.13 |
| 24 | 3.00 | 0.82 | 0.59 | 0.67 | 0.12 |
| 25 | 3.20 | 0.84 | 0.61 | 0.69 | 0.11 |
| 26 | 3.40 | 0.84 | 0.64 | 0.71 | 0.10 |
| 27 | 3.60 | 0.86 | 0.66 | 0.73 | 0.10 |
| 28 | 3.80 | 0.86 | 0.68 | 0.74 | 0.09 |
| 29 | 4.00 | 0.87 | 0.70 | 0.76 | 0.09 |
| 30 | 4.20 | 0.88 | 0.72 | 0.78 | 0.08 |
| 31 | 4.40 | 0.89 | 0.74 | 0.79 | 0.08 |
| 32 | 4.60 | 0.89 | 0.75 | 0.80 | 0.07 |
| 33 | 4.80 | 0.90 | 0.77 | 0.81 | 0.07 |
| 34 | 5.00 | 0.91 | 0.78 | 0.83 | 0.06 |
| 35 | 5.50 | 0.92 | 0.81 | 0.85 | 0.05 |
| 36 | 6.00 | 0.93 | 0.84 | 0.87 | 0.05 |
| 37 | 6.50 | 0.94 | 0.86 | 0.89 | 0.04 |
| 38 | 7.00 | 0.95 | 0.88 | 0.90 | 0.04 |
| 39 | 7.50 | 0.96 | 0.90 | 0.92 | 0.03 |
| 40 | 8.00 | 0.96 | 0.91 | 0.93 | 0.03 |
| 41 | 8.50 | 0.97 | 0.92 | 0.94 | 0.02 |
| 42 | 9.00 | 0.97 | 0.93 | 0.95 | 0.02 |
| 43 | 9.50 | 0.98 | 0.94 | 0.95 | 0.02 |
| 44 | 10.00 | 0.98 | 0.95 | 0.96 | 0.02 |
| 45 | 11.00 | 0.98 | 0.96 | 0.97 | 0.01 |
| 46 | 12.00 | 0.98 | 0.97 | 0.97 | 0.01 |
| 47 | 13.00 | 0.99 | 0.97 | 0.98 | 0.01 |
| 48 | 14.00 | 0.99 | 0.98 | 0.98 | 0.01 |
| 49 | 15.00 | 0.99 | 0.98 | 0.98 | 0.01 |
| 50 | 16.00 | 0.99 | 0.98 | 0.99 | 0.01 |
| 51 | 17.00 | 1.00 | 0.99 | 0.99 | 0.01 |
| 52 | 18.00 | 0.99 | 0.99 | 0.99 | 0.00 |
| 53 | 19.00 | 1.00 | 0.99 | 0.99 | 0.00 |
| 54 | 20.00 | 1.00 | 0.99 | 0.99 | 0.00 |

| | | | | | |
|----|--------|------|------|------|------|
| 55 | 22.00 | 1.00 | 0.99 | 0.99 | 0.06 |
| 56 | 24.00 | 1.00 | 0.99 | 0.99 | 0.00 |
| 57 | 26.00 | 1.00 | 0.99 | 1.00 | 0.00 |
| 58 | 28.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 59 | 30.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 60 | 32.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 61 | 34.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 62 | 36.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 63 | 38.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 64 | 40.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 65 | 45.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 66 | 50.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 67 | 55.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 68 | 60.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 69 | 65.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 70 | 70.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 71 | 75.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 72 | 80.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 73 | 85.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 74 | 90.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 75 | 95.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 76 | 100.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 77 | 110.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 78 | 120.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 79 | 130.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 80 | 140.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 81 | 150.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 82 | 160.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 83 | 170.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 84 | 180.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 85 | 190.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 86 | 200.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 87 | 220.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 88 | 240.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 89 | 260.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 90 | 280.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 91 | 300.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 92 | 350.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 93 | 400.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 94 | 450.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 95 | 500.00 | 1.00 | 1.00 | 1.00 | 0.00 |

ステップ温度変化の基本解

表 1. 4 評価断面 4 の温度

断面 4 の温度

| ステップ | 時間(S) | FINAS解 | | | |
|------|-------|--------|------|------|------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.01 | 0.06 | 0.00 | 0.00 | 0.00 |
| 3 | 0.04 | 0.22 | 0.00 | 0.01 | 0.02 |
| 4 | 0.07 | 0.25 | 0.00 | 0.01 | 0.04 |
| 5 | 0.10 | 0.30 | 0.00 | 0.02 | 0.05 |
| 6 | 0.20 | 0.39 | 0.00 | 0.04 | 0.09 |
| 7 | 0.30 | 0.45 | 0.00 | 0.05 | 0.13 |
| 8 | 0.40 | 0.48 | 0.00 | 0.07 | 0.15 |
| 9 | 0.50 | 0.52 | 0.00 | 0.08 | 0.18 |
| 10 | 0.60 | 0.54 | 0.00 | 0.09 | 0.20 |
| 11 | 0.70 | 0.56 | 0.00 | 0.10 | 0.22 |
| 12 | 0.80 | 0.58 | 0.00 | 0.11 | 0.23 |
| 13 | 0.90 | 0.60 | 0.00 | 0.12 | 0.24 |
| 14 | 1.00 | 0.61 | 0.00 | 0.14 | 0.26 |
| 15 | 1.20 | 0.63 | 0.00 | 0.15 | 0.28 |
| 16 | 1.40 | 0.65 | 0.01 | 0.17 | 0.29 |
| 17 | 1.60 | 0.67 | 0.01 | 0.19 | 0.30 |
| 18 | 1.80 | 0.68 | 0.02 | 0.21 | 0.31 |
| 19 | 2.00 | 0.70 | 0.02 | 0.22 | 0.32 |
| 20 | 2.20 | 0.71 | 0.03 | 0.24 | 0.32 |
| 21 | 2.40 | 0.72 | 0.04 | 0.25 | 0.33 |
| 22 | 2.60 | 0.73 | 0.05 | 0.27 | 0.33 |
| 23 | 2.80 | 0.74 | 0.07 | 0.28 | 0.33 |
| 24 | 3.00 | 0.74 | 0.08 | 0.29 | 0.33 |
| 25 | 3.20 | 0.75 | 0.09 | 0.31 | 0.33 |
| 26 | 3.40 | 0.76 | 0.10 | 0.32 | 0.33 |
| 27 | 3.60 | 0.76 | 0.11 | 0.33 | 0.32 |
| 28 | 3.80 | 0.77 | 0.13 | 0.34 | 0.32 |
| 29 | 4.00 | 0.77 | 0.14 | 0.35 | 0.32 |
| 30 | 4.20 | 0.78 | 0.15 | 0.36 | 0.31 |
| 31 | 4.40 | 0.78 | 0.17 | 0.38 | 0.31 |
| 32 | 4.60 | 0.79 | 0.18 | 0.39 | 0.31 |
| 33 | 4.80 | 0.79 | 0.19 | 0.40 | 0.30 |
| 34 | 5.00 | 0.80 | 0.20 | 0.41 | 0.30 |
| 35 | 5.50 | 0.81 | 0.24 | 0.43 | 0.29 |
| 36 | 6.00 | 0.81 | 0.27 | 0.45 | 0.28 |
| 37 | 6.50 | 0.82 | 0.29 | 0.48 | 0.27 |
| 38 | 7.00 | 0.83 | 0.32 | 0.50 | 0.26 |
| 39 | 7.50 | 0.84 | 0.35 | 0.52 | 0.25 |
| 40 | 8.00 | 0.84 | 0.37 | 0.53 | 0.24 |
| 41 | 8.50 | 0.85 | 0.40 | 0.55 | 0.23 |
| 42 | 9.00 | 0.85 | 0.42 | 0.57 | 0.22 |
| 43 | 9.50 | 0.86 | 0.44 | 0.59 | 0.21 |
| 44 | 10.00 | 0.87 | 0.46 | 0.60 | 0.21 |
| 45 | 11.00 | 0.88 | 0.50 | 0.63 | 0.19 |
| 46 | 12.00 | 0.88 | 0.53 | 0.66 | 0.18 |
| 47 | 13.00 | 0.89 | 0.57 | 0.68 | 0.17 |
| 48 | 14.00 | 0.90 | 0.60 | 0.70 | 0.16 |
| 49 | 15.00 | 0.91 | 0.62 | 0.72 | 0.15 |
| 50 | 16.00 | 0.91 | 0.65 | 0.74 | 0.14 |
| 51 | 17.00 | 0.92 | 0.67 | 0.76 | 0.13 |
| 52 | 18.00 | 0.92 | 0.69 | 0.77 | 0.12 |
| 53 | 19.00 | 0.93 | 0.71 | 0.78 | 0.11 |
| 54 | 20.00 | 0.93 | 0.72 | 0.80 | 0.11 |

| | | | | | |
|----|--------|------|------|------|------|
| 55 | 22.00 | 0.94 | 0.75 | 0.82 | 0.10 |
| 56 | 24.00 | 0.95 | 0.78 | 0.84 | 0.09 |
| 57 | 26.00 | 0.95 | 0.80 | 0.85 | 0.08 |
| 58 | 28.00 | 0.96 | 0.82 | 0.87 | 0.07 |
| 59 | 30.00 | 0.96 | 0.84 | 0.88 | 0.06 |
| 60 | 32.00 | 0.97 | 0.85 | 0.89 | 0.06 |
| 61 | 34.00 | 0.97 | 0.86 | 0.90 | 0.05 |
| 62 | 36.00 | 0.97 | 0.87 | 0.91 | 0.05 |
| 63 | 38.00 | 0.97 | 0.88 | 0.91 | 0.05 |
| 64 | 40.00 | 0.97 | 0.89 | 0.92 | 0.04 |
| 65 | 45.00 | 0.98 | 0.91 | 0.93 | 0.04 |
| 66 | 50.00 | 0.98 | 0.92 | 0.94 | 0.03 |
| 67 | 55.00 | 0.98 | 0.93 | 0.95 | 0.03 |
| 68 | 60.00 | 0.99 | 0.94 | 0.95 | 0.03 |
| 69 | 65.00 | 0.99 | 0.94 | 0.96 | 0.02 |
| 70 | 70.00 | 0.99 | 0.95 | 0.96 | 0.02 |
| 71 | 75.00 | 0.99 | 0.95 | 0.96 | 0.02 |
| 72 | 80.00 | 0.99 | 0.95 | 0.97 | 0.02 |
| 73 | 85.00 | 0.99 | 0.96 | 0.97 | 0.02 |
| 74 | 90.00 | 0.99 | 0.96 | 0.97 | 0.02 |
| 75 | 95.00 | 0.99 | 0.96 | 0.97 | 0.02 |
| 76 | 100.00 | 0.99 | 0.97 | 0.97 | 0.01 |
| 77 | 110.00 | 0.99 | 0.97 | 0.98 | 0.01 |
| 78 | 120.00 | 1.00 | 0.97 | 0.98 | 0.01 |
| 79 | 130.00 | 1.00 | 0.98 | 0.98 | 0.01 |
| 80 | 140.00 | 1.00 | 0.98 | 0.98 | 0.01 |
| 81 | 150.00 | 1.00 | 0.98 | 0.98 | 0.01 |
| 82 | 160.00 | 1.00 | 0.98 | 0.99 | 0.01 |
| 83 | 170.00 | 1.00 | 0.98 | 0.99 | 0.01 |
| 84 | 180.00 | 1.00 | 0.99 | 0.99 | 0.01 |
| 85 | 190.00 | 1.00 | 0.99 | 0.99 | 0.01 |
| 86 | 200.00 | 1.00 | 0.99 | 0.99 | 0.01 |
| 87 | 220.00 | 1.00 | 0.99 | 0.99 | 0.00 |
| 88 | 240.00 | 1.00 | 0.99 | 0.99 | 0.00 |
| 89 | 260.00 | 1.00 | 0.99 | 0.99 | 0.00 |
| 90 | 280.00 | 1.00 | 1.00 | 0.99 | 0.00 |
| 91 | 300.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 92 | 350.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 93 | 400.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 94 | 450.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 95 | 500.00 | 1.00 | 1.00 | 1.00 | 0.00 |

ステップ温度変化の基本解

表1. 5 評価断面5の温度

断面5の温度

| ステップ | 時間(S) | FINAS解 | | | |
|------|-------|--------|------|------|------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 |
| 3 | 0.04 | 0.14 | 0.00 | 0.01 | 0.02 |
| 4 | 0.07 | 0.21 | 0.00 | 0.01 | 0.04 |
| 5 | 0.10 | 0.26 | 0.00 | 0.02 | 0.05 |
| 6 | 0.20 | 0.37 | 0.00 | 0.03 | 0.08 |
| 7 | 0.30 | 0.43 | 0.00 | 0.05 | 0.11 |
| 8 | 0.40 | 0.47 | 0.00 | 0.06 | 0.14 |
| 9 | 0.50 | 0.50 | 0.00 | 0.07 | 0.16 |
| 10 | 0.60 | 0.53 | 0.00 | 0.08 | 0.18 |
| 11 | 0.70 | 0.55 | 0.00 | 0.09 | 0.19 |
| 12 | 0.80 | 0.57 | 0.00 | 0.10 | 0.21 |
| 13 | 0.90 | 0.58 | 0.00 | 0.11 | 0.22 |
| 14 | 1.00 | 0.60 | 0.00 | 0.12 | 0.24 |
| 15 | 1.20 | 0.62 | 0.00 | 0.13 | 0.26 |
| 16 | 1.40 | 0.64 | 0.00 | 0.15 | 0.28 |
| 17 | 1.60 | 0.66 | 0.00 | 0.16 | 0.29 |
| 18 | 1.80 | 0.67 | 0.00 | 0.17 | 0.30 |
| 19 | 2.00 | 0.69 | 0.01 | 0.19 | 0.31 |
| 20 | 2.20 | 0.70 | 0.01 | 0.20 | 0.32 |
| 21 | 2.40 | 0.71 | 0.01 | 0.21 | 0.33 |
| 22 | 2.60 | 0.72 | 0.02 | 0.22 | 0.34 |
| 23 | 2.80 | 0.73 | 0.02 | 0.24 | 0.34 |
| 24 | 3.00 | 0.73 | 0.03 | 0.25 | 0.34 |
| 25 | 3.20 | 0.74 | 0.04 | 0.26 | 0.35 |
| 26 | 3.40 | 0.75 | 0.04 | 0.27 | 0.35 |
| 27 | 3.60 | 0.75 | 0.05 | 0.28 | 0.35 |
| 28 | 3.80 | 0.76 | 0.06 | 0.29 | 0.35 |
| 29 | 4.00 | 0.76 | 0.06 | 0.30 | 0.35 |
| 30 | 4.20 | 0.77 | 0.07 | 0.30 | 0.35 |
| 31 | 4.40 | 0.77 | 0.08 | 0.31 | 0.35 |
| 32 | 4.60 | 0.78 | 0.09 | 0.32 | 0.35 |
| 33 | 4.80 | 0.78 | 0.10 | 0.33 | 0.35 |
| 34 | 5.00 | 0.78 | 0.10 | 0.34 | 0.35 |
| 35 | 5.50 | 0.79 | 0.12 | 0.36 | 0.34 |
| 36 | 6.00 | 0.80 | 0.14 | 0.37 | 0.34 |
| 37 | 6.50 | 0.81 | 0.16 | 0.39 | 0.33 |
| 38 | 7.00 | 0.81 | 0.18 | 0.41 | 0.32 |
| 39 | 7.50 | 0.82 | 0.20 | 0.42 | 0.32 |
| 40 | 8.00 | 0.82 | 0.22 | 0.44 | 0.31 |
| 41 | 8.50 | 0.83 | 0.24 | 0.45 | 0.31 |
| 42 | 9.00 | 0.83 | 0.25 | 0.46 | 0.30 |
| 43 | 9.50 | 0.84 | 0.27 | 0.48 | 0.29 |
| 44 | 10.00 | 0.84 | 0.29 | 0.49 | 0.29 |
| 45 | 11.00 | 0.85 | 0.32 | 0.51 | 0.28 |
| 46 | 12.00 | 0.85 | 0.35 | 0.53 | 0.26 |
| 47 | 13.00 | 0.85 | 0.37 | 0.55 | 0.25 |
| 48 | 14.00 | 0.86 | 0.40 | 0.57 | 0.24 |
| 49 | 15.00 | 0.87 | 0.42 | 0.58 | 0.23 |
| 50 | 16.00 | 0.87 | 0.44 | 0.60 | 0.23 |
| 51 | 17.00 | 0.88 | 0.46 | 0.61 | 0.22 |
| 52 | 18.00 | 0.88 | 0.48 | 0.63 | 0.21 |
| 53 | 19.00 | 0.89 | 0.50 | 0.64 | 0.20 |
| 54 | 20.00 | 0.89 | 0.51 | 0.65 | 0.20 |

| | | | | | |
|----|--------|------|------|------|------|
| 55 | 22.00 | 0.89 | 0.54 | 0.67 | 0.18 |
| 56 | 24.00 | 0.90 | 0.57 | 0.69 | 0.17 |
| 57 | 26.00 | 0.91 | 0.59 | 0.71 | 0.16 |
| 58 | 28.00 | 0.91 | 0.61 | 0.72 | 0.16 |
| 59 | 30.00 | 0.92 | 0.63 | 0.73 | 0.15 |
| 60 | 32.00 | 0.92 | 0.65 | 0.75 | 0.14 |
| 61 | 34.00 | 0.92 | 0.66 | 0.76 | 0.13 |
| 62 | 36.00 | 0.93 | 0.68 | 0.77 | 0.13 |
| 63 | 38.00 | 0.93 | 0.69 | 0.78 | 0.12 |
| 64 | 40.00 | 0.93 | 0.70 | 0.79 | 0.12 |
| 65 | 45.00 | 0.94 | 0.73 | 0.81 | 0.11 |
| 66 | 50.00 | 0.94 | 0.75 | 0.82 | 0.10 |
| 67 | 55.00 | 0.95 | 0.77 | 0.84 | 0.09 |
| 68 | 60.00 | 0.95 | 0.79 | 0.85 | 0.09 |
| 69 | 65.00 | 0.95 | 0.80 | 0.86 | 0.08 |
| 70 | 70.00 | 0.96 | 0.82 | 0.87 | 0.07 |
| 71 | 75.00 | 0.96 | 0.83 | 0.88 | 0.07 |
| 72 | 80.00 | 0.96 | 0.84 | 0.88 | 0.07 |
| 73 | 85.00 | 0.96 | 0.85 | 0.89 | 0.06 |
| 74 | 90.00 | 0.97 | 0.86 | 0.90 | 0.06 |
| 75 | 95.00 | 0.97 | 0.87 | 0.90 | 0.05 |
| 76 | 100.00 | 0.97 | 0.87 | 0.91 | 0.05 |
| 77 | 110.00 | 0.97 | 0.89 | 0.92 | 0.05 |
| 78 | 120.00 | 0.98 | 0.90 | 0.93 | 0.04 |
| 79 | 130.00 | 0.98 | 0.91 | 0.93 | 0.04 |
| 80 | 140.00 | 0.98 | 0.92 | 0.94 | 0.03 |
| 81 | 150.00 | 0.98 | 0.92 | 0.94 | 0.03 |
| 82 | 160.00 | 0.98 | 0.93 | 0.95 | 0.03 |
| 83 | 170.00 | 0.99 | 0.94 | 0.95 | 0.03 |
| 84 | 180.00 | 0.99 | 0.94 | 0.96 | 0.02 |
| 85 | 190.00 | 0.99 | 0.95 | 0.96 | 0.02 |
| 86 | 200.00 | 0.99 | 0.95 | 0.97 | 0.02 |
| 87 | 220.00 | 0.99 | 0.96 | 0.97 | 0.02 |
| 88 | 240.00 | 0.99 | 0.97 | 0.98 | 0.01 |
| 89 | 260.00 | 0.99 | 0.97 | 0.98 | 0.01 |
| 90 | 280.00 | 0.99 | 0.98 | 0.98 | 0.01 |
| 91 | 300.00 | 1.00 | 0.98 | 0.99 | 0.01 |
| 92 | 350.00 | 1.00 | 0.99 | 0.99 | 0.01 |
| 93 | 400.00 | 1.00 | 0.99 | 0.99 | 0.00 |
| 94 | 450.00 | 1.00 | 1.00 | 1.00 | 0.00 |
| 95 | 500.00 | 1.00 | 1.00 | 1.00 | 0.00 |

ステップ温度変化の基本解 表1. 6 評価断面6の温度

断面6の温度

| ステップ | 時間(S) | FINAS解 | | | |
|------|-------|--------|------|------|------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 |
| 3 | 0.04 | 0.14 | 0.00 | 0.00 | 0.01 |
| 4 | 0.07 | 0.22 | 0.00 | 0.00 | 0.01 |
| 5 | 0.10 | 0.27 | 0.00 | 0.01 | 0.02 |
| 6 | 0.20 | 0.37 | 0.00 | 0.01 | 0.03 |
| 7 | 0.30 | 0.43 | 0.00 | 0.01 | 0.04 |
| 8 | 0.40 | 0.47 | 0.00 | 0.02 | 0.05 |
| 9 | 0.50 | 0.50 | 0.00 | 0.02 | 0.06 |
| 10 | 0.60 | 0.53 | 0.00 | 0.03 | 0.07 |
| 11 | 0.70 | 0.55 | 0.00 | 0.03 | 0.08 |
| 12 | 0.80 | 0.57 | 0.00 | 0.03 | 0.08 |
| 13 | 0.90 | 0.59 | 0.00 | 0.03 | 0.09 |
| 14 | 1.00 | 0.60 | 0.00 | 0.04 | 0.10 |
| 15 | 1.20 | 0.63 | 0.00 | 0.04 | 0.11 |
| 16 | 1.40 | 0.65 | 0.00 | 0.05 | 0.12 |
| 17 | 1.60 | 0.67 | 0.00 | 0.05 | 0.13 |
| 18 | 1.80 | 0.68 | 0.00 | 0.05 | 0.14 |
| 19 | 2.00 | 0.70 | 0.00 | 0.06 | 0.15 |
| 20 | 2.20 | 0.71 | 0.00 | 0.06 | 0.16 |
| 21 | 2.40 | 0.72 | 0.00 | 0.07 | 0.17 |
| 22 | 2.60 | 0.73 | 0.00 | 0.07 | 0.18 |
| 23 | 2.80 | 0.74 | 0.00 | 0.07 | 0.19 |
| 24 | 3.00 | 0.75 | 0.00 | 0.08 | 0.19 |
| 25 | 3.20 | 0.75 | 0.00 | 0.08 | 0.20 |
| 26 | 3.40 | 0.76 | 0.00 | 0.08 | 0.21 |
| 27 | 3.60 | 0.77 | 0.00 | 0.09 | 0.21 |
| 28 | 3.80 | 0.77 | 0.00 | 0.09 | 0.22 |
| 29 | 4.00 | 0.78 | 0.00 | 0.09 | 0.23 |
| 30 | 4.20 | 0.78 | 0.00 | 0.10 | 0.23 |
| 31 | 4.40 | 0.79 | 0.00 | 0.10 | 0.24 |
| 32 | 4.60 | 0.79 | 0.00 | 0.10 | 0.24 |
| 33 | 4.80 | 0.80 | 0.00 | 0.11 | 0.25 |
| 34 | 5.00 | 0.80 | 0.00 | 0.11 | 0.26 |
| 35 | 5.50 | 0.81 | 0.00 | 0.12 | 0.27 |
| 36 | 6.00 | 0.82 | 0.00 | 0.12 | 0.28 |
| 37 | 6.50 | 0.82 | 0.00 | 0.13 | 0.29 |
| 38 | 7.00 | 0.83 | 0.00 | 0.14 | 0.30 |
| 39 | 7.50 | 0.84 | 0.01 | 0.15 | 0.31 |
| 40 | 8.00 | 0.84 | 0.01 | 0.15 | 0.32 |
| 41 | 8.50 | 0.85 | 0.01 | 0.16 | 0.32 |
| 42 | 9.00 | 0.85 | 0.01 | 0.17 | 0.33 |
| 43 | 9.50 | 0.86 | 0.01 | 0.18 | 0.34 |
| 44 | 10.00 | 0.86 | 0.02 | 0.18 | 0.34 |
| 45 | 11.00 | 0.87 | 0.02 | 0.20 | 0.35 |
| 46 | 12.00 | 0.87 | 0.03 | 0.21 | 0.36 |
| 47 | 13.00 | 0.88 | 0.04 | 0.23 | 0.37 |
| 48 | 14.00 | 0.88 | 0.05 | 0.24 | 0.37 |
| 49 | 15.00 | 0.89 | 0.06 | 0.25 | 0.37 |
| 50 | 16.00 | 0.89 | 0.06 | 0.27 | 0.38 |
| 51 | 17.00 | 0.90 | 0.07 | 0.28 | 0.38 |
| 52 | 18.00 | 0.90 | 0.08 | 0.29 | 0.38 |
| 53 | 19.00 | 0.90 | 0.09 | 0.30 | 0.38 |
| 54 | 20.00 | 0.91 | 0.10 | 0.32 | 0.38 |

| | | | | | |
|----|--------|------|------|------|------|
| 55 | 22.00 | 0.91 | 0.13 | 0.34 | 0.38 |
| 56 | 24.00 | 0.92 | 0.15 | 0.36 | 0.37 |
| 57 | 26.00 | 0.92 | 0.17 | 0.38 | 0.37 |
| 58 | 28.00 | 0.92 | 0.19 | 0.40 | 0.36 |
| 59 | 30.00 | 0.93 | 0.21 | 0.42 | 0.36 |
| 60 | 32.00 | 0.93 | 0.23 | 0.44 | 0.35 |
| 61 | 34.00 | 0.93 | 0.25 | 0.45 | 0.35 |
| 62 | 36.00 | 0.94 | 0.27 | 0.47 | 0.34 |
| 63 | 38.00 | 0.94 | 0.28 | 0.49 | 0.33 |
| 64 | 40.00 | 0.94 | 0.30 | 0.50 | 0.32 |
| 65 | 45.00 | 0.95 | 0.35 | 0.53 | 0.31 |
| 66 | 50.00 | 0.95 | 0.39 | 0.56 | 0.29 |
| 67 | 55.00 | 0.95 | 0.42 | 0.59 | 0.27 |
| 68 | 60.00 | 0.96 | 0.46 | 0.62 | 0.26 |
| 69 | 65.00 | 0.96 | 0.49 | 0.64 | 0.24 |
| 70 | 70.00 | 0.96 | 0.52 | 0.66 | 0.23 |
| 71 | 75.00 | 0.96 | 0.54 | 0.68 | 0.22 |
| 72 | 80.00 | 0.97 | 0.57 | 0.70 | 0.21 |
| 73 | 85.00 | 0.97 | 0.59 | 0.71 | 0.20 |
| 74 | 90.00 | 0.97 | 0.61 | 0.73 | 0.19 |
| 75 | 95.00 | 0.97 | 0.63 | 0.74 | 0.18 |
| 76 | 100.00 | 0.97 | 0.65 | 0.75 | 0.17 |
| 77 | 110.00 | 0.98 | 0.68 | 0.78 | 0.15 |
| 78 | 120.00 | 0.98 | 0.71 | 0.80 | 0.14 |
| 79 | 130.00 | 0.98 | 0.74 | 0.82 | 0.13 |
| 80 | 140.00 | 0.98 | 0.76 | 0.83 | 0.11 |
| 81 | 150.00 | 0.98 | 0.78 | 0.85 | 0.10 |
| 82 | 160.00 | 0.98 | 0.80 | 0.86 | 0.10 |
| 83 | 170.00 | 0.99 | 0.82 | 0.87 | 0.09 |
| 84 | 180.00 | 0.99 | 0.84 | 0.88 | 0.08 |
| 85 | 190.00 | 0.99 | 0.85 | 0.89 | 0.07 |
| 86 | 200.00 | 0.99 | 0.86 | 0.90 | 0.07 |
| 87 | 220.00 | 0.99 | 0.88 | 0.92 | 0.06 |
| 88 | 240.00 | 0.99 | 0.90 | 0.93 | 0.05 |
| 89 | 260.00 | 0.99 | 0.92 | 0.94 | 0.04 |
| 90 | 280.00 | 0.99 | 0.93 | 0.95 | 0.04 |
| 91 | 300.00 | 0.99 | 0.94 | 0.96 | 0.03 |
| 92 | 350.00 | 1.00 | 0.96 | 0.97 | 0.02 |
| 93 | 400.00 | 1.00 | 0.97 | 0.98 | 0.01 |
| 94 | 450.00 | 1.00 | 0.98 | 0.99 | 0.01 |
| 95 | 500.00 | 1.00 | 0.99 | 0.99 | 0.01 |

ステップ温度変化の基本解 表1. 7 評価断面7の温度

断面7の温度

| ステップ | 時間(S) | FINAS解 | | | |
|------|-------|--------|------|------|------|
| | | 内面值 | 外面値 | 平均値 | 曲げ液分 |
| 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 |
| 3 | 0.04 | 0.13 | 0.00 | 0.00 | 0.01 |
| 4 | 0.07 | 0.20 | 0.00 | 0.01 | 0.02 |
| 5 | 0.10 | 0.26 | 0.00 | 0.01 | 0.03 |
| 6 | 0.20 | 0.36 | 0.00 | 0.01 | 0.04 |
| 7 | 0.30 | 0.42 | 0.00 | 0.02 | 0.05 |
| 8 | 0.40 | 0.46 | 0.00 | 0.02 | 0.06 |
| 9 | 0.50 | 0.49 | 0.00 | 0.03 | 0.07 |
| 10 | 0.60 | 0.52 | 0.00 | 0.03 | 0.08 |
| 11 | 0.70 | 0.54 | 0.00 | 0.03 | 0.09 |
| 12 | 0.80 | 0.56 | 0.00 | 0.04 | 0.10 |
| 13 | 0.90 | 0.58 | 0.00 | 0.04 | 0.10 |
| 14 | 1.00 | 0.59 | 0.00 | 0.04 | 0.11 |
| 15 | 1.20 | 0.62 | 0.00 | 0.05 | 0.12 |
| 16 | 1.40 | 0.64 | 0.00 | 0.05 | 0.13 |
| 17 | 1.60 | 0.66 | 0.00 | 0.06 | 0.14 |
| 18 | 1.80 | 0.67 | 0.00 | 0.06 | 0.15 |
| 19 | 2.00 | 0.69 | 0.00 | 0.06 | 0.16 |
| 20 | 2.20 | 0.70 | 0.00 | 0.07 | 0.17 |
| 21 | 2.40 | 0.71 | 0.00 | 0.07 | 0.18 |
| 22 | 2.60 | 0.72 | 0.00 | 0.07 | 0.19 |
| 23 | 2.80 | 0.73 | 0.00 | 0.08 | 0.19 |
| 24 | 3.00 | 0.73 | 0.00 | 0.08 | 0.20 |
| 25 | 3.20 | 0.74 | 0.00 | 0.08 | 0.21 |
| 26 | 3.40 | 0.75 | 0.00 | 0.09 | 0.21 |
| 27 | 3.60 | 0.75 | 0.00 | 0.09 | 0.22 |
| 28 | 3.80 | 0.76 | 0.00 | 0.09 | 0.22 |
| 29 | 4.00 | 0.77 | 0.00 | 0.10 | 0.23 |
| 30 | 4.20 | 0.77 | 0.00 | 0.10 | 0.24 |
| 31 | 4.40 | 0.77 | 0.00 | 0.10 | 0.24 |
| 32 | 4.60 | 0.78 | 0.00 | 0.10 | 0.25 |
| 33 | 4.80 | 0.78 | 0.00 | 0.11 | 0.25 |
| 34 | 5.00 | 0.79 | 0.00 | 0.11 | 0.25 |
| 35 | 5.50 | 0.80 | 0.00 | 0.11 | 0.27 |
| 36 | 6.00 | 0.80 | 0.00 | 0.12 | 0.28 |
| 37 | 6.50 | 0.81 | 0.00 | 0.12 | 0.28 |
| 38 | 7.00 | 0.82 | 0.00 | 0.13 | 0.29 |
| 39 | 7.50 | 0.82 | 0.00 | 0.13 | 0.30 |
| 40 | 8.00 | 0.83 | 0.00 | 0.14 | 0.31 |
| 41 | 8.50 | 0.83 | 0.00 | 0.14 | 0.32 |
| 42 | 9.00 | 0.84 | 0.00 | 0.15 | 0.32 |
| 43 | 9.50 | 0.84 | 0.00 | 0.15 | 0.33 |
| 44 | 10.00 | 0.84 | 0.00 | 0.16 | 0.34 |
| 45 | 11.00 | 0.85 | 0.00 | 0.17 | 0.35 |
| 46 | 12.00 | 0.86 | 0.00 | 0.17 | 0.36 |
| 47 | 13.00 | 0.86 | 0.00 | 0.18 | 0.37 |
| 48 | 14.00 | 0.87 | 0.00 | 0.19 | 0.37 |
| 49 | 15.00 | 0.87 | 0.00 | 0.20 | 0.38 |
| 50 | 16.00 | 0.87 | 0.00 | 0.20 | 0.39 |
| 51 | 17.00 | 0.88 | 0.00 | 0.21 | 0.39 |
| 52 | 18.00 | 0.88 | 0.00 | 0.22 | 0.40 |
| 53 | 19.00 | 0.88 | 0.00 | 0.22 | 0.40 |
| 54 | 20.00 | 0.89 | 0.00 | 0.23 | 0.41 |

| | | | | | |
|----|--------|------|------|------|------|
| 55 | 22.00 | 0.89 | 0.01 | 0.24 | 0.42 |
| 56 | 24.00 | 0.90 | 0.01 | 0.26 | 0.42 |
| 57 | 26.00 | 0.90 | 0.02 | 0.27 | 0.43 |
| 58 | 28.00 | 0.90 | 0.02 | 0.28 | 0.43 |
| 59 | 30.00 | 0.91 | 0.03 | 0.29 | 0.43 |
| 60 | 32.00 | 0.91 | 0.03 | 0.30 | 0.43 |
| 61 | 34.00 | 0.91 | 0.04 | 0.31 | 0.43 |
| 62 | 36.00 | 0.91 | 0.05 | 0.32 | 0.43 |
| 63 | 38.00 | 0.92 | 0.06 | 0.33 | 0.43 |
| 64 | 40.00 | 0.92 | 0.07 | 0.34 | 0.43 |
| 65 | 45.00 | 0.92 | 0.09 | 0.36 | 0.42 |
| 66 | 50.00 | 0.93 | 0.11 | 0.38 | 0.42 |
| 67 | 55.00 | 0.93 | 0.13 | 0.40 | 0.41 |
| 68 | 60.00 | 0.93 | 0.16 | 0.42 | 0.40 |
| 69 | 65.00 | 0.93 | 0.18 | 0.44 | 0.39 |
| 70 | 70.00 | 0.94 | 0.21 | 0.46 | 0.38 |
| 71 | 75.00 | 0.94 | 0.23 | 0.48 | 0.36 |
| 72 | 80.00 | 0.94 | 0.26 | 0.50 | 0.35 |
| 73 | 85.00 | 0.94 | 0.28 | 0.51 | 0.34 |
| 74 | 90.00 | 0.95 | 0.30 | 0.53 | 0.33 |
| 75 | 95.00 | 0.95 | 0.32 | 0.54 | 0.32 |
| 76 | 100.00 | 0.95 | 0.35 | 0.56 | 0.31 |
| 77 | 110.00 | 0.95 | 0.39 | 0.59 | 0.29 |
| 78 | 120.00 | 0.96 | 0.43 | 0.61 | 0.27 |
| 79 | 130.00 | 0.96 | 0.46 | 0.64 | 0.26 |
| 80 | 140.00 | 0.96 | 0.50 | 0.66 | 0.24 |
| 81 | 150.00 | 0.96 | 0.53 | 0.68 | 0.23 |
| 82 | 160.00 | 0.97 | 0.56 | 0.70 | 0.21 |
| 83 | 170.00 | 0.97 | 0.59 | 0.72 | 0.20 |
| 84 | 180.00 | 0.97 | 0.61 | 0.74 | 0.19 |
| 85 | 190.00 | 0.97 | 0.64 | 0.75 | 0.17 |
| 86 | 200.00 | 0.97 | 0.66 | 0.77 | 0.16 |
| 87 | 220.00 | 0.98 | 0.70 | 0.80 | 0.14 |
| 88 | 240.00 | 0.98 | 0.74 | 0.82 | 0.13 |
| 89 | 260.00 | 0.98 | 0.77 | 0.84 | 0.11 |
| 90 | 280.00 | 0.98 | 0.80 | 0.86 | 0.10 |
| 91 | 300.00 | 0.99 | 0.82 | 0.88 | 0.08 |
| 92 | 350.00 | 0.99 | 0.87 | 0.91 | 0.06 |
| 93 | 400.00 | 0.99 | 0.91 | 0.94 | 0.04 |
| 94 | 450.00 | 0.99 | 0.94 | 0.96 | 0.03 |
| 95 | 500.00 | 1.00 | 0.96 | 0.97 | 0.02 |

表2. 1(1) 評価断面1の応力テンソル成分1、2

ステップ温度変化の基本解

断面1

| ステップ | 時間(S) | 応力成分1 | | | | 応力成分2 | | | |
|------|-------|---------|---------|---------|---------|---------|--------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.01 | -0.0075 | 0.0000 | -0.0003 | -0.0009 | -0.0337 | 0.0015 | -0.0008 | -0.0062 |
| 3 | 0.04 | -0.0047 | 0.0000 | -0.0006 | -0.0011 | -0.0930 | 0.0103 | -0.0026 | -0.0301 |
| 4 | 0.07 | -0.0016 | 0.0000 | -0.0007 | -0.0009 | -0.0993 | 0.0181 | -0.0031 | -0.0451 |
| 5 | 0.10 | -0.0034 | 0.0000 | -0.0008 | -0.0010 | -0.1181 | 0.0254 | -0.0037 | -0.0577 |
| 6 | 0.20 | -0.0005 | -0.0002 | -0.0010 | -0.0005 | -0.1302 | 0.0450 | -0.0045 | -0.0836 |
| 7 | 0.30 | -0.0023 | -0.0002 | -0.0011 | -0.0005 | -0.1400 | 0.0571 | -0.0048 | -0.0958 |
| 8 | 0.40 | -0.0001 | -0.0004 | -0.0010 | -0.0002 | -0.1345 | 0.0626 | -0.0047 | -0.1003 |
| 9 | 0.50 | -0.0023 | -0.0004 | -0.0011 | -0.0003 | -0.1366 | 0.0642 | -0.0047 | -0.1010 |
| 10 | 0.60 | -0.0001 | -0.0004 | -0.0010 | -0.0001 | -0.1279 | 0.0638 | -0.0045 | -0.0990 |
| 11 | 0.70 | -0.0018 | -0.0004 | -0.0010 | -0.0002 | -0.1271 | 0.0625 | -0.0044 | -0.0965 |
| 12 | 0.80 | 0.0002 | -0.0004 | -0.0009 | -0.0001 | -0.1181 | 0.0606 | -0.0041 | -0.0928 |
| 13 | 0.90 | -0.0014 | -0.0004 | -0.0009 | -0.0002 | -0.1165 | 0.0584 | -0.0040 | -0.0895 |
| 14 | 1.00 | 0.0006 | -0.0004 | -0.0008 | 0.0000 | -0.1080 | 0.0560 | -0.0038 | -0.0855 |
| 15 | 1.20 | -0.0012 | -0.0004 | -0.0008 | -0.0001 | -0.1019 | 0.0513 | -0.0035 | -0.0784 |
| 16 | 1.40 | 0.0004 | -0.0002 | -0.0007 | 0.0000 | -0.0901 | 0.0468 | -0.0032 | -0.0715 |
| 17 | 1.60 | -0.0011 | 0.0000 | -0.0007 | -0.0001 | -0.0848 | 0.0427 | -0.0030 | -0.0654 |
| 18 | 1.80 | 0.0006 | 0.0000 | -0.0006 | 0.0000 | -0.0745 | 0.0389 | -0.0027 | -0.0595 |
| 19 | 2.00 | -0.0009 | 0.0002 | -0.0005 | -0.0001 | -0.0705 | 0.0354 | -0.0025 | -0.0545 |
| 20 | 2.20 | 0.0010 | 0.0002 | -0.0004 | 0.0000 | -0.0614 | 0.0322 | -0.0022 | -0.0495 |
| 21 | 2.40 | -0.0007 | 0.0002 | -0.0004 | -0.0001 | -0.0585 | 0.0295 | -0.0020 | -0.0453 |
| 22 | 2.60 | 0.0009 | 0.0002 | -0.0003 | 0.0001 | -0.0507 | 0.0269 | -0.0018 | -0.0411 |
| 23 | 2.80 | -0.0005 | 0.0002 | -0.0004 | -0.0001 | -0.0487 | 0.0245 | -0.0017 | -0.0377 |
| 24 | 3.00 | 0.0011 | 0.0002 | -0.0003 | 0.0001 | -0.0422 | 0.0225 | -0.0015 | -0.0343 |
| 25 | 3.20 | -0.0003 | 0.0002 | -0.0003 | 0.0000 | -0.0407 | 0.0205 | -0.0014 | -0.0314 |
| 26 | 3.40 | 0.0013 | 0.0004 | -0.0002 | 0.0001 | -0.0346 | 0.0185 | -0.0012 | -0.0285 |
| 27 | 3.60 | 0.0000 | 0.0006 | -0.0002 | 0.0000 | -0.0334 | 0.0168 | -0.0011 | -0.0261 |
| 28 | 3.80 | 0.0015 | 0.0006 | -0.0001 | 0.0001 | -0.0283 | 0.0152 | -0.0010 | -0.0237 |
| 29 | 4.00 | 0.0002 | 0.0006 | -0.0002 | 0.0000 | -0.0276 | 0.0138 | -0.0010 | -0.0218 |
| 30 | 4.20 | 0.0017 | 0.0006 | -0.0001 | 0.0002 | -0.0229 | 0.0128 | -0.0008 | -0.0198 |
| 31 | 4.40 | 0.0002 | 0.0006 | -0.0001 | 0.0001 | -0.0229 | 0.0116 | -0.0008 | -0.0183 |
| 32 | 4.60 | 0.0015 | 0.0006 | -0.0001 | 0.0002 | -0.0188 | 0.0105 | -0.0007 | -0.0165 |
| 33 | 4.80 | 0.0004 | 0.0006 | -0.0001 | 0.0001 | -0.0188 | 0.0097 | -0.0007 | -0.0153 |
| 34 | 5.00 | 0.0019 | 0.0006 | 0.0000 | 0.0003 | -0.0152 | 0.0090 | -0.0006 | -0.0139 |
| 35 | 5.50 | 0.0004 | 0.0006 | -0.0001 | 0.0001 | -0.0135 | 0.0072 | -0.0005 | -0.0112 |
| 36 | 6.00 | 0.0017 | 0.0006 | 0.0000 | 0.0002 | -0.0086 | 0.0059 | -0.0003 | -0.0088 |
| 37 | 6.50 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | -0.0081 | 0.0048 | -0.0003 | -0.0072 |
| 38 | 7.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | -0.0045 | 0.0040 | -0.0001 | -0.0057 |
| 39 | 7.50 | 0.0000 | 0.0005 | 0.0000 | 0.0000 | -0.0051 | 0.0032 | -0.0002 | -0.0047 |
| 40 | 8.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | -0.0019 | 0.0025 | -0.0001 | -0.0036 |
| 41 | 8.50 | 0.0002 | 0.0005 | 0.0000 | 0.0001 | -0.0030 | 0.0021 | -0.0001 | -0.0030 |
| 42 | 9.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | -0.0005 | 0.0016 | 0.0000 | -0.0022 |
| 43 | 9.50 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | -0.0015 | 0.0013 | -0.0001 | -0.0018 |
| 44 | 10.00 | 0.0017 | 0.0005 | 0.0001 | 0.0002 | 0.0009 | 0.0011 | 0.0000 | -0.0013 |
| 45 | 11.00 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | -0.0005 | 0.0009 | 0.0000 | -0.0010 |
| 46 | 12.00 | 0.0017 | 0.0005 | 0.0001 | 0.0002 | 0.0018 | 0.0006 | 0.0000 | -0.0004 |
| 47 | 13.00 | 0.0006 | 0.0005 | 0.0000 | 0.0001 | 0.0005 | 0.0005 | 0.0000 | -0.0003 |
| 48 | 14.00 | 0.0018 | 0.0005 | 0.0001 | 0.0003 | 0.0025 | 0.0004 | 0.0001 | -0.0001 |
| 49 | 15.00 | 0.0006 | 0.0005 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | 0.0000 |
| 50 | 16.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | 0.0023 | 0.0003 | 0.0001 | 0.0001 |
| 51 | 17.00 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | -0.0001 |
| 52 | 18.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | 0.0023 | 0.0003 | 0.0001 | 0.0001 |
| 53 | 19.00 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | -0.0001 |
| 54 | 20.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | 0.0023 | 0.0003 | 0.0001 | 0.0001 |

| | | | | | | | | | |
|----|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| 55 | 22.00 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | -0.0001 |
| 56 | 24.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | 0.0023 | 0.0003 | 0.0001 | 0.0001 |
| 57 | 26.00 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | -0.0001 |
| 58 | 28.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | 0.0023 | 0.0003 | 0.0001 | 0.0001 |
| 59 | 30.00 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | -0.0001 |
| 60 | 32.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | 0.0023 | 0.0003 | 0.0001 | 0.0001 |
| 61 | 34.00 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | -0.0001 |
| 62 | 36.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | 0.0023 | 0.0003 | 0.0001 | 0.0001 |
| 63 | 38.00 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | -0.0001 |
| 64 | 40.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | 0.0023 | 0.0003 | 0.0001 | 0.0001 |
| 65 | 45.00 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | -0.0001 |
| 66 | 50.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | 0.0023 | 0.0003 | 0.0001 | 0.0001 |
| 67 | 55.00 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | -0.0001 |
| 68 | 60.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | 0.0023 | 0.0003 | 0.0001 | 0.0001 |
| 69 | 65.00 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | -0.0001 |
| 70 | 70.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | 0.0023 | 0.0003 | 0.0001 | 0.0001 |
| 71 | 75.00 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | -0.0001 |
| 72 | 80.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | 0.0023 | 0.0003 | 0.0001 | 0.0001 |
| 73 | 85.00 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | -0.0001 |
| 74 | 90.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | 0.0023 | 0.0003 | 0.0001 | 0.0001 |
| 75 | 95.00 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | -0.0001 |
| 76 | 100.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | 0.0023 | 0.0003 | 0.0001 | 0.0001 |
| 77 | 110.00 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | -0.0001 |
| 78 | 120.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | 0.0023 | 0.0003 | 0.0001 | 0.0001 |
| 79 | 130.00 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | -0.0001 |
| 80 | 140.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | 0.0023 | 0.0003 | 0.0001 | 0.0001 |
| 81 | 150.00 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | -0.0001 |
| 82 | 160.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | 0.0023 | 0.0003 | 0.0001 | 0.0001 |
| 83 | 170.00 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | -0.0001 |
| 84 | 180.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | 0.0023 | 0.0003 | 0.0001 | 0.0001 |
| 85 | 190.00 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | -0.0001 |
| 86 | 200.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | 0.0023 | 0.0003 | 0.0001 | 0.0001 |
| 87 | 220.00 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | -0.0001 |
| 88 | 240.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | 0.0023 | 0.0003 | 0.0001 | 0.0001 |
| 89 | 260.00 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | -0.0001 |
| 90 | 280.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | 0.0023 | 0.0003 | 0.0001 | 0.0001 |
| 91 | 300.00 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | -0.0001 |
| 92 | 350.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | 0.0023 | 0.0003 | 0.0001 | 0.0001 |
| 93 | 400.00 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | -0.0001 |
| 94 | 450.00 | 0.0015 | 0.0005 | 0.0001 | 0.0002 | 0.0023 | 0.0003 | 0.0001 | 0.0001 |
| 95 | 500.00 | 0.0004 | 0.0005 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | -0.0001 |

表2. 1(2) 評価断面1の応力テンソル成分3、4

ステップ温度変化の基本解

断面1

| ステップ | 時間(S) | 応力成分3 | | | | 応力成分4 | | | |
|------|-------|---------|--------|---------|---------|--------|--------|--------|--------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.01 | -0.0337 | 0.0015 | -0.0008 | -0.0062 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 3 | 0.04 | -0.0930 | 0.0103 | -0.0024 | -0.0300 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 4 | 0.07 | -0.0993 | 0.0181 | -0.0029 | -0.0450 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 5 | 0.10 | -0.1181 | 0.0254 | -0.0033 | -0.0575 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 6 | 0.20 | -0.1302 | 0.0450 | -0.0039 | -0.0834 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 7 | 0.30 | -0.1400 | 0.0571 | -0.0042 | -0.0957 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 8 | 0.40 | -0.1345 | 0.0626 | -0.0041 | -0.1001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 9 | 0.50 | -0.1366 | 0.0642 | -0.0040 | -0.1008 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 10 | 0.60 | -0.1279 | 0.0638 | -0.0038 | -0.0989 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 11 | 0.70 | -0.1271 | 0.0625 | -0.0038 | -0.0964 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 12 | 0.80 | -0.1181 | 0.0606 | -0.0035 | -0.0927 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 13 | 0.90 | -0.1165 | 0.0584 | -0.0035 | -0.0894 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 14 | 1.00 | -0.1080 | 0.0560 | -0.0032 | -0.0854 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 15 | 1.20 | -0.1019 | 0.0513 | -0.0030 | -0.0783 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 16 | 1.40 | -0.0901 | 0.0468 | -0.0027 | -0.0714 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 17 | 1.60 | -0.0848 | 0.0427 | -0.0025 | -0.0654 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 18 | 1.80 | -0.0745 | 0.0389 | -0.0023 | -0.0595 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 19 | 2.00 | -0.0705 | 0.0354 | -0.0021 | -0.0545 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 20 | 2.20 | -0.0614 | 0.0322 | -0.0019 | -0.0495 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 21 | 2.40 | -0.0585 | 0.0295 | -0.0017 | -0.0453 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 22 | 2.60 | -0.0507 | 0.0269 | -0.0015 | -0.0411 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 23 | 2.80 | -0.0487 | 0.0245 | -0.0015 | -0.0376 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 24 | 3.00 | -0.0422 | 0.0225 | -0.0013 | -0.0343 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 25 | 3.20 | -0.0407 | 0.0205 | -0.0012 | -0.0314 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 26 | 3.40 | -0.0346 | 0.0185 | -0.0010 | -0.0284 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 27 | 3.60 | -0.0334 | 0.0168 | -0.0010 | -0.0261 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 28 | 3.80 | -0.0283 | 0.0152 | -0.0008 | -0.0237 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 29 | 4.00 | -0.0276 | 0.0138 | -0.0008 | -0.0217 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 30 | 4.20 | -0.0229 | 0.0128 | -0.0007 | -0.0198 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 31 | 4.40 | -0.0229 | 0.0116 | -0.0007 | -0.0183 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 32 | 4.60 | -0.0188 | 0.0105 | -0.0006 | -0.0165 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 33 | 4.80 | -0.0188 | 0.0097 | -0.0006 | -0.0153 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 34 | 5.00 | -0.0152 | 0.0090 | -0.0005 | -0.0139 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 35 | 5.50 | -0.0135 | 0.0072 | -0.0004 | -0.0112 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 36 | 6.00 | -0.0086 | 0.0059 | -0.0003 | -0.0088 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 37 | 6.50 | -0.0081 | 0.0048 | -0.0002 | -0.0071 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 38 | 7.00 | -0.0045 | 0.0040 | -0.0001 | -0.0057 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 39 | 7.50 | -0.0051 | 0.0032 | -0.0001 | -0.0047 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 40 | 8.00 | -0.0019 | 0.0025 | 0.0000 | -0.0036 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 41 | 8.50 | -0.0030 | 0.0021 | -0.0001 | -0.0030 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 42 | 9.00 | -0.0005 | 0.0016 | 0.0000 | -0.0022 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 43 | 9.50 | -0.0015 | 0.0013 | 0.0000 | -0.0018 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 44 | 10.00 | 0.0009 | 0.0011 | 0.0000 | -0.0013 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 45 | 11.00 | -0.0005 | 0.0009 | 0.0000 | -0.0010 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 46 | 12.00 | 0.0017 | 0.0006 | 0.0000 | -0.0004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 47 | 13.00 | 0.0005 | 0.0005 | 0.0000 | -0.0003 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 48 | 14.00 | 0.0025 | 0.0004 | 0.0001 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 49 | 15.00 | 0.0008 | 0.0003 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 50 | 16.00 | 0.0023 | 0.0003 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 51 | 17.00 | 0.0008 | 0.0003 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 52 | 18.00 | 0.0023 | 0.0003 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 53 | 19.00 | 0.0008 | 0.0003 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 54 | 20.00 | 0.0023 | 0.0003 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

| | | | | | | | | | |
|----|--------|--------|--------|--------|---------|--------|--------|--------|--------|
| 55 | 22.00 | 0.0008 | 0.0003 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 56 | 24.00 | 0.0023 | 0.0003 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 57 | 26.00 | 0.0008 | 0.0003 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 58 | 28.00 | 0.0023 | 0.0003 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 59 | 30.00 | 0.0008 | 0.0003 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 60 | 32.00 | 0.0023 | 0.0003 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 61 | 34.00 | 0.0008 | 0.0003 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 62 | 36.00 | 0.0023 | 0.0003 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 63 | 38.00 | 0.0008 | 0.0003 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 64 | 40.00 | 0.0023 | 0.0003 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 65 | 45.00 | 0.0008 | 0.0003 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 66 | 50.00 | 0.0023 | 0.0003 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 67 | 55.00 | 0.0008 | 0.0003 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 68 | 60.00 | 0.0023 | 0.0003 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 69 | 65.00 | 0.0008 | 0.0003 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 70 | 70.00 | 0.0023 | 0.0003 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 71 | 75.00 | 0.0008 | 0.0003 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 72 | 80.00 | 0.0023 | 0.0003 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 73 | 85.00 | 0.0008 | 0.0003 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 74 | 90.00 | 0.0023 | 0.0003 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 75 | 95.00 | 0.0008 | 0.0003 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 76 | 100.00 | 0.0023 | 0.0003 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 77 | 110.00 | 0.0008 | 0.0003 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 78 | 120.00 | 0.0023 | 0.0003 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 79 | 130.00 | 0.0008 | 0.0003 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 80 | 140.00 | 0.0023 | 0.0003 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 81 | 150.00 | 0.0008 | 0.0003 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 82 | 160.00 | 0.0023 | 0.0003 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 83 | 170.00 | 0.0008 | 0.0003 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 84 | 180.00 | 0.0023 | 0.0003 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 85 | 190.00 | 0.0008 | 0.0003 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 86 | 200.00 | 0.0023 | 0.0003 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 87 | 220.00 | 0.0008 | 0.0003 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 88 | 240.00 | 0.0023 | 0.0003 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 89 | 260.00 | 0.0008 | 0.0003 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 90 | 280.00 | 0.0023 | 0.0003 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 91 | 300.00 | 0.0008 | 0.0003 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 92 | 350.00 | 0.0023 | 0.0003 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 93 | 400.00 | 0.0008 | 0.0003 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 94 | 450.00 | 0.0023 | 0.0003 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 95 | 500.00 | 0.0008 | 0.0003 | 0.0000 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

表2. 2(1) 評価断面2の応力テンソル成分1、2

ステップ温度変化の基本解

断面2

| ステップ | 時間(S) | 応力成分1 | | | | 応力成分2 | | | |
|------|-------|---------|---------|---------|---------|---------|--------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.01 | -0.0058 | 0.0000 | -0.0005 | -0.0008 | -0.0352 | 0.0024 | -0.0001 | -0.0053 |
| 3 | 0.04 | -0.0021 | -0.0001 | -0.0019 | -0.0017 | -0.1014 | 0.0159 | -0.0006 | -0.0311 |
| 4 | 0.07 | -0.0006 | -0.0001 | -0.0030 | -0.0024 | -0.1159 | 0.0279 | -0.0019 | -0.0520 |
| 5 | 0.10 | -0.0008 | -0.0001 | -0.0038 | -0.0030 | -0.1396 | 0.0391 | -0.0026 | -0.0690 |
| 6 | 0.20 | 0.0008 | -0.0002 | -0.0057 | -0.0038 | -0.1697 | 0.0694 | -0.0037 | -0.1087 |
| 7 | 0.30 | -0.0003 | -0.0002 | -0.0067 | -0.0044 | -0.1918 | 0.0898 | -0.0041 | -0.1314 |
| 8 | 0.40 | 0.0007 | -0.0004 | -0.0071 | -0.0045 | -0.1964 | 0.1017 | -0.0042 | -0.1440 |
| 9 | 0.50 | -0.0006 | -0.0008 | -0.0074 | -0.0048 | -0.2048 | 0.1083 | -0.0042 | -0.1508 |
| 10 | 0.60 | 0.0005 | -0.0008 | -0.0074 | -0.0048 | -0.2018 | 0.1122 | -0.0042 | -0.1538 |
| 11 | 0.70 | -0.0007 | -0.0008 | -0.0075 | -0.0049 | -0.2041 | 0.1138 | -0.0041 | -0.1544 |
| 12 | 0.80 | 0.0003 | -0.0008 | -0.0074 | -0.0048 | -0.1982 | 0.1144 | -0.0040 | -0.1537 |
| 13 | 0.90 | -0.0006 | -0.0008 | -0.0073 | -0.0048 | -0.1981 | 0.1142 | -0.0039 | -0.1522 |
| 14 | 1.00 | 0.0006 | -0.0007 | -0.0071 | -0.0046 | -0.1911 | 0.1133 | -0.0037 | -0.1498 |
| 15 | 1.20 | -0.0004 | -0.0004 | -0.0069 | -0.0046 | -0.1859 | 0.1107 | -0.0035 | -0.1447 |
| 16 | 1.40 | 0.0007 | -0.0004 | -0.0066 | -0.0043 | -0.1746 | 0.1072 | -0.0033 | -0.1388 |
| 17 | 1.60 | -0.0004 | -0.0006 | -0.0063 | -0.0043 | -0.1688 | 0.1033 | -0.0031 | -0.1331 |
| 18 | 1.80 | 0.0008 | -0.0005 | -0.0059 | -0.0040 | -0.1582 | 0.0998 | -0.0028 | -0.1274 |
| 19 | 2.00 | -0.0003 | -0.0005 | -0.0057 | -0.0039 | -0.1532 | 0.0963 | -0.0026 | -0.1219 |
| 20 | 2.20 | 0.0005 | -0.0003 | -0.0054 | -0.0037 | -0.1436 | 0.0931 | -0.0025 | -0.1168 |
| 21 | 2.40 | -0.0006 | -0.0002 | -0.0052 | -0.0036 | -0.1393 | 0.0901 | -0.0023 | -0.1120 |
| 22 | 2.60 | 0.0004 | 0.0002 | -0.0050 | -0.0034 | -0.1306 | 0.0873 | -0.0022 | -0.1073 |
| 23 | 2.80 | -0.0006 | 0.0000 | -0.0048 | -0.0034 | -0.1271 | 0.0839 | -0.0020 | -0.1031 |
| 24 | 3.00 | 0.0004 | 0.0002 | -0.0045 | -0.0031 | -0.1189 | 0.0814 | -0.0019 | -0.0989 |
| 25 | 3.20 | -0.0007 | 0.0002 | -0.0044 | -0.0031 | -0.1159 | 0.0787 | -0.0018 | -0.0951 |
| 26 | 3.40 | 0.0005 | 0.0001 | -0.0042 | -0.0029 | -0.1087 | 0.0761 | -0.0017 | -0.0913 |
| 27 | 3.60 | -0.0006 | 0.0001 | -0.0041 | -0.0029 | -0.1066 | 0.0737 | -0.0016 | -0.0880 |
| 28 | 3.80 | 0.0001 | 0.0001 | -0.0039 | -0.0027 | -0.1003 | 0.0715 | -0.0015 | -0.0848 |
| 29 | 4.00 | -0.0010 | 0.0001 | -0.0038 | -0.0027 | -0.0984 | 0.0691 | -0.0014 | -0.0818 |
| 30 | 4.20 | 0.0001 | 0.0003 | -0.0036 | -0.0025 | -0.0926 | 0.0671 | -0.0013 | -0.0788 |
| 31 | 4.40 | -0.0011 | 0.0003 | -0.0035 | -0.0025 | -0.0909 | 0.0650 | -0.0012 | -0.0760 |
| 32 | 4.60 | -0.0001 | 0.0004 | -0.0033 | -0.0024 | -0.0855 | 0.0634 | -0.0011 | -0.0735 |
| 33 | 4.80 | -0.0009 | 0.0004 | -0.0033 | -0.0024 | -0.0840 | 0.0617 | -0.0011 | -0.0711 |
| 34 | 5.00 | 0.0001 | 0.0004 | -0.0031 | -0.0022 | -0.0791 | 0.0601 | -0.0009 | -0.0688 |
| 35 | 5.50 | -0.0008 | 0.0006 | -0.0029 | -0.0021 | -0.0743 | 0.0560 | -0.0008 | -0.0634 |
| 36 | 6.00 | -0.0001 | 0.0007 | -0.0027 | -0.0019 | -0.0663 | 0.0525 | -0.0007 | -0.0584 |
| 37 | 6.50 | -0.0010 | 0.0009 | -0.0025 | -0.0018 | -0.0628 | 0.0492 | -0.0007 | -0.0541 |
| 38 | 7.00 | 0.0000 | 0.0008 | -0.0023 | -0.0016 | -0.0562 | 0.0462 | -0.0006 | -0.0501 |
| 39 | 7.50 | -0.0011 | 0.0009 | -0.0022 | -0.0015 | -0.0541 | 0.0432 | -0.0006 | -0.0467 |
| 40 | 8.00 | -0.0002 | 0.0009 | -0.0020 | -0.0014 | -0.0488 | 0.0404 | -0.0006 | -0.0433 |
| 41 | 8.50 | -0.0010 | 0.0009 | -0.0019 | -0.0014 | -0.0471 | 0.0379 | -0.0005 | -0.0404 |
| 42 | 9.00 | 0.0002 | 0.0009 | -0.0017 | -0.0012 | -0.0421 | 0.0357 | -0.0004 | -0.0376 |
| 43 | 9.50 | -0.0009 | 0.0009 | -0.0016 | -0.0012 | -0.0407 | 0.0337 | -0.0003 | -0.0352 |
| 44 | 10.00 | -0.0002 | 0.0009 | -0.0015 | -0.0011 | -0.0364 | 0.0318 | -0.0003 | -0.0329 |
| 45 | 11.00 | -0.0012 | 0.0008 | -0.0013 | -0.0010 | -0.0334 | 0.0281 | -0.0003 | -0.0287 |
| 46 | 12.00 | -0.0004 | 0.0008 | -0.0012 | -0.0008 | -0.0277 | 0.0249 | -0.0002 | -0.0250 |
| 47 | 13.00 | -0.0013 | 0.0008 | -0.0010 | -0.0008 | -0.0258 | 0.0220 | -0.0002 | -0.0219 |
| 48 | 14.00 | -0.0004 | 0.0010 | -0.0009 | -0.0006 | -0.0207 | 0.0195 | -0.0001 | -0.0189 |
| 49 | 15.00 | -0.0012 | 0.0008 | -0.0008 | -0.0007 | -0.0195 | 0.0167 | -0.0001 | -0.0164 |
| 50 | 16.00 | -0.0005 | 0.0007 | -0.0007 | -0.0005 | -0.0153 | 0.0145 | 0.0000 | -0.0140 |
| 51 | 17.00 | -0.0015 | 0.0007 | -0.0006 | -0.0005 | -0.0149 | 0.0127 | 0.0000 | -0.0120 |
| 52 | 18.00 | -0.0005 | 0.0007 | -0.0005 | -0.0003 | -0.0111 | 0.0109 | 0.0000 | -0.0100 |
| 53 | 19.00 | -0.0016 | 0.0007 | -0.0005 | -0.0004 | -0.0108 | 0.0094 | 0.0000 | -0.0084 |
| 54 | 20.00 | -0.0006 | 0.0007 | -0.0004 | -0.0002 | -0.0073 | 0.0079 | 0.0000 | -0.0068 |

| | | | | | | | | | |
|----|--------|---------|--------|---------|---------|---------|---------|--------|---------|
| 55 | 22.00 | -0.0017 | 0.0008 | -0.0003 | -0.0003 | -0.0061 | 0.0056 | 0.0000 | -0.0043 |
| 56 | 24.00 | -0.0007 | 0.0007 | -0.0002 | -0.0001 | -0.0019 | 0.0035 | 0.0000 | -0.0020 |
| 57 | 26.00 | -0.0015 | 0.0007 | -0.0002 | -0.0001 | -0.0016 | 0.0018 | 0.0000 | -0.0003 |
| 58 | 28.00 | -0.0006 | 0.0007 | -0.0001 | 0.0000 | 0.0015 | 0.0004 | 0.0001 | 0.0013 |
| 59 | 30.00 | -0.0015 | 0.0007 | -0.0001 | 0.0000 | 0.0014 | -0.0007 | 0.0001 | 0.0024 |
| 60 | 32.00 | -0.0006 | 0.0007 | 0.0000 | 0.0001 | 0.0040 | -0.0017 | 0.0001 | 0.0035 |
| 61 | 34.00 | -0.0015 | 0.0007 | 0.0000 | 0.0001 | 0.0033 | -0.0024 | 0.0001 | 0.0043 |
| 62 | 36.00 | -0.0007 | 0.0007 | 0.0001 | 0.0002 | 0.0055 | -0.0030 | 0.0001 | 0.0050 |
| 63 | 38.00 | -0.0015 | 0.0007 | 0.0000 | 0.0001 | 0.0046 | -0.0035 | 0.0001 | 0.0055 |
| 64 | 40.00 | -0.0007 | 0.0007 | 0.0001 | 0.0002 | 0.0065 | -0.0039 | 0.0001 | 0.0060 |
| 65 | 45.00 | -0.0016 | 0.0007 | 0.0001 | 0.0002 | 0.0059 | -0.0046 | 0.0001 | 0.0067 |
| 66 | 50.00 | -0.0007 | 0.0007 | 0.0001 | 0.0003 | 0.0078 | -0.0050 | 0.0001 | 0.0071 |
| 67 | 55.00 | -0.0016 | 0.0007 | 0.0001 | 0.0002 | 0.0064 | -0.0052 | 0.0001 | 0.0072 |
| 68 | 60.00 | -0.0008 | 0.0007 | 0.0001 | 0.0003 | 0.0080 | -0.0052 | 0.0001 | 0.0073 |
| 69 | 65.00 | -0.0016 | 0.0007 | 0.0001 | 0.0002 | 0.0064 | -0.0051 | 0.0001 | 0.0072 |
| 70 | 70.00 | -0.0008 | 0.0007 | 0.0001 | 0.0003 | 0.0077 | -0.0050 | 0.0001 | 0.0071 |
| 71 | 75.00 | -0.0016 | 0.0007 | 0.0001 | 0.0002 | 0.0061 | -0.0048 | 0.0001 | 0.0069 |
| 72 | 80.00 | -0.0008 | 0.0007 | 0.0001 | 0.0003 | 0.0074 | -0.0047 | 0.0001 | 0.0068 |
| 73 | 85.00 | -0.0016 | 0.0007 | 0.0001 | 0.0002 | 0.0056 | -0.0045 | 0.0001 | 0.0065 |
| 74 | 90.00 | -0.0008 | 0.0007 | 0.0001 | 0.0002 | 0.0069 | -0.0043 | 0.0001 | 0.0064 |
| 75 | 95.00 | -0.0016 | 0.0007 | 0.0001 | 0.0001 | 0.0052 | -0.0041 | 0.0001 | 0.0061 |
| 76 | 100.00 | -0.0008 | 0.0007 | 0.0001 | 0.0002 | 0.0065 | -0.0039 | 0.0001 | 0.0059 |
| 77 | 110.00 | -0.0016 | 0.0007 | 0.0000 | 0.0001 | 0.0045 | -0.0035 | 0.0001 | 0.0055 |
| 78 | 120.00 | -0.0008 | 0.0007 | 0.0001 | 0.0002 | 0.0056 | -0.0032 | 0.0001 | 0.0052 |
| 79 | 130.00 | -0.0016 | 0.0007 | 0.0000 | 0.0001 | 0.0038 | -0.0028 | 0.0001 | 0.0047 |
| 80 | 140.00 | -0.0008 | 0.0007 | 0.0000 | 0.0002 | 0.0049 | -0.0026 | 0.0001 | 0.0045 |
| 81 | 150.00 | -0.0016 | 0.0007 | 0.0000 | 0.0001 | 0.0031 | -0.0023 | 0.0001 | 0.0041 |
| 82 | 160.00 | -0.0008 | 0.0007 | 0.0000 | 0.0001 | 0.0043 | -0.0020 | 0.0001 | 0.0039 |
| 83 | 170.00 | -0.0016 | 0.0007 | 0.0000 | 0.0000 | 0.0025 | -0.0017 | 0.0001 | 0.0035 |
| 84 | 180.00 | -0.0008 | 0.0007 | 0.0000 | 0.0001 | 0.0037 | -0.0015 | 0.0001 | 0.0034 |
| 85 | 190.00 | -0.0016 | 0.0007 | -0.0001 | 0.0000 | 0.0019 | -0.0013 | 0.0001 | 0.0030 |
| 86 | 200.00 | -0.0008 | 0.0007 | 0.0000 | 0.0001 | 0.0032 | -0.0011 | 0.0001 | 0.0029 |
| 87 | 220.00 | -0.0016 | 0.0007 | -0.0001 | 0.0000 | 0.0013 | -0.0007 | 0.0001 | 0.0024 |
| 88 | 240.00 | -0.0008 | 0.0007 | -0.0001 | 0.0001 | 0.0024 | -0.0004 | 0.0001 | 0.0022 |
| 89 | 260.00 | -0.0016 | 0.0007 | -0.0001 | 0.0000 | 0.0006 | -0.0001 | 0.0001 | 0.0018 |
| 90 | 280.00 | -0.0008 | 0.0007 | -0.0001 | 0.0000 | 0.0018 | 0.0001 | 0.0001 | 0.0016 |
| 91 | 300.00 | -0.0016 | 0.0007 | -0.0001 | -0.0001 | 0.0001 | 0.0004 | 0.0001 | 0.0013 |
| 92 | 350.00 | -0.0008 | 0.0007 | -0.0001 | 0.0000 | 0.0011 | 0.0008 | 0.0001 | 0.0009 |
| 93 | 400.00 | -0.0016 | 0.0007 | -0.0002 | -0.0001 | -0.0008 | 0.0011 | 0.0000 | 0.0004 |
| 94 | 450.00 | -0.0008 | 0.0007 | -0.0001 | 0.0000 | 0.0005 | 0.0013 | 0.0001 | 0.0003 |
| 95 | 500.00 | -0.0016 | 0.0007 | -0.0002 | -0.0001 | -0.0012 | 0.0015 | 0.0000 | 0.0000 |

表2. 2(2) 評価断面2の応力テンソル成分3、4

ステップ温度変化の基本解

断面2

| ステップ | 時間(S) | 応力成分3 | | | | 応力成分4 | | | |
|------|-------|---------|--------|--------|---------|--------|---------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.01 | -0.0340 | 0.0020 | 0.0000 | -0.0047 | 0.0006 | 0.0000 | 0.0000 | 0.0001 |
| 3 | 0.04 | -0.0927 | 0.0130 | 0.0003 | -0.0270 | 0.0017 | -0.0001 | -0.0002 | 0.0005 |
| 4 | 0.07 | -0.1005 | 0.0228 | 0.0000 | -0.0443 | 0.0019 | -0.0002 | -0.0004 | 0.0006 |
| 5 | 0.10 | -0.1181 | 0.0321 | 0.0002 | -0.0579 | 0.0021 | -0.0003 | -0.0006 | 0.0007 |
| 6 | 0.20 | -0.1323 | 0.0570 | 0.0021 | -0.0880 | 0.0021 | -0.0005 | -0.0013 | 0.0009 |
| 7 | 0.30 | -0.1425 | 0.0733 | 0.0044 | -0.1032 | 0.0021 | -0.0007 | -0.0019 | 0.0009 |
| 8 | 0.40 | -0.1385 | 0.0823 | 0.0065 | -0.1103 | 0.0019 | -0.0008 | -0.0023 | 0.0008 |
| 9 | 0.50 | -0.1405 | 0.0869 | 0.0084 | -0.1130 | 0.0019 | -0.0008 | -0.0026 | 0.0007 |
| 10 | 0.60 | -0.1328 | 0.0895 | 0.0099 | -0.1130 | 0.0017 | -0.0009 | -0.0029 | 0.0006 |
| 11 | 0.70 | -0.1320 | 0.0901 | 0.0110 | -0.1115 | 0.0018 | -0.0009 | -0.0031 | 0.0005 |
| 12 | 0.80 | -0.1238 | 0.0901 | 0.0120 | -0.1092 | 0.0016 | -0.0009 | -0.0033 | 0.0004 |
| 13 | 0.90 | -0.1223 | 0.0895 | 0.0127 | -0.1067 | 0.0016 | -0.0009 | -0.0034 | 0.0003 |
| 14 | 1.00 | -0.1147 | 0.0884 | 0.0134 | -0.1038 | 0.0015 | -0.0008 | -0.0035 | 0.0002 |
| 15 | 1.20 | -0.1087 | 0.0856 | 0.0141 | -0.0979 | 0.0015 | -0.0008 | -0.0036 | 0.0001 |
| 16 | 1.40 | -0.0977 | 0.0820 | 0.0144 | -0.0918 | 0.0013 | -0.0008 | -0.0036 | 0.0001 |
| 17 | 1.60 | -0.0930 | 0.0779 | 0.0144 | -0.0863 | 0.0014 | -0.0007 | -0.0036 | 0.0000 |
| 18 | 1.80 | -0.0837 | 0.0743 | 0.0143 | -0.0810 | 0.0012 | -0.0007 | -0.0036 | -0.0001 |
| 19 | 2.00 | -0.0802 | 0.0706 | 0.0140 | -0.0760 | 0.0011 | -0.0007 | -0.0036 | -0.0002 |
| 20 | 2.20 | -0.0722 | 0.0673 | 0.0135 | -0.0713 | 0.0010 | -0.0006 | -0.0035 | -0.0002 |
| 21 | 2.40 | -0.0697 | 0.0641 | 0.0130 | -0.0671 | 0.0010 | -0.0006 | -0.0034 | -0.0002 |
| 22 | 2.60 | -0.0626 | 0.0612 | 0.0125 | -0.0631 | 0.0009 | -0.0006 | -0.0034 | -0.0002 |
| 23 | 2.80 | -0.0608 | 0.0578 | 0.0121 | -0.0595 | 0.0009 | -0.0006 | -0.0033 | -0.0002 |
| 24 | 3.00 | -0.0544 | 0.0551 | 0.0116 | -0.0560 | 0.0007 | -0.0005 | -0.0032 | -0.0003 |
| 25 | 3.20 | -0.0532 | 0.0524 | 0.0110 | -0.0529 | 0.0007 | -0.0005 | -0.0032 | -0.0003 |
| 26 | 3.40 | -0.0476 | 0.0498 | 0.0105 | -0.0498 | 0.0006 | -0.0005 | -0.0031 | -0.0003 |
| 27 | 3.60 | -0.0469 | 0.0474 | 0.0100 | -0.0472 | 0.0007 | -0.0005 | -0.0030 | -0.0003 |
| 28 | 3.80 | -0.0421 | 0.0453 | 0.0096 | -0.0446 | 0.0006 | -0.0005 | -0.0030 | -0.0003 |
| 29 | 4.00 | -0.0417 | 0.0430 | 0.0091 | -0.0423 | 0.0007 | -0.0005 | -0.0029 | -0.0003 |
| 30 | 4.20 | -0.0374 | 0.0411 | 0.0087 | -0.0401 | 0.0006 | -0.0004 | -0.0028 | -0.0003 |
| 31 | 4.40 | -0.0371 | 0.0392 | 0.0083 | -0.0380 | 0.0006 | -0.0004 | -0.0027 | -0.0004 |
| 32 | 4.60 | -0.0330 | 0.0377 | 0.0080 | -0.0361 | 0.0005 | -0.0004 | -0.0027 | -0.0004 |
| 33 | 4.80 | -0.0330 | 0.0363 | 0.0076 | -0.0345 | 0.0006 | -0.0004 | -0.0026 | -0.0004 |
| 34 | 5.00 | -0.0293 | 0.0349 | 0.0074 | -0.0328 | 0.0005 | -0.0004 | -0.0026 | -0.0004 |
| 35 | 5.50 | -0.0274 | 0.0315 | 0.0066 | -0.0291 | 0.0005 | -0.0003 | -0.0024 | -0.0005 |
| 36 | 6.00 | -0.0222 | 0.0287 | 0.0060 | -0.0257 | 0.0004 | -0.0003 | -0.0023 | -0.0005 |
| 37 | 6.50 | -0.0213 | 0.0262 | 0.0054 | -0.0229 | 0.0004 | -0.0003 | -0.0022 | -0.0005 |
| 38 | 7.00 | -0.0171 | 0.0242 | 0.0050 | -0.0206 | 0.0004 | -0.0002 | -0.0021 | -0.0005 |
| 39 | 7.50 | -0.0171 | 0.0222 | 0.0046 | -0.0187 | 0.0004 | -0.0002 | -0.0020 | -0.0005 |
| 40 | 8.00 | -0.0138 | 0.0204 | 0.0043 | -0.0167 | 0.0004 | -0.0002 | -0.0018 | -0.0005 |
| 41 | 8.50 | -0.0141 | 0.0189 | 0.0040 | -0.0153 | 0.0004 | -0.0002 | -0.0017 | -0.0004 |
| 42 | 9.00 | -0.0111 | 0.0178 | 0.0039 | -0.0139 | 0.0004 | -0.0002 | -0.0017 | -0.0004 |
| 43 | 9.50 | -0.0115 | 0.0167 | 0.0037 | -0.0129 | 0.0004 | -0.0002 | -0.0016 | -0.0005 |
| 44 | 10.00 | -0.0089 | 0.0158 | 0.0035 | -0.0118 | 0.0004 | -0.0001 | -0.0015 | -0.0005 |
| 45 | 11.00 | -0.0092 | 0.0138 | 0.0030 | -0.0100 | 0.0004 | -0.0001 | -0.0013 | -0.0005 |
| 46 | 12.00 | -0.0062 | 0.0123 | 0.0027 | -0.0085 | 0.0004 | -0.0001 | -0.0012 | -0.0004 |
| 47 | 13.00 | -0.0070 | 0.0109 | 0.0023 | -0.0075 | 0.0004 | -0.0001 | -0.0011 | -0.0004 |
| 48 | 14.00 | -0.0043 | 0.0098 | 0.0020 | -0.0063 | 0.0004 | 0.0000 | -0.0009 | -0.0004 |
| 49 | 15.00 | -0.0053 | 0.0082 | 0.0017 | -0.0055 | 0.0004 | 0.0000 | -0.0008 | -0.0004 |
| 50 | 16.00 | -0.0031 | 0.0072 | 0.0015 | -0.0045 | 0.0004 | 0.0000 | -0.0007 | -0.0004 |
| 51 | 17.00 | -0.0046 | 0.0062 | 0.0011 | -0.0039 | 0.0004 | 0.0000 | -0.0006 | -0.0004 |
| 52 | 18.00 | -0.0025 | 0.0051 | 0.0007 | -0.0031 | 0.0004 | 0.0000 | -0.0005 | -0.0003 |
| 53 | 19.00 | -0.0039 | 0.0045 | 0.0004 | -0.0027 | 0.0004 | 0.0000 | -0.0004 | -0.0003 |
| 54 | 20.00 | -0.0020 | 0.0038 | 0.0001 | -0.0022 | 0.0004 | 0.0000 | -0.0003 | -0.0003 |

| | | | | | | | | | |
|----|--------|---------|---------|---------|---------|--------|--------|---------|---------|
| 55 | 22.00 | -0.0033 | 0.0026 | -0.0004 | -0.0016 | 0.0005 | 0.0001 | -0.0002 | -0.0003 |
| 56 | 24.00 | -0.0014 | 0.0015 | -0.0008 | -0.0009 | 0.0005 | 0.0001 | -0.0001 | -0.0002 |
| 57 | 26.00 | -0.0029 | 0.0006 | -0.0013 | -0.0004 | 0.0005 | 0.0001 | 0.0000 | -0.0002 |
| 58 | 28.00 | -0.0013 | -0.0003 | -0.0016 | 0.0001 | 0.0005 | 0.0001 | 0.0001 | -0.0002 |
| 59 | 30.00 | -0.0027 | -0.0009 | -0.0020 | 0.0005 | 0.0005 | 0.0001 | 0.0002 | -0.0002 |
| 60 | 32.00 | -0.0012 | -0.0016 | -0.0023 | 0.0008 | 0.0005 | 0.0001 | 0.0002 | -0.0001 |
| 61 | 34.00 | -0.0027 | -0.0021 | -0.0026 | 0.0010 | 0.0005 | 0.0001 | 0.0003 | -0.0001 |
| 62 | 36.00 | -0.0013 | -0.0025 | -0.0028 | 0.0013 | 0.0005 | 0.0001 | 0.0003 | -0.0001 |
| 63 | 38.00 | -0.0028 | -0.0028 | -0.0030 | 0.0014 | 0.0005 | 0.0001 | 0.0004 | -0.0001 |
| 64 | 40.00 | -0.0014 | -0.0032 | -0.0032 | 0.0016 | 0.0005 | 0.0001 | 0.0004 | -0.0001 |
| 65 | 45.00 | -0.0030 | -0.0037 | -0.0036 | 0.0018 | 0.0005 | 0.0001 | 0.0005 | -0.0001 |
| 66 | 50.00 | -0.0017 | -0.0041 | -0.0038 | 0.0020 | 0.0005 | 0.0001 | 0.0005 | -0.0001 |
| 67 | 55.00 | -0.0033 | -0.0043 | -0.0040 | 0.0020 | 0.0005 | 0.0001 | 0.0005 | -0.0001 |
| 68 | 60.00 | -0.0019 | -0.0044 | -0.0041 | 0.0020 | 0.0005 | 0.0001 | 0.0005 | -0.0001 |
| 69 | 65.00 | -0.0035 | -0.0045 | -0.0041 | 0.0019 | 0.0005 | 0.0001 | 0.0005 | -0.0001 |
| 70 | 70.00 | -0.0020 | -0.0045 | -0.0041 | 0.0020 | 0.0005 | 0.0001 | 0.0005 | -0.0001 |
| 71 | 75.00 | -0.0036 | -0.0044 | -0.0041 | 0.0018 | 0.0005 | 0.0001 | 0.0005 | -0.0001 |
| 72 | 80.00 | -0.0022 | -0.0043 | -0.0041 | 0.0018 | 0.0005 | 0.0001 | 0.0005 | -0.0001 |
| 73 | 85.00 | -0.0037 | -0.0042 | -0.0041 | 0.0017 | 0.0005 | 0.0001 | 0.0005 | -0.0001 |
| 74 | 90.00 | -0.0022 | -0.0041 | -0.0041 | 0.0017 | 0.0005 | 0.0001 | 0.0005 | -0.0001 |
| 75 | 95.00 | -0.0037 | -0.0040 | -0.0040 | 0.0016 | 0.0005 | 0.0001 | 0.0005 | -0.0001 |
| 76 | 100.00 | -0.0022 | -0.0039 | -0.0039 | 0.0016 | 0.0005 | 0.0001 | 0.0005 | -0.0001 |
| 77 | 110.00 | -0.0037 | -0.0036 | -0.0038 | 0.0014 | 0.0005 | 0.0001 | 0.0004 | -0.0001 |
| 78 | 120.00 | -0.0021 | -0.0034 | -0.0036 | 0.0013 | 0.0005 | 0.0001 | 0.0004 | -0.0001 |
| 79 | 130.00 | -0.0036 | -0.0031 | -0.0035 | 0.0012 | 0.0005 | 0.0001 | 0.0004 | -0.0001 |
| 80 | 140.00 | -0.0020 | -0.0029 | -0.0033 | 0.0011 | 0.0005 | 0.0001 | 0.0004 | -0.0001 |
| 81 | 150.00 | -0.0035 | -0.0026 | -0.0032 | 0.0010 | 0.0005 | 0.0001 | 0.0003 | -0.0001 |
| 82 | 160.00 | -0.0019 | -0.0024 | -0.0030 | 0.0009 | 0.0005 | 0.0001 | 0.0003 | -0.0001 |
| 83 | 170.00 | -0.0033 | -0.0021 | -0.0028 | 0.0008 | 0.0005 | 0.0001 | 0.0003 | -0.0001 |
| 84 | 180.00 | -0.0018 | -0.0019 | -0.0027 | 0.0008 | 0.0005 | 0.0001 | 0.0003 | -0.0001 |
| 85 | 190.00 | -0.0032 | -0.0017 | -0.0026 | 0.0006 | 0.0005 | 0.0001 | 0.0002 | -0.0001 |
| 86 | 200.00 | -0.0016 | -0.0015 | -0.0024 | 0.0006 | 0.0005 | 0.0001 | 0.0002 | -0.0001 |
| 87 | 220.00 | -0.0030 | -0.0011 | -0.0022 | 0.0005 | 0.0005 | 0.0001 | 0.0002 | -0.0001 |
| 88 | 240.00 | -0.0014 | -0.0009 | -0.0020 | 0.0004 | 0.0005 | 0.0001 | 0.0002 | -0.0002 |
| 89 | 260.00 | -0.0028 | -0.0005 | -0.0018 | 0.0003 | 0.0005 | 0.0001 | 0.0001 | -0.0002 |
| 90 | 280.00 | -0.0012 | -0.0003 | -0.0016 | 0.0002 | 0.0005 | 0.0001 | 0.0001 | -0.0002 |
| 91 | 300.00 | -0.0026 | 0.0000 | -0.0014 | 0.0001 | 0.0005 | 0.0001 | 0.0001 | -0.0002 |
| 92 | 350.00 | -0.0009 | 0.0004 | -0.0011 | 0.0000 | 0.0005 | 0.0001 | 0.0001 | -0.0002 |
| 93 | 400.00 | -0.0022 | 0.0008 | -0.0009 | -0.0001 | 0.0005 | 0.0001 | 0.0000 | -0.0002 |
| 94 | 450.00 | -0.0006 | 0.0010 | -0.0007 | -0.0001 | 0.0005 | 0.0001 | 0.0000 | -0.0002 |
| 95 | 500.00 | -0.0020 | 0.0012 | -0.0005 | -0.0003 | 0.0005 | 0.0001 | 0.0000 | -0.0002 |

表2. 3 (1) 評価断面3の応力テンソル成分1、2

ステップ温度変化の基本解

断面3

| ステップ | 時間(S) | 応力成分1 | | | | 応力成分2 | | | |
|------|-------|---------|---------|---------|---------|---------|--------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.01 | -0.0072 | 0.0000 | -0.0001 | -0.0004 | -0.0343 | 0.0016 | -0.0001 | -0.0040 |
| 3 | 0.04 | -0.0039 | -0.0001 | 0.0006 | -0.0001 | -0.0947 | 0.0104 | 0.0002 | -0.0220 |
| 4 | 0.07 | -0.0011 | -0.0002 | 0.0013 | 0.0001 | -0.1023 | 0.0183 | 0.0004 | -0.0358 |
| 5 | 0.10 | -0.0026 | -0.0003 | 0.0018 | 0.0001 | -0.1219 | 0.0258 | 0.0006 | -0.0478 |
| 6 | 0.20 | 0.0004 | -0.0004 | 0.0032 | 0.0002 | -0.1382 | 0.0488 | 0.0012 | -0.0775 |
| 7 | 0.30 | -0.0012 | -0.0007 | 0.0041 | 0.0000 | -0.1522 | 0.0675 | 0.0015 | -0.0969 |
| 8 | 0.40 | 0.0009 | -0.0010 | 0.0047 | -0.0001 | -0.1515 | 0.0815 | 0.0017 | -0.1094 |
| 9 | 0.50 | -0.0009 | -0.0010 | 0.0051 | -0.0003 | -0.1583 | 0.0919 | 0.0017 | -0.1179 |
| 10 | 0.60 | 0.0011 | -0.0011 | 0.0055 | -0.0004 | -0.1545 | 0.0989 | 0.0018 | -0.1231 |
| 11 | 0.70 | -0.0008 | -0.0012 | 0.0056 | -0.0005 | -0.1584 | 0.1039 | 0.0017 | -0.1264 |
| 12 | 0.80 | 0.0011 | -0.0013 | 0.0057 | -0.0005 | -0.1535 | 0.1072 | 0.0017 | -0.1282 |
| 13 | 0.90 | -0.0006 | -0.0013 | 0.0058 | -0.0007 | -0.1555 | 0.1094 | 0.0017 | -0.1290 |
| 14 | 1.00 | 0.0010 | -0.0013 | 0.0058 | -0.0006 | -0.1503 | 0.1109 | 0.0016 | -0.1290 |
| 15 | 1.20 | -0.0008 | -0.0013 | 0.0057 | -0.0008 | -0.1493 | 0.1117 | 0.0014 | -0.1276 |
| 16 | 1.40 | 0.0007 | -0.0011 | 0.0056 | -0.0008 | -0.1414 | 0.1111 | 0.0013 | -0.1249 |
| 17 | 1.60 | -0.0011 | -0.0012 | 0.0054 | -0.0009 | -0.1396 | 0.1096 | 0.0011 | -0.1217 |
| 18 | 1.80 | 0.0003 | -0.0010 | 0.0053 | -0.0008 | -0.1315 | 0.1076 | 0.0010 | -0.1180 |
| 19 | 2.00 | -0.0017 | -0.0011 | 0.0051 | -0.0009 | -0.1295 | 0.1052 | 0.0009 | -0.1144 |
| 20 | 2.20 | -0.0001 | -0.0010 | 0.0049 | -0.0008 | -0.1217 | 0.1026 | 0.0008 | -0.1104 |
| 21 | 2.40 | -0.0017 | -0.0009 | 0.0047 | -0.0009 | -0.1195 | 0.1000 | 0.0007 | -0.1068 |
| 22 | 2.60 | -0.0004 | -0.0008 | 0.0046 | -0.0009 | -0.1124 | 0.0973 | 0.0006 | -0.1031 |
| 23 | 2.80 | -0.0019 | -0.0007 | 0.0044 | -0.0010 | -0.1105 | 0.0947 | 0.0005 | -0.0997 |
| 24 | 3.00 | -0.0004 | -0.0006 | 0.0043 | -0.0009 | -0.1038 | 0.0921 | 0.0005 | -0.0962 |
| 25 | 3.20 | -0.0019 | -0.0005 | 0.0041 | -0.0010 | -0.1024 | 0.0895 | 0.0004 | -0.0931 |
| 26 | 3.40 | -0.0002 | -0.0005 | 0.0040 | -0.0009 | -0.0961 | 0.0869 | 0.0004 | -0.0899 |
| 27 | 3.60 | -0.0017 | -0.0004 | 0.0039 | -0.0010 | -0.0948 | 0.0847 | 0.0003 | -0.0870 |
| 28 | 3.80 | -0.0003 | -0.0006 | 0.0038 | -0.0009 | -0.0891 | 0.0820 | 0.0003 | -0.0840 |
| 29 | 4.00 | -0.0017 | -0.0006 | 0.0036 | -0.0009 | -0.0879 | 0.0798 | 0.0002 | -0.0814 |
| 30 | 4.20 | -0.0003 | -0.0004 | 0.0035 | -0.0009 | -0.0828 | 0.0775 | 0.0002 | -0.0787 |
| 31 | 4.40 | -0.0016 | -0.0004 | 0.0033 | -0.0010 | -0.0819 | 0.0756 | 0.0001 | -0.0763 |
| 32 | 4.60 | -0.0004 | -0.0004 | 0.0033 | -0.0009 | -0.0771 | 0.0736 | 0.0001 | -0.0738 |
| 33 | 4.80 | -0.0015 | -0.0004 | 0.0032 | -0.0009 | -0.0763 | 0.0717 | 0.0001 | -0.0716 |
| 34 | 5.00 | -0.0003 | -0.0004 | 0.0031 | -0.0008 | -0.0717 | 0.0699 | 0.0001 | -0.0694 |
| 35 | 5.50 | -0.0013 | -0.0003 | 0.0028 | -0.0008 | -0.0677 | 0.0656 | 0.0000 | -0.0645 |
| 36 | 6.00 | -0.0002 | -0.0002 | 0.0026 | -0.0007 | -0.0608 | 0.0615 | -0.0001 | -0.0599 |
| 37 | 6.50 | -0.0014 | -0.0001 | 0.0024 | -0.0007 | -0.0581 | 0.0578 | -0.0001 | -0.0559 |
| 38 | 7.00 | -0.0001 | -0.0001 | 0.0023 | -0.0006 | -0.0520 | 0.0543 | -0.0001 | -0.0521 |
| 39 | 7.50 | -0.0013 | 0.0000 | 0.0021 | -0.0007 | -0.0501 | 0.0511 | -0.0002 | -0.0488 |
| 40 | 8.00 | 0.0001 | 0.0002 | 0.0020 | -0.0006 | -0.0448 | 0.0481 | -0.0002 | -0.0456 |
| 41 | 8.50 | -0.0009 | 0.0003 | 0.0018 | -0.0006 | -0.0435 | 0.0454 | -0.0002 | -0.0428 |
| 42 | 9.00 | 0.0002 | 0.0004 | 0.0018 | -0.0005 | -0.0389 | 0.0427 | -0.0002 | -0.0401 |
| 43 | 9.50 | -0.0008 | 0.0006 | 0.0016 | -0.0006 | -0.0382 | 0.0402 | -0.0002 | -0.0377 |
| 44 | 10.00 | 0.0004 | 0.0005 | 0.0015 | -0.0004 | -0.0341 | 0.0378 | -0.0002 | -0.0353 |
| 45 | 11.00 | -0.0007 | 0.0005 | 0.0013 | -0.0004 | -0.0314 | 0.0335 | -0.0002 | -0.0311 |
| 46 | 12.00 | 0.0005 | 0.0007 | 0.0011 | -0.0003 | -0.0257 | 0.0294 | -0.0002 | -0.0272 |
| 47 | 13.00 | -0.0005 | 0.0008 | 0.0010 | -0.0003 | -0.0239 | 0.0257 | -0.0002 | -0.0238 |
| 48 | 14.00 | 0.0006 | 0.0008 | 0.0009 | -0.0002 | -0.0191 | 0.0224 | -0.0002 | -0.0206 |
| 49 | 15.00 | -0.0004 | 0.0008 | 0.0007 | -0.0003 | -0.0181 | 0.0192 | -0.0002 | -0.0178 |
| 50 | 16.00 | 0.0009 | 0.0009 | 0.0006 | -0.0001 | -0.0137 | 0.0164 | -0.0001 | -0.0151 |
| 51 | 17.00 | -0.0001 | 0.0009 | 0.0005 | -0.0002 | -0.0131 | 0.0137 | -0.0001 | -0.0128 |
| 52 | 18.00 | 0.0009 | 0.0009 | 0.0004 | -0.0001 | -0.0095 | 0.0114 | -0.0001 | -0.0106 |
| 53 | 19.00 | -0.0001 | 0.0010 | 0.0004 | -0.0001 | -0.0092 | 0.0091 | -0.0001 | -0.0086 |
| 54 | 20.00 | 0.0012 | 0.0010 | 0.0003 | 0.0000 | -0.0056 | 0.0071 | 0.0000 | -0.0067 |

| | | | | | | | | | |
|----|--------|--------|--------|---------|---------|---------|---------|--------|---------|
| 55 | 22.00 | 0.0003 | 0.0011 | 0.0002 | -0.0001 | -0.0041 | 0.0037 | 0.0000 | -0.0036 |
| 56 | 24.00 | 0.0016 | 0.0011 | 0.0001 | 0.0000 | 0.0004 | 0.0006 | 0.0001 | -0.0008 |
| 57 | 26.00 | 0.0004 | 0.0011 | 0.0000 | 0.0000 | 0.0009 | -0.0020 | 0.0001 | 0.0014 |
| 58 | 28.00 | 0.0016 | 0.0011 | -0.0001 | 0.0001 | 0.0047 | -0.0041 | 0.0002 | 0.0034 |
| 59 | 30.00 | 0.0006 | 0.0011 | -0.0002 | 0.0001 | 0.0048 | -0.0058 | 0.0002 | 0.0050 |
| 60 | 32.00 | 0.0016 | 0.0011 | -0.0002 | 0.0001 | 0.0077 | -0.0075 | 0.0002 | 0.0065 |
| 61 | 34.00 | 0.0005 | 0.0011 | -0.0002 | 0.0000 | 0.0072 | -0.0088 | 0.0002 | 0.0076 |
| 62 | 36.00 | 0.0015 | 0.0011 | -0.0003 | 0.0001 | 0.0096 | -0.0100 | 0.0002 | 0.0085 |
| 63 | 38.00 | 0.0003 | 0.0012 | -0.0003 | 0.0001 | 0.0088 | -0.0110 | 0.0002 | 0.0093 |
| 64 | 40.00 | 0.0013 | 0.0012 | -0.0004 | 0.0001 | 0.0109 | -0.0117 | 0.0002 | 0.0100 |
| 65 | 45.00 | 0.0002 | 0.0012 | -0.0004 | 0.0000 | 0.0105 | -0.0131 | 0.0002 | 0.0111 |
| 66 | 50.00 | 0.0012 | 0.0012 | -0.0004 | 0.0001 | 0.0127 | -0.0139 | 0.0003 | 0.0119 |
| 67 | 55.00 | 0.0001 | 0.0012 | -0.0005 | 0.0000 | 0.0116 | -0.0144 | 0.0002 | 0.0122 |
| 68 | 60.00 | 0.0012 | 0.0012 | -0.0005 | 0.0001 | 0.0133 | -0.0146 | 0.0003 | 0.0125 |
| 69 | 65.00 | 0.0001 | 0.0012 | -0.0005 | 0.0000 | 0.0118 | -0.0146 | 0.0003 | 0.0124 |
| 70 | 70.00 | 0.0012 | 0.0012 | -0.0005 | 0.0001 | 0.0132 | -0.0145 | 0.0003 | 0.0124 |
| 71 | 75.00 | 0.0001 | 0.0012 | -0.0005 | 0.0000 | 0.0115 | -0.0143 | 0.0002 | 0.0122 |
| 72 | 80.00 | 0.0012 | 0.0012 | -0.0005 | 0.0001 | 0.0129 | -0.0141 | 0.0003 | 0.0121 |
| 73 | 85.00 | 0.0001 | 0.0012 | -0.0005 | 0.0000 | 0.0111 | -0.0138 | 0.0002 | 0.0117 |
| 74 | 90.00 | 0.0012 | 0.0012 | -0.0004 | 0.0001 | 0.0124 | -0.0135 | 0.0003 | 0.0116 |
| 75 | 95.00 | 0.0001 | 0.0012 | -0.0005 | 0.0000 | 0.0106 | -0.0132 | 0.0002 | 0.0112 |
| 76 | 100.00 | 0.0012 | 0.0012 | -0.0004 | 0.0001 | 0.0118 | -0.0129 | 0.0002 | 0.0110 |
| 77 | 110.00 | 0.0001 | 0.0012 | -0.0004 | 0.0000 | 0.0097 | -0.0123 | 0.0002 | 0.0103 |
| 78 | 120.00 | 0.0012 | 0.0012 | -0.0004 | 0.0001 | 0.0107 | -0.0116 | 0.0002 | 0.0098 |
| 79 | 130.00 | 0.0001 | 0.0012 | -0.0004 | 0.0000 | 0.0087 | -0.0110 | 0.0002 | 0.0092 |
| 80 | 140.00 | 0.0012 | 0.0012 | -0.0003 | 0.0001 | 0.0097 | -0.0104 | 0.0002 | 0.0087 |
| 81 | 150.00 | 0.0000 | 0.0012 | -0.0003 | 0.0000 | 0.0076 | -0.0099 | 0.0002 | 0.0081 |
| 82 | 160.00 | 0.0011 | 0.0012 | -0.0003 | 0.0001 | 0.0087 | -0.0093 | 0.0002 | 0.0077 |
| 83 | 170.00 | 0.0000 | 0.0012 | -0.0003 | 0.0000 | 0.0067 | -0.0088 | 0.0001 | 0.0072 |
| 84 | 180.00 | 0.0011 | 0.0012 | -0.0003 | 0.0000 | 0.0078 | -0.0083 | 0.0001 | 0.0068 |
| 85 | 190.00 | 0.0000 | 0.0012 | -0.0003 | 0.0000 | 0.0058 | -0.0078 | 0.0001 | 0.0063 |
| 86 | 200.00 | 0.0011 | 0.0012 | -0.0002 | 0.0000 | 0.0070 | -0.0074 | 0.0001 | 0.0060 |
| 87 | 220.00 | 0.0000 | 0.0012 | -0.0002 | -0.0001 | 0.0048 | -0.0066 | 0.0001 | 0.0052 |
| 88 | 240.00 | 0.0011 | 0.0012 | -0.0002 | 0.0000 | 0.0057 | -0.0059 | 0.0001 | 0.0046 |
| 89 | 260.00 | 0.0000 | 0.0012 | -0.0002 | -0.0001 | 0.0036 | -0.0052 | 0.0001 | 0.0040 |
| 90 | 280.00 | 0.0011 | 0.0011 | -0.0001 | 0.0000 | 0.0046 | -0.0047 | 0.0001 | 0.0036 |
| 91 | 300.00 | 0.0000 | 0.0011 | -0.0001 | -0.0001 | 0.0026 | -0.0042 | 0.0000 | 0.0030 |
| 92 | 350.00 | 0.0011 | 0.0011 | -0.0001 | 0.0000 | 0.0033 | -0.0032 | 0.0000 | 0.0022 |
| 93 | 400.00 | 0.0000 | 0.0011 | -0.0001 | -0.0001 | 0.0011 | -0.0024 | 0.0000 | 0.0014 |
| 94 | 450.00 | 0.0011 | 0.0011 | 0.0000 | 0.0000 | 0.0022 | -0.0019 | 0.0000 | 0.0010 |
| 95 | 500.00 | 0.0000 | 0.0011 | 0.0000 | -0.0001 | 0.0003 | -0.0015 | 0.0000 | 0.0006 |

表2. 3(2) 評価断面3の応力テンソル成分3、4

ステップ温度変化の基本解

断面3

| ステップ | 時間(S) | 応力成分3 | | | | 応力成分4 | | | |
|------|-------|---------|--------|---------|---------|--------|---------|---------|--------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.01 | -0.0342 | 0.0015 | 0.0001 | -0.0038 | 0.0003 | 0.0000 | 0.0000 | 0.0001 |
| 3 | 0.04 | -0.0944 | 0.0098 | 0.0015 | -0.0211 | 0.0008 | -0.0002 | -0.0003 | 0.0004 |
| 4 | 0.07 | -0.1018 | 0.0173 | 0.0027 | -0.0344 | 0.0007 | -0.0004 | -0.0006 | 0.0006 |
| 5 | 0.10 | -0.1211 | 0.0243 | 0.0037 | -0.0460 | 0.0008 | -0.0006 | -0.0008 | 0.0008 |
| 6 | 0.20 | -0.1365 | 0.0455 | 0.0063 | -0.0745 | 0.0009 | -0.0012 | -0.0015 | 0.0015 |
| 7 | 0.30 | -0.1491 | 0.0622 | 0.0082 | -0.0925 | 0.0010 | -0.0016 | -0.0021 | 0.0020 |
| 8 | 0.40 | -0.1465 | 0.0743 | 0.0097 | -0.1035 | 0.0009 | -0.0020 | -0.0026 | 0.0025 |
| 9 | 0.50 | -0.1509 | 0.0825 | 0.0107 | -0.1101 | 0.0010 | -0.0022 | -0.0030 | 0.0028 |
| 10 | 0.60 | -0.1447 | 0.0874 | 0.0116 | -0.1133 | 0.0009 | -0.0023 | -0.0034 | 0.0031 |
| 11 | 0.70 | -0.1461 | 0.0904 | 0.0122 | -0.1146 | 0.0010 | -0.0024 | -0.0036 | 0.0033 |
| 12 | 0.80 | -0.1389 | 0.0918 | 0.0127 | -0.1144 | 0.0009 | -0.0025 | -0.0038 | 0.0034 |
| 13 | 0.90 | -0.1389 | 0.0923 | 0.0130 | -0.1135 | 0.0009 | -0.0026 | -0.0040 | 0.0035 |
| 14 | 1.00 | -0.1316 | 0.0921 | 0.0132 | -0.1117 | 0.0009 | -0.0026 | -0.0041 | 0.0035 |
| 15 | 1.20 | -0.1272 | 0.0901 | 0.0134 | -0.1074 | 0.0009 | -0.0027 | -0.0043 | 0.0036 |
| 16 | 1.40 | -0.1168 | 0.0872 | 0.0132 | -0.1024 | 0.0008 | -0.0026 | -0.0044 | 0.0036 |
| 17 | 1.60 | -0.1130 | 0.0837 | 0.0128 | -0.0973 | 0.0008 | -0.0026 | -0.0044 | 0.0036 |
| 18 | 1.80 | -0.1038 | 0.0801 | 0.0122 | -0.0923 | 0.0007 | -0.0026 | -0.0043 | 0.0035 |
| 19 | 2.00 | -0.1009 | 0.0763 | 0.0115 | -0.0875 | 0.0007 | -0.0026 | -0.0042 | 0.0034 |
| 20 | 2.20 | -0.0927 | 0.0726 | 0.0107 | -0.0828 | 0.0006 | -0.0025 | -0.0041 | 0.0033 |
| 21 | 2.40 | -0.0902 | 0.0690 | 0.0099 | -0.0786 | 0.0006 | -0.0024 | -0.0040 | 0.0032 |
| 22 | 2.60 | -0.0830 | 0.0654 | 0.0091 | -0.0744 | 0.0006 | -0.0023 | -0.0039 | 0.0031 |
| 23 | 2.80 | -0.0813 | 0.0621 | 0.0083 | -0.0707 | 0.0006 | -0.0023 | -0.0038 | 0.0030 |
| 24 | 3.00 | -0.0749 | 0.0588 | 0.0075 | -0.0670 | 0.0005 | -0.0022 | -0.0036 | 0.0029 |
| 25 | 3.20 | -0.0738 | 0.0557 | 0.0067 | -0.0637 | 0.0005 | -0.0021 | -0.0035 | 0.0028 |
| 26 | 3.40 | -0.0679 | 0.0528 | 0.0060 | -0.0605 | 0.0005 | -0.0020 | -0.0034 | 0.0027 |
| 27 | 3.60 | -0.0670 | 0.0501 | 0.0052 | -0.0576 | 0.0005 | -0.0019 | -0.0033 | 0.0026 |
| 28 | 3.80 | -0.0618 | 0.0473 | 0.0046 | -0.0547 | 0.0004 | -0.0018 | -0.0031 | 0.0025 |
| 29 | 4.00 | -0.0611 | 0.0448 | 0.0039 | -0.0522 | 0.0004 | -0.0018 | -0.0030 | 0.0024 |
| 30 | 4.20 | -0.0565 | 0.0423 | 0.0033 | -0.0496 | 0.0004 | -0.0017 | -0.0029 | 0.0023 |
| 31 | 4.40 | -0.0562 | 0.0403 | 0.0027 | -0.0475 | 0.0004 | -0.0017 | -0.0028 | 0.0022 |
| 32 | 4.60 | -0.0518 | 0.0383 | 0.0022 | -0.0452 | 0.0004 | -0.0016 | -0.0027 | 0.0022 |
| 33 | 4.80 | -0.0516 | 0.0364 | 0.0017 | -0.0432 | 0.0004 | -0.0015 | -0.0026 | 0.0021 |
| 34 | 5.00 | -0.0475 | 0.0347 | 0.0012 | -0.0413 | 0.0004 | -0.0015 | -0.0025 | 0.0020 |
| 35 | 5.50 | -0.0447 | 0.0307 | 0.0003 | -0.0370 | 0.0004 | -0.0014 | -0.0023 | 0.0019 |
| 36 | 6.00 | -0.0389 | 0.0272 | -0.0004 | -0.0333 | 0.0003 | -0.0013 | -0.0022 | 0.0017 |
| 37 | 6.50 | -0.0372 | 0.0243 | -0.0010 | -0.0301 | 0.0003 | -0.0013 | -0.0020 | 0.0016 |
| 38 | 7.00 | -0.0321 | 0.0219 | -0.0014 | -0.0272 | 0.0003 | -0.0011 | -0.0019 | 0.0015 |
| 39 | 7.50 | -0.0311 | 0.0196 | -0.0018 | -0.0249 | 0.0003 | -0.0010 | -0.0018 | 0.0014 |
| 40 | 8.00 | -0.0268 | 0.0178 | -0.0019 | -0.0227 | 0.0002 | -0.0010 | -0.0016 | 0.0013 |
| 41 | 8.50 | -0.0262 | 0.0163 | -0.0021 | -0.0208 | 0.0003 | -0.0010 | -0.0015 | 0.0012 |
| 42 | 9.00 | -0.0226 | 0.0148 | -0.0021 | -0.0191 | 0.0002 | -0.0009 | -0.0015 | 0.0012 |
| 43 | 9.50 | -0.0226 | 0.0136 | -0.0022 | -0.0177 | 0.0002 | -0.0009 | -0.0014 | 0.0012 |
| 44 | 10.00 | -0.0194 | 0.0125 | -0.0022 | -0.0162 | 0.0002 | -0.0008 | -0.0013 | 0.0011 |
| 45 | 11.00 | -0.0181 | 0.0107 | -0.0021 | -0.0140 | 0.0002 | -0.0007 | -0.0012 | 0.0010 |
| 46 | 12.00 | -0.0139 | 0.0093 | -0.0019 | -0.0120 | 0.0002 | -0.0007 | -0.0010 | 0.0009 |
| 47 | 13.00 | -0.0136 | 0.0081 | -0.0017 | -0.0105 | 0.0001 | -0.0006 | -0.0009 | 0.0008 |
| 48 | 14.00 | -0.0102 | 0.0070 | -0.0015 | -0.0089 | 0.0001 | -0.0006 | -0.0008 | 0.0007 |
| 49 | 15.00 | -0.0104 | 0.0059 | -0.0014 | -0.0077 | 0.0001 | -0.0005 | -0.0007 | 0.0006 |
| 50 | 16.00 | -0.0073 | 0.0050 | -0.0013 | -0.0066 | 0.0001 | -0.0005 | -0.0006 | 0.0006 |
| 51 | 17.00 | -0.0078 | 0.0043 | -0.0011 | -0.0057 | 0.0001 | -0.0004 | -0.0005 | 0.0005 |
| 52 | 18.00 | -0.0053 | 0.0036 | -0.0010 | -0.0047 | 0.0000 | -0.0004 | -0.0004 | 0.0005 |
| 53 | 19.00 | -0.0061 | 0.0028 | -0.0009 | -0.0040 | 0.0000 | -0.0003 | -0.0003 | 0.0004 |
| 54 | 20.00 | -0.0035 | 0.0023 | -0.0008 | -0.0033 | 0.0000 | -0.0003 | -0.0002 | 0.0004 |

| | | | | | | | | | |
|----|--------|---------|---------|---------|---------|---------|---------|---------|---------|
| 55 | 22.00 | -0.0039 | 0.0012 | -0.0008 | -0.0022 | 0.0000 | -0.0002 | -0.0001 | 0.0003 |
| 56 | 24.00 | -0.0010 | 0.0003 | -0.0007 | -0.0012 | 0.0000 | -0.0001 | 0.0000 | 0.0002 |
| 57 | 26.00 | -0.0020 | -0.0006 | -0.0009 | -0.0005 | 0.0000 | 0.0000 | 0.0002 | 0.0001 |
| 58 | 28.00 | 0.0003 | -0.0014 | -0.0010 | 0.0002 | 0.0000 | 0.0001 | 0.0003 | 0.0000 |
| 59 | 30.00 | -0.0007 | -0.0022 | -0.0012 | 0.0008 | 0.0000 | 0.0001 | 0.0003 | 0.0000 |
| 60 | 32.00 | 0.0013 | -0.0030 | -0.0012 | 0.0014 | 0.0000 | 0.0001 | 0.0004 | 0.0000 |
| 61 | 34.00 | 0.0001 | -0.0034 | -0.0013 | 0.0017 | 0.0000 | 0.0001 | 0.0005 | 0.0000 |
| 62 | 36.00 | 0.0018 | -0.0038 | -0.0013 | 0.0020 | 0.0000 | 0.0002 | 0.0005 | -0.0001 |
| 63 | 38.00 | 0.0005 | -0.0041 | -0.0014 | 0.0022 | 0.0000 | 0.0003 | 0.0006 | -0.0001 |
| 64 | 40.00 | 0.0021 | -0.0044 | -0.0015 | 0.0024 | 0.0000 | 0.0003 | 0.0006 | -0.0001 |
| 65 | 45.00 | 0.0007 | -0.0051 | -0.0017 | 0.0028 | 0.0000 | 0.0003 | 0.0007 | -0.0002 |
| 66 | 50.00 | 0.0023 | -0.0055 | -0.0019 | 0.0030 | -0.0001 | 0.0003 | 0.0008 | -0.0002 |
| 67 | 55.00 | 0.0007 | -0.0058 | -0.0021 | 0.0030 | 0.0000 | 0.0003 | 0.0008 | -0.0003 |
| 68 | 60.00 | 0.0021 | -0.0061 | -0.0023 | 0.0032 | 0.0000 | 0.0003 | 0.0008 | -0.0003 |
| 69 | 65.00 | 0.0004 | -0.0062 | -0.0024 | 0.0031 | 0.0000 | 0.0003 | 0.0008 | -0.0003 |
| 70 | 70.00 | 0.0018 | -0.0062 | -0.0025 | 0.0032 | 0.0000 | 0.0003 | 0.0008 | -0.0003 |
| 71 | 75.00 | 0.0002 | -0.0063 | -0.0026 | 0.0030 | 0.0000 | 0.0003 | 0.0008 | -0.0003 |
| 72 | 80.00 | 0.0016 | -0.0063 | -0.0026 | 0.0030 | 0.0000 | 0.0003 | 0.0008 | -0.0003 |
| 73 | 85.00 | -0.0001 | -0.0062 | -0.0027 | 0.0029 | 0.0000 | 0.0003 | 0.0008 | -0.0002 |
| 74 | 90.00 | 0.0013 | -0.0062 | -0.0027 | 0.0029 | 0.0000 | 0.0003 | 0.0008 | -0.0002 |
| 75 | 95.00 | -0.0003 | -0.0061 | -0.0028 | 0.0027 | 0.0000 | 0.0003 | 0.0008 | -0.0002 |
| 76 | 100.00 | 0.0012 | -0.0060 | -0.0027 | 0.0027 | 0.0000 | 0.0003 | 0.0008 | -0.0002 |
| 77 | 110.00 | -0.0005 | -0.0058 | -0.0027 | 0.0024 | 0.0000 | 0.0003 | 0.0008 | -0.0002 |
| 78 | 120.00 | 0.0009 | -0.0055 | -0.0026 | 0.0024 | 0.0000 | 0.0003 | 0.0007 | -0.0002 |
| 79 | 130.00 | -0.0007 | -0.0053 | -0.0026 | 0.0021 | 0.0000 | 0.0002 | 0.0007 | -0.0002 |
| 80 | 140.00 | 0.0008 | -0.0050 | -0.0025 | 0.0020 | 0.0000 | 0.0002 | 0.0006 | -0.0002 |
| 81 | 150.00 | -0.0008 | -0.0047 | -0.0024 | 0.0018 | 0.0000 | 0.0002 | 0.0006 | -0.0001 |
| 82 | 160.00 | 0.0007 | -0.0045 | -0.0022 | 0.0017 | 0.0000 | 0.0002 | 0.0006 | -0.0001 |
| 83 | 170.00 | -0.0009 | -0.0042 | -0.0022 | 0.0015 | 0.0000 | 0.0002 | 0.0005 | -0.0001 |
| 84 | 180.00 | 0.0006 | -0.0040 | -0.0020 | 0.0014 | 0.0000 | 0.0002 | 0.0005 | -0.0001 |
| 85 | 190.00 | -0.0010 | -0.0037 | -0.0020 | 0.0012 | 0.0000 | 0.0002 | 0.0005 | -0.0001 |
| 86 | 200.00 | 0.0005 | -0.0035 | -0.0018 | 0.0012 | 0.0000 | 0.0002 | 0.0005 | -0.0001 |
| 87 | 220.00 | -0.0010 | -0.0031 | -0.0017 | 0.0009 | 0.0000 | 0.0001 | 0.0004 | 0.0000 |
| 88 | 240.00 | 0.0005 | -0.0027 | -0.0015 | 0.0008 | 0.0000 | 0.0001 | 0.0003 | 0.0000 |
| 89 | 260.00 | -0.0010 | -0.0023 | -0.0013 | 0.0005 | 0.0000 | 0.0001 | 0.0003 | 0.0000 |
| 90 | 280.00 | 0.0005 | -0.0020 | -0.0011 | 0.0004 | 0.0000 | 0.0001 | 0.0003 | 0.0000 |
| 91 | 300.00 | -0.0010 | -0.0017 | -0.0010 | 0.0002 | 0.0000 | 0.0001 | 0.0002 | 0.0000 |
| 92 | 350.00 | 0.0006 | -0.0011 | -0.0007 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0001 |
| 93 | 400.00 | -0.0009 | -0.0007 | -0.0005 | -0.0003 | 0.0000 | 0.0000 | 0.0001 | 0.0001 |
| 94 | 450.00 | 0.0006 | -0.0003 | -0.0003 | -0.0003 | 0.0000 | 0.0000 | 0.0001 | 0.0001 |
| 95 | 500.00 | -0.0009 | -0.0001 | -0.0002 | -0.0005 | 0.0000 | 0.0000 | 0.0000 | 0.0001 |

表2. 4 (1) 評価断面4の応力テンソル成分1、2

ステップ温度変化の基本解

断面4

| ステップ | 時間(S) | 応力成分1 | | | | 応力成分2 | | | |
|------|-------|---------|---------|---------|---------|---------|--------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.01 | -0.0127 | 0.0000 | -0.0004 | -0.0009 | -0.0317 | 0.0010 | -0.0002 | -0.0026 |
| 3 | 0.04 | -0.0249 | -0.0001 | -0.0007 | -0.0019 | -0.1089 | 0.0062 | -0.0007 | -0.0143 |
| 4 | 0.07 | -0.0106 | -0.0001 | -0.0003 | -0.0009 | -0.1175 | 0.0107 | -0.0007 | -0.0232 |
| 5 | 0.10 | -0.0144 | -0.0001 | -0.0003 | -0.0010 | -0.1420 | 0.0149 | -0.0009 | -0.0317 |
| 6 | 0.20 | -0.0068 | -0.0002 | 0.0000 | -0.0007 | -0.1749 | 0.0276 | -0.0013 | -0.0555 |
| 7 | 0.30 | -0.0085 | -0.0003 | -0.0001 | -0.0010 | -0.2014 | 0.0387 | -0.0016 | -0.0752 |
| 8 | 0.40 | -0.0050 | -0.0004 | 0.0000 | -0.0011 | -0.2139 | 0.0490 | -0.0019 | -0.0921 |
| 9 | 0.50 | -0.0067 | -0.0005 | 0.0000 | -0.0014 | -0.2289 | 0.0585 | -0.0022 | -0.1070 |
| 10 | 0.60 | -0.0044 | -0.0006 | 0.0001 | -0.0015 | -0.2363 | 0.0674 | -0.0024 | -0.1201 |
| 11 | 0.70 | -0.0055 | -0.0007 | 0.0001 | -0.0017 | -0.2463 | 0.0759 | -0.0026 | -0.1320 |
| 12 | 0.80 | -0.0043 | -0.0007 | 0.0002 | -0.0018 | -0.2514 | 0.0840 | -0.0027 | -0.1426 |
| 13 | 0.90 | -0.0054 | -0.0010 | 0.0002 | -0.0020 | -0.2588 | 0.0918 | -0.0029 | -0.1523 |
| 14 | 1.00 | -0.0045 | -0.0011 | 0.0003 | -0.0020 | -0.2627 | 0.0990 | -0.0030 | -0.1611 |
| 15 | 1.20 | -0.0053 | -0.0014 | 0.0003 | -0.0022 | -0.2718 | 0.1125 | -0.0033 | -0.1764 |
| 16 | 1.40 | -0.0045 | -0.0013 | 0.0005 | -0.0023 | -0.2772 | 0.1245 | -0.0034 | -0.1892 |
| 17 | 1.60 | -0.0048 | -0.0016 | 0.0007 | -0.0024 | -0.2827 | 0.1349 | -0.0036 | -0.2000 |
| 18 | 1.80 | -0.0043 | -0.0019 | 0.0008 | -0.0024 | -0.2859 | 0.1441 | -0.0037 | -0.2091 |
| 19 | 2.00 | -0.0047 | -0.0020 | 0.0009 | -0.0025 | -0.2896 | 0.1521 | -0.0038 | -0.2167 |
| 20 | 2.20 | -0.0042 | -0.0020 | 0.0011 | -0.0025 | -0.2915 | 0.1592 | -0.0039 | -0.2232 |
| 21 | 2.40 | -0.0046 | -0.0020 | 0.0013 | -0.0026 | -0.2939 | 0.1652 | -0.0039 | -0.2287 |
| 22 | 2.60 | -0.0043 | -0.0021 | 0.0015 | -0.0026 | -0.2949 | 0.1706 | -0.0040 | -0.2333 |
| 23 | 2.80 | -0.0044 | -0.0022 | 0.0016 | -0.0026 | -0.2964 | 0.1753 | -0.0040 | -0.2372 |
| 24 | 3.00 | -0.0038 | -0.0022 | 0.0018 | -0.0025 | -0.2966 | 0.1793 | -0.0040 | -0.2405 |
| 25 | 3.20 | -0.0042 | -0.0023 | 0.0019 | -0.0026 | -0.2977 | 0.1829 | -0.0041 | -0.2433 |
| 26 | 3.40 | -0.0040 | -0.0025 | 0.0020 | -0.0025 | -0.2977 | 0.1862 | -0.0041 | -0.2456 |
| 27 | 3.60 | -0.0044 | -0.0024 | 0.0021 | -0.0026 | -0.2983 | 0.1891 | -0.0041 | -0.2476 |
| 28 | 3.80 | -0.0043 | -0.0024 | 0.0022 | -0.0026 | -0.2979 | 0.1916 | -0.0041 | -0.2492 |
| 29 | 4.00 | -0.0046 | -0.0025 | 0.0023 | -0.0026 | -0.2980 | 0.1937 | -0.0041 | -0.2505 |
| 30 | 4.20 | -0.0043 | -0.0025 | 0.0024 | -0.0026 | -0.2974 | 0.1956 | -0.0041 | -0.2516 |
| 31 | 4.40 | -0.0043 | -0.0025 | 0.0026 | -0.0026 | -0.2971 | 0.1975 | -0.0041 | -0.2525 |
| 32 | 4.60 | -0.0040 | -0.0025 | 0.0027 | -0.0025 | -0.2963 | 0.1991 | -0.0041 | -0.2532 |
| 33 | 4.80 | -0.0042 | -0.0026 | 0.0027 | -0.0026 | -0.2960 | 0.2002 | -0.0041 | -0.2536 |
| 34 | 5.00 | -0.0042 | -0.0025 | 0.0028 | -0.0026 | -0.2953 | 0.2014 | -0.0041 | -0.2541 |
| 35 | 5.50 | -0.0041 | -0.0024 | 0.0031 | -0.0026 | -0.2936 | 0.2038 | -0.0041 | -0.2546 |
| 36 | 6.00 | -0.0039 | -0.0027 | 0.0032 | -0.0026 | -0.2910 | 0.2053 | -0.0040 | -0.2546 |
| 37 | 6.50 | -0.0039 | -0.0027 | 0.0034 | -0.0025 | -0.2886 | 0.2068 | -0.0040 | -0.2542 |
| 38 | 7.00 | -0.0036 | -0.0026 | 0.0036 | -0.0025 | -0.2858 | 0.2077 | -0.0040 | -0.2535 |
| 39 | 7.50 | -0.0036 | -0.0026 | 0.0037 | -0.0025 | -0.2832 | 0.2084 | -0.0039 | -0.2527 |
| 40 | 8.00 | -0.0035 | -0.0026 | 0.0038 | -0.0025 | -0.2806 | 0.2091 | -0.0039 | -0.2519 |
| 41 | 8.50 | -0.0037 | -0.0027 | 0.0040 | -0.0024 | -0.2783 | 0.2095 | -0.0038 | -0.2508 |
| 42 | 9.00 | -0.0036 | -0.0027 | 0.0041 | -0.0023 | -0.2758 | 0.2099 | -0.0038 | -0.2498 |
| 43 | 9.50 | -0.0037 | -0.0026 | 0.0042 | -0.0023 | -0.2735 | 0.2102 | -0.0037 | -0.2487 |
| 44 | 10.00 | -0.0035 | -0.0025 | 0.0043 | -0.0023 | -0.2709 | 0.2104 | -0.0037 | -0.2476 |
| 45 | 11.00 | -0.0036 | -0.0025 | 0.0043 | -0.0023 | -0.2667 | 0.2103 | -0.0037 | -0.2453 |
| 46 | 12.00 | -0.0034 | -0.0025 | 0.0044 | -0.0022 | -0.2625 | 0.2101 | -0.0036 | -0.2431 |
| 47 | 13.00 | -0.0036 | -0.0026 | 0.0045 | -0.0021 | -0.2591 | 0.2097 | -0.0036 | -0.2409 |
| 48 | 14.00 | -0.0033 | -0.0025 | 0.0046 | -0.0020 | -0.2551 | 0.2092 | -0.0036 | -0.2388 |
| 49 | 15.00 | -0.0034 | -0.0027 | 0.0047 | -0.0019 | -0.2521 | 0.2087 | -0.0035 | -0.2369 |
| 50 | 16.00 | -0.0032 | -0.0026 | 0.0048 | -0.0019 | -0.2487 | 0.2080 | -0.0034 | -0.2349 |
| 51 | 17.00 | -0.0033 | -0.0025 | 0.0049 | -0.0019 | -0.2457 | 0.2073 | -0.0034 | -0.2329 |
| 52 | 18.00 | -0.0031 | -0.0024 | 0.0050 | -0.0018 | -0.2426 | 0.2066 | -0.0034 | -0.2311 |
| 53 | 19.00 | -0.0030 | -0.0024 | 0.0051 | -0.0017 | -0.2402 | 0.2060 | -0.0033 | -0.2295 |
| 54 | 20.00 | -0.0029 | -0.0024 | 0.0051 | -0.0016 | -0.2373 | 0.2053 | -0.0033 | -0.2278 |

| | | | | | | | | | |
|----|--------|---------|---------|--------|---------|---------|--------|---------|---------|
| 55 | 22.00 | -0.0027 | -0.0024 | 0.0052 | -0.0016 | -0.2326 | 0.2036 | -0.0032 | -0.2246 |
| 56 | 24.00 | -0.0027 | -0.0023 | 0.0053 | -0.0015 | -0.2282 | 0.2021 | -0.0031 | -0.2216 |
| 57 | 26.00 | -0.0026 | -0.0023 | 0.0053 | -0.0014 | -0.2245 | 0.2004 | -0.0030 | -0.2188 |
| 58 | 28.00 | -0.0025 | -0.0023 | 0.0054 | -0.0013 | -0.2210 | 0.1986 | -0.0030 | -0.2160 |
| 59 | 30.00 | -0.0025 | -0.0024 | 0.0054 | -0.0012 | -0.2176 | 0.1970 | -0.0030 | -0.2134 |
| 60 | 32.00 | -0.0024 | -0.0023 | 0.0054 | -0.0012 | -0.2145 | 0.1952 | -0.0029 | -0.2110 |
| 61 | 34.00 | -0.0024 | -0.0023 | 0.0054 | -0.0012 | -0.2114 | 0.1934 | -0.0029 | -0.2085 |
| 62 | 36.00 | -0.0024 | -0.0022 | 0.0054 | -0.0011 | -0.2085 | 0.1915 | -0.0029 | -0.2061 |
| 63 | 38.00 | -0.0022 | -0.0022 | 0.0055 | -0.0010 | -0.2057 | 0.1897 | -0.0028 | -0.2037 |
| 64 | 40.00 | -0.0020 | -0.0022 | 0.0054 | -0.0010 | -0.2029 | 0.1876 | -0.0028 | -0.2013 |
| 65 | 45.00 | -0.0019 | -0.0021 | 0.0053 | -0.0009 | -0.1965 | 0.1828 | -0.0027 | -0.1955 |
| 66 | 50.00 | -0.0017 | -0.0020 | 0.0053 | -0.0008 | -0.1902 | 0.1779 | -0.0026 | -0.1898 |
| 67 | 55.00 | -0.0015 | -0.0019 | 0.0053 | -0.0007 | -0.1842 | 0.1729 | -0.0025 | -0.1841 |
| 68 | 60.00 | -0.0016 | -0.0018 | 0.0052 | -0.0007 | -0.1786 | 0.1677 | -0.0024 | -0.1785 |
| 69 | 65.00 | -0.0014 | -0.0017 | 0.0050 | -0.0006 | -0.1731 | 0.1626 | -0.0024 | -0.1730 |
| 70 | 70.00 | -0.0012 | -0.0017 | 0.0049 | -0.0005 | -0.1673 | 0.1577 | -0.0022 | -0.1675 |
| 71 | 75.00 | -0.0013 | -0.0015 | 0.0048 | -0.0005 | -0.1619 | 0.1528 | -0.0022 | -0.1622 |
| 72 | 80.00 | -0.0013 | -0.0015 | 0.0047 | -0.0005 | -0.1567 | 0.1478 | -0.0021 | -0.1570 |
| 73 | 85.00 | -0.0012 | -0.0015 | 0.0045 | -0.0005 | -0.1519 | 0.1430 | -0.0020 | -0.1519 |
| 74 | 90.00 | -0.0009 | -0.0014 | 0.0044 | -0.0004 | -0.1467 | 0.1385 | -0.0020 | -0.1470 |
| 75 | 95.00 | -0.0009 | -0.0014 | 0.0043 | -0.0004 | -0.1421 | 0.1339 | -0.0019 | -0.1422 |
| 76 | 100.00 | -0.0006 | -0.0013 | 0.0042 | -0.0004 | -0.1371 | 0.1296 | -0.0018 | -0.1375 |
| 77 | 110.00 | -0.0005 | -0.0011 | 0.0040 | -0.0004 | -0.1282 | 0.1213 | -0.0017 | -0.1287 |
| 78 | 120.00 | -0.0004 | -0.0009 | 0.0038 | -0.0004 | -0.1199 | 0.1136 | -0.0016 | -0.1204 |
| 79 | 130.00 | -0.0003 | -0.0009 | 0.0036 | -0.0004 | -0.1123 | 0.1063 | -0.0014 | -0.1126 |
| 80 | 140.00 | 0.0000 | -0.0008 | 0.0034 | -0.0003 | -0.1048 | 0.0993 | -0.0013 | -0.1052 |
| 81 | 150.00 | 0.0001 | -0.0007 | 0.0033 | -0.0003 | -0.0980 | 0.0929 | -0.0012 | -0.0984 |
| 82 | 160.00 | 0.0002 | -0.0007 | 0.0031 | -0.0003 | -0.0913 | 0.0868 | -0.0011 | -0.0920 |
| 83 | 170.00 | -0.0001 | -0.0006 | 0.0029 | -0.0002 | -0.0855 | 0.0813 | -0.0011 | -0.0859 |
| 84 | 180.00 | 0.0002 | -0.0006 | 0.0027 | -0.0001 | -0.0796 | 0.0761 | -0.0010 | -0.0803 |
| 85 | 190.00 | -0.0001 | -0.0005 | 0.0026 | -0.0002 | -0.0746 | 0.0713 | -0.0009 | -0.0751 |
| 86 | 200.00 | 0.0000 | -0.0004 | 0.0025 | -0.0002 | -0.0695 | 0.0665 | -0.0008 | -0.0702 |
| 87 | 220.00 | 0.0000 | -0.0003 | 0.0023 | -0.0002 | -0.0608 | 0.0582 | -0.0007 | -0.0614 |
| 88 | 240.00 | 0.0001 | -0.0002 | 0.0020 | -0.0001 | -0.0527 | 0.0512 | -0.0005 | -0.0537 |
| 89 | 260.00 | -0.0001 | -0.0001 | 0.0019 | -0.0002 | -0.0461 | 0.0447 | -0.0004 | -0.0469 |
| 90 | 280.00 | 0.0000 | -0.0001 | 0.0017 | -0.0002 | -0.0401 | 0.0389 | -0.0004 | -0.0409 |
| 91 | 300.00 | 0.0000 | -0.0001 | 0.0015 | -0.0001 | -0.0349 | 0.0341 | -0.0003 | -0.0357 |
| 92 | 350.00 | 0.0002 | 0.0000 | 0.0012 | -0.0001 | -0.0244 | 0.0243 | -0.0002 | -0.0254 |
| 93 | 400.00 | 0.0001 | 0.0002 | 0.0010 | -0.0002 | -0.0169 | 0.0174 | -0.0001 | -0.0181 |
| 94 | 450.00 | 0.0001 | 0.0002 | 0.0008 | -0.0001 | -0.0118 | 0.0126 | 0.0000 | -0.0128 |
| 95 | 500.00 | 0.0002 | 0.0003 | 0.0007 | -0.0001 | -0.0081 | 0.0093 | 0.0001 | -0.0091 |

表2. 4 (2) 評価断面4の応力テンソル成分3、4

ステップ温度変化の基本解

断面4

| ステップ | 時間(S) | 応力成分3 | | | | 応力成分4 | | | |
|------|-------|---------|--------|--------|---------|--------|--------|---------|--------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.01 | -0.0314 | 0.0008 | 0.0000 | -0.0022 | 0.0016 | 0.0000 | -0.0001 | 0.0001 |
| 3 | 0.04 | -0.1068 | 0.0049 | 0.0002 | -0.0121 | 0.0072 | 0.0001 | -0.0004 | 0.0010 |
| 4 | 0.07 | -0.1137 | 0.0084 | 0.0007 | -0.0195 | 0.0092 | 0.0002 | -0.0007 | 0.0018 |
| 5 | 0.10 | -0.1368 | 0.0117 | 0.0010 | -0.0266 | 0.0111 | 0.0002 | -0.0009 | 0.0024 |
| 6 | 0.20 | -0.1653 | 0.0215 | 0.0019 | -0.0464 | 0.0147 | 0.0005 | -0.0016 | 0.0043 |
| 7 | 0.30 | -0.1881 | 0.0301 | 0.0026 | -0.0627 | 0.0168 | 0.0006 | -0.0023 | 0.0058 |
| 8 | 0.40 | -0.1970 | 0.0381 | 0.0033 | -0.0765 | 0.0182 | 0.0008 | -0.0029 | 0.0071 |
| 9 | 0.50 | -0.2087 | 0.0455 | 0.0039 | -0.0885 | 0.0194 | 0.0010 | -0.0034 | 0.0083 |
| 10 | 0.60 | -0.2129 | 0.0524 | 0.0045 | -0.0989 | 0.0202 | 0.0011 | -0.0040 | 0.0092 |
| 11 | 0.70 | -0.2199 | 0.0591 | 0.0052 | -0.1083 | 0.0210 | 0.0013 | -0.0045 | 0.0101 |
| 12 | 0.80 | -0.2222 | 0.0655 | 0.0057 | -0.1165 | 0.0216 | 0.0014 | -0.0050 | 0.0109 |
| 13 | 0.90 | -0.2268 | 0.0716 | 0.0062 | -0.1239 | 0.0222 | 0.0015 | -0.0054 | 0.0116 |
| 14 | 1.00 | -0.2280 | 0.0771 | 0.0067 | -0.1304 | 0.0226 | 0.0016 | -0.0059 | 0.0123 |
| 15 | 1.20 | -0.2321 | 0.0875 | 0.0078 | -0.1416 | 0.0233 | 0.0019 | -0.0067 | 0.0134 |
| 16 | 1.40 | -0.2327 | 0.0968 | 0.0089 | -0.1505 | 0.0238 | 0.0021 | -0.0075 | 0.0142 |
| 17 | 1.60 | -0.2338 | 0.1047 | 0.0099 | -0.1577 | 0.0243 | 0.0022 | -0.0082 | 0.0150 |
| 18 | 1.80 | -0.2327 | 0.1117 | 0.0110 | -0.1634 | 0.0245 | 0.0024 | -0.0089 | 0.0156 |
| 19 | 2.00 | -0.2324 | 0.1174 | 0.0119 | -0.1679 | 0.0248 | 0.0025 | -0.0095 | 0.0161 |
| 20 | 2.20 | -0.2303 | 0.1224 | 0.0129 | -0.1713 | 0.0250 | 0.0027 | -0.0101 | 0.0166 |
| 21 | 2.40 | -0.2291 | 0.1265 | 0.0139 | -0.1740 | 0.0252 | 0.0028 | -0.0106 | 0.0169 |
| 22 | 2.60 | -0.2266 | 0.1299 | 0.0149 | -0.1758 | 0.0254 | 0.0029 | -0.0111 | 0.0173 |
| 23 | 2.80 | -0.2247 | 0.1329 | 0.0158 | -0.1772 | 0.0255 | 0.0029 | -0.0116 | 0.0176 |
| 24 | 3.00 | -0.2216 | 0.1353 | 0.0166 | -0.1779 | 0.0256 | 0.0029 | -0.0121 | 0.0179 |
| 25 | 3.20 | -0.2196 | 0.1374 | 0.0174 | -0.1783 | 0.0256 | 0.0030 | -0.0125 | 0.0181 |
| 26 | 3.40 | -0.2168 | 0.1393 | 0.0183 | -0.1785 | 0.0256 | 0.0031 | -0.0129 | 0.0182 |
| 27 | 3.60 | -0.2145 | 0.1406 | 0.0190 | -0.1783 | 0.0257 | 0.0031 | -0.0132 | 0.0184 |
| 28 | 3.80 | -0.2114 | 0.1416 | 0.0198 | -0.1778 | 0.0256 | 0.0032 | -0.0136 | 0.0185 |
| 29 | 4.00 | -0.2090 | 0.1424 | 0.0205 | -0.1772 | 0.0256 | 0.0032 | -0.0139 | 0.0186 |
| 30 | 4.20 | -0.2057 | 0.1431 | 0.0213 | -0.1764 | 0.0255 | 0.0032 | -0.0142 | 0.0187 |
| 31 | 4.40 | -0.2031 | 0.1436 | 0.0219 | -0.1755 | 0.0255 | 0.0032 | -0.0145 | 0.0188 |
| 32 | 4.60 | -0.2000 | 0.1440 | 0.0226 | -0.1744 | 0.0255 | 0.0032 | -0.0148 | 0.0189 |
| 33 | 4.80 | -0.1976 | 0.1440 | 0.0232 | -0.1733 | 0.0255 | 0.0033 | -0.0150 | 0.0189 |
| 34 | 5.00 | -0.1947 | 0.1444 | 0.0239 | -0.1722 | 0.0254 | 0.0033 | -0.0153 | 0.0189 |
| 35 | 5.50 | -0.1879 | 0.1446 | 0.0255 | -0.1690 | 0.0252 | 0.0034 | -0.0158 | 0.0189 |
| 36 | 6.00 | -0.1808 | 0.1442 | 0.0268 | -0.1658 | 0.0250 | 0.0034 | -0.0163 | 0.0189 |
| 37 | 6.50 | -0.1742 | 0.1439 | 0.0282 | -0.1624 | 0.0248 | 0.0035 | -0.0167 | 0.0189 |
| 38 | 7.00 | -0.1676 | 0.1434 | 0.0294 | -0.1591 | 0.0246 | 0.0035 | -0.0171 | 0.0188 |
| 39 | 7.50 | -0.1615 | 0.1428 | 0.0306 | -0.1558 | 0.0243 | 0.0035 | -0.0174 | 0.0187 |
| 40 | 8.00 | -0.1553 | 0.1421 | 0.0318 | -0.1525 | 0.0241 | 0.0036 | -0.0177 | 0.0186 |
| 41 | 8.50 | -0.1500 | 0.1413 | 0.0329 | -0.1493 | 0.0239 | 0.0036 | -0.0179 | 0.0186 |
| 42 | 9.00 | -0.1446 | 0.1405 | 0.0340 | -0.1463 | 0.0237 | 0.0036 | -0.0182 | 0.0185 |
| 43 | 9.50 | -0.1395 | 0.1398 | 0.0350 | -0.1433 | 0.0235 | 0.0037 | -0.0184 | 0.0184 |
| 44 | 10.00 | -0.1343 | 0.1390 | 0.0359 | -0.1405 | 0.0233 | 0.0037 | -0.0185 | 0.0183 |
| 45 | 11.00 | -0.1250 | 0.1378 | 0.0377 | -0.1351 | 0.0229 | 0.0037 | -0.0188 | 0.0181 |
| 46 | 12.00 | -0.1163 | 0.1365 | 0.0395 | -0.1301 | 0.0225 | 0.0037 | -0.0191 | 0.0179 |
| 47 | 13.00 | -0.1087 | 0.1354 | 0.0411 | -0.1255 | 0.0222 | 0.0037 | -0.0193 | 0.0177 |
| 48 | 14.00 | -0.1011 | 0.1343 | 0.0426 | -0.1213 | 0.0218 | 0.0037 | -0.0195 | 0.0176 |
| 49 | 15.00 | -0.0944 | 0.1334 | 0.0442 | -0.1173 | 0.0216 | 0.0037 | -0.0196 | 0.0174 |
| 50 | 16.00 | -0.0881 | 0.1325 | 0.0456 | -0.1137 | 0.0213 | 0.0036 | -0.0197 | 0.0172 |
| 51 | 17.00 | -0.0825 | 0.1317 | 0.0469 | -0.1104 | 0.0211 | 0.0036 | -0.0198 | 0.0170 |
| 52 | 18.00 | -0.0770 | 0.1311 | 0.0480 | -0.1073 | 0.0208 | 0.0035 | -0.0199 | 0.0168 |
| 53 | 19.00 | -0.0720 | 0.1304 | 0.0493 | -0.1044 | 0.0206 | 0.0035 | -0.0200 | 0.0166 |
| 54 | 20.00 | -0.0672 | 0.1299 | 0.0503 | -0.1018 | 0.0203 | 0.0035 | -0.0200 | 0.0165 |

| | | | | | | | | | |
|----|--------|---------|--------|--------|---------|--------|--------|---------|--------|
| 55 | 22.00 | -0.0589 | 0.1289 | 0.0523 | -0.0971 | 0.0199 | 0.0034 | -0.0201 | 0.0162 |
| 56 | 24.00 | -0.0514 | 0.1279 | 0.0541 | -0.0929 | 0.0195 | 0.0034 | -0.0202 | 0.0160 |
| 57 | 26.00 | -0.0453 | 0.1270 | 0.0556 | -0.0893 | 0.0191 | 0.0034 | -0.0202 | 0.0157 |
| 58 | 28.00 | -0.0400 | 0.1260 | 0.0569 | -0.0861 | 0.0188 | 0.0034 | -0.0202 | 0.0155 |
| 59 | 30.00 | -0.0352 | 0.1253 | 0.0580 | -0.0832 | 0.0185 | 0.0034 | -0.0202 | 0.0152 |
| 60 | 32.00 | -0.0308 | 0.1244 | 0.0589 | -0.0806 | 0.0183 | 0.0034 | -0.0202 | 0.0150 |
| 61 | 34.00 | -0.0272 | 0.1235 | 0.0596 | -0.0783 | 0.0180 | 0.0034 | -0.0202 | 0.0148 |
| 62 | 36.00 | -0.0239 | 0.1228 | 0.0603 | -0.0762 | 0.0177 | 0.0034 | -0.0201 | 0.0146 |
| 63 | 38.00 | -0.0209 | 0.1220 | 0.0608 | -0.0743 | 0.0175 | 0.0033 | -0.0200 | 0.0145 |
| 64 | 40.00 | -0.0184 | 0.1210 | 0.0611 | -0.0725 | 0.0173 | 0.0033 | -0.0199 | 0.0143 |
| 65 | 45.00 | -0.0134 | 0.1186 | 0.0614 | -0.0687 | 0.0167 | 0.0033 | -0.0197 | 0.0138 |
| 66 | 50.00 | -0.0097 | 0.1160 | 0.0613 | -0.0654 | 0.0162 | 0.0033 | -0.0193 | 0.0134 |
| 67 | 55.00 | -0.0068 | 0.1133 | 0.0608 | -0.0625 | 0.0157 | 0.0032 | -0.0190 | 0.0130 |
| 68 | 60.00 | -0.0047 | 0.1105 | 0.0601 | -0.0598 | 0.0153 | 0.0030 | -0.0186 | 0.0126 |
| 69 | 65.00 | -0.0033 | 0.1075 | 0.0590 | -0.0574 | 0.0148 | 0.0030 | -0.0181 | 0.0123 |
| 70 | 70.00 | -0.0018 | 0.1045 | 0.0579 | -0.0552 | 0.0143 | 0.0029 | -0.0177 | 0.0118 |
| 71 | 75.00 | -0.0008 | 0.1016 | 0.0566 | -0.0531 | 0.0138 | 0.0028 | -0.0172 | 0.0115 |
| 72 | 80.00 | 0.0000 | 0.0984 | 0.0553 | -0.0511 | 0.0134 | 0.0027 | -0.0167 | 0.0111 |
| 73 | 85.00 | 0.0005 | 0.0956 | 0.0540 | -0.0492 | 0.0129 | 0.0027 | -0.0163 | 0.0108 |
| 74 | 90.00 | 0.0014 | 0.0926 | 0.0526 | -0.0473 | 0.0125 | 0.0026 | -0.0158 | 0.0104 |
| 75 | 95.00 | 0.0017 | 0.0897 | 0.0512 | -0.0456 | 0.0121 | 0.0025 | -0.0153 | 0.0101 |
| 76 | 100.00 | 0.0023 | 0.0869 | 0.0498 | -0.0440 | 0.0117 | 0.0024 | -0.0149 | 0.0098 |
| 77 | 110.00 | 0.0029 | 0.0816 | 0.0471 | -0.0409 | 0.0110 | 0.0022 | -0.0140 | 0.0092 |
| 78 | 120.00 | 0.0033 | 0.0767 | 0.0445 | -0.0381 | 0.0102 | 0.0020 | -0.0132 | 0.0087 |
| 79 | 130.00 | 0.0034 | 0.0720 | 0.0420 | -0.0355 | 0.0096 | 0.0020 | -0.0124 | 0.0081 |
| 80 | 140.00 | 0.0039 | 0.0673 | 0.0396 | -0.0330 | 0.0089 | 0.0018 | -0.0117 | 0.0076 |
| 81 | 150.00 | 0.0038 | 0.0631 | 0.0373 | -0.0308 | 0.0084 | 0.0017 | -0.0109 | 0.0071 |
| 82 | 160.00 | 0.0040 | 0.0591 | 0.0351 | -0.0287 | 0.0078 | 0.0016 | -0.0103 | 0.0067 |
| 83 | 170.00 | 0.0037 | 0.0553 | 0.0329 | -0.0267 | 0.0073 | 0.0015 | -0.0096 | 0.0063 |
| 84 | 180.00 | 0.0040 | 0.0517 | 0.0310 | -0.0249 | 0.0068 | 0.0014 | -0.0091 | 0.0059 |
| 85 | 190.00 | 0.0037 | 0.0485 | 0.0291 | -0.0233 | 0.0063 | 0.0013 | -0.0085 | 0.0055 |
| 86 | 200.00 | 0.0037 | 0.0455 | 0.0274 | -0.0218 | 0.0059 | 0.0012 | -0.0080 | 0.0051 |
| 87 | 220.00 | 0.0033 | 0.0399 | 0.0242 | -0.0190 | 0.0052 | 0.0011 | -0.0070 | 0.0045 |
| 88 | 240.00 | 0.0033 | 0.0350 | 0.0213 | -0.0166 | 0.0045 | 0.0010 | -0.0062 | 0.0039 |
| 89 | 260.00 | 0.0028 | 0.0304 | 0.0188 | -0.0145 | 0.0039 | 0.0008 | -0.0054 | 0.0034 |
| 90 | 280.00 | 0.0026 | 0.0266 | 0.0165 | -0.0127 | 0.0034 | 0.0007 | -0.0048 | 0.0030 |
| 91 | 300.00 | 0.0024 | 0.0232 | 0.0145 | -0.0110 | 0.0030 | 0.0007 | -0.0042 | 0.0026 |
| 92 | 350.00 | 0.0019 | 0.0164 | 0.0105 | -0.0078 | 0.0021 | 0.0005 | -0.0030 | 0.0018 |
| 93 | 400.00 | 0.0015 | 0.0116 | 0.0075 | -0.0056 | 0.0015 | 0.0004 | -0.0022 | 0.0013 |
| 94 | 450.00 | 0.0011 | 0.0081 | 0.0054 | -0.0039 | 0.0011 | 0.0003 | -0.0016 | 0.0010 |
| 95 | 500.00 | 0.0008 | 0.0055 | 0.0038 | -0.0026 | 0.0008 | 0.0002 | -0.0012 | 0.0008 |

表2. 5 (1) 評価断面5の応力テンソル成分1、2

ステップ温度変化の基本解

断面5

| ステップ | 時間(S) | 応力成分1 | | | | 応力成分2 | | | |
|------|-------|---------|--------|---------|---------|---------|--------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.01 | -0.0109 | 0.0000 | -0.0004 | -0.0014 | -0.0105 | 0.0008 | -0.0002 | -0.0015 |
| 3 | 0.04 | -0.0562 | 0.0001 | -0.0020 | -0.0076 | -0.0536 | 0.0052 | -0.0009 | -0.0085 |
| 4 | 0.07 | -0.0759 | 0.0001 | -0.0028 | -0.0114 | -0.0732 | 0.0091 | -0.0010 | -0.0135 |
| 5 | 0.10 | -0.0883 | 0.0002 | -0.0035 | -0.0145 | -0.0869 | 0.0125 | -0.0011 | -0.0180 |
| 6 | 0.20 | -0.1080 | 0.0003 | -0.0050 | -0.0221 | -0.1122 | 0.0229 | -0.0015 | -0.0310 |
| 7 | 0.30 | -0.1127 | 0.0005 | -0.0059 | -0.0273 | -0.1220 | 0.0319 | -0.0017 | -0.0413 |
| 8 | 0.40 | -0.1152 | 0.0006 | -0.0067 | -0.0316 | -0.1278 | 0.0402 | -0.0018 | -0.0502 |
| 9 | 0.50 | -0.1165 | 0.0007 | -0.0074 | -0.0353 | -0.1317 | 0.0479 | -0.0019 | -0.0580 |
| 10 | 0.60 | -0.1174 | 0.0008 | -0.0080 | -0.0385 | -0.1343 | 0.0550 | -0.0019 | -0.0649 |
| 11 | 0.70 | -0.1181 | 0.0009 | -0.0086 | -0.0415 | -0.1362 | 0.0620 | -0.0018 | -0.0712 |
| 12 | 0.80 | -0.1188 | 0.0010 | -0.0092 | -0.0441 | -0.1382 | 0.0685 | -0.0017 | -0.0769 |
| 13 | 0.90 | -0.1193 | 0.0011 | -0.0098 | -0.0464 | -0.1397 | 0.0749 | -0.0017 | -0.0822 |
| 14 | 1.00 | -0.1199 | 0.0012 | -0.0103 | -0.0485 | -0.1410 | 0.0808 | -0.0016 | -0.0870 |
| 15 | 1.20 | -0.1206 | 0.0013 | -0.0113 | -0.0521 | -0.1431 | 0.0921 | -0.0015 | -0.0957 |
| 16 | 1.40 | -0.1209 | 0.0013 | -0.0122 | -0.0551 | -0.1441 | 0.1025 | -0.0013 | -0.1032 |
| 17 | 1.60 | -0.1209 | 0.0015 | -0.0130 | -0.0575 | -0.1445 | 0.1124 | -0.0010 | -0.1097 |
| 18 | 1.80 | -0.1208 | 0.0016 | -0.0138 | -0.0596 | -0.1449 | 0.1216 | -0.0008 | -0.1155 |
| 19 | 2.00 | -0.1207 | 0.0017 | -0.0144 | -0.0613 | -0.1449 | 0.1300 | -0.0006 | -0.1205 |
| 20 | 2.20 | -0.1206 | 0.0017 | -0.0150 | -0.0627 | -0.1448 | 0.1379 | -0.0004 | -0.1249 |
| 21 | 2.40 | -0.1205 | 0.0018 | -0.0155 | -0.0638 | -0.1448 | 0.1452 | -0.0002 | -0.1289 |
| 22 | 2.60 | -0.1203 | 0.0018 | -0.0161 | -0.0649 | -0.1447 | 0.1519 | 0.0000 | -0.1324 |
| 23 | 2.80 | -0.1197 | 0.0018 | -0.0165 | -0.0655 | -0.1441 | 0.1581 | 0.0003 | -0.1354 |
| 24 | 3.00 | -0.1193 | 0.0019 | -0.0169 | -0.0662 | -0.1434 | 0.1642 | 0.0005 | -0.1382 |
| 25 | 3.20 | -0.1190 | 0.0020 | -0.0173 | -0.0668 | -0.1430 | 0.1695 | 0.0007 | -0.1407 |
| 26 | 3.40 | -0.1183 | 0.0020 | -0.0175 | -0.0672 | -0.1424 | 0.1746 | 0.0010 | -0.1429 |
| 27 | 3.60 | -0.1177 | 0.0022 | -0.0178 | -0.0675 | -0.1418 | 0.1794 | 0.0012 | -0.1450 |
| 28 | 3.80 | -0.1170 | 0.0023 | -0.0180 | -0.0677 | -0.1409 | 0.1838 | 0.0013 | -0.1468 |
| 29 | 4.00 | -0.1166 | 0.0024 | -0.0182 | -0.0680 | -0.1404 | 0.1878 | 0.0015 | -0.1484 |
| 30 | 4.20 | -0.1161 | 0.0024 | -0.0184 | -0.0682 | -0.1398 | 0.1919 | 0.0017 | -0.1499 |
| 31 | 4.40 | -0.1154 | 0.0024 | -0.0185 | -0.0683 | -0.1389 | 0.1957 | 0.0019 | -0.1512 |
| 32 | 4.60 | -0.1148 | 0.0026 | -0.0186 | -0.0684 | -0.1381 | 0.1993 | 0.0020 | -0.1524 |
| 33 | 4.80 | -0.1140 | 0.0027 | -0.0186 | -0.0684 | -0.1373 | 0.2025 | 0.0022 | -0.1534 |
| 34 | 5.00 | -0.1135 | 0.0028 | -0.0187 | -0.0685 | -0.1367 | 0.2056 | 0.0024 | -0.1545 |
| 35 | 5.50 | -0.1120 | 0.0029 | -0.0188 | -0.0685 | -0.1347 | 0.2126 | 0.0027 | -0.1566 |
| 36 | 6.00 | -0.1106 | 0.0032 | -0.0189 | -0.0684 | -0.1334 | 0.2187 | 0.0030 | -0.1584 |
| 37 | 6.50 | -0.1095 | 0.0033 | -0.0189 | -0.0681 | -0.1319 | 0.2243 | 0.0034 | -0.1598 |
| 38 | 7.00 | -0.1082 | 0.0034 | -0.0188 | -0.0678 | -0.1303 | 0.2290 | 0.0036 | -0.1609 |
| 39 | 7.50 | -0.1072 | 0.0034 | -0.0188 | -0.0675 | -0.1292 | 0.2334 | 0.0039 | -0.1618 |
| 40 | 8.00 | -0.1060 | 0.0036 | -0.0186 | -0.0672 | -0.1278 | 0.2373 | 0.0041 | -0.1626 |
| 41 | 8.50 | -0.1051 | 0.0036 | -0.0184 | -0.0669 | -0.1268 | 0.2406 | 0.0043 | -0.1632 |
| 42 | 9.00 | -0.1038 | 0.0037 | -0.0182 | -0.0665 | -0.1254 | 0.2439 | 0.0046 | -0.1637 |
| 43 | 9.50 | -0.1028 | 0.0034 | -0.0181 | -0.0661 | -0.1242 | 0.2463 | 0.0047 | -0.1641 |
| 44 | 10.00 | -0.1018 | 0.0035 | -0.0179 | -0.0658 | -0.1232 | 0.2489 | 0.0049 | -0.1644 |
| 45 | 11.00 | -0.0999 | 0.0036 | -0.0174 | -0.0651 | -0.1210 | 0.2535 | 0.0052 | -0.1649 |
| 46 | 12.00 | -0.0979 | 0.0037 | -0.0169 | -0.0644 | -0.1189 | 0.2574 | 0.0055 | -0.1652 |
| 47 | 13.00 | -0.0962 | 0.0038 | -0.0164 | -0.0638 | -0.1170 | 0.2608 | 0.0058 | -0.1654 |
| 48 | 14.00 | -0.0946 | 0.0040 | -0.0159 | -0.0631 | -0.1153 | 0.2639 | 0.0060 | -0.1655 |
| 49 | 15.00 | -0.0934 | 0.0041 | -0.0155 | -0.0625 | -0.1138 | 0.2666 | 0.0062 | -0.1656 |
| 50 | 16.00 | -0.0917 | 0.0042 | -0.0149 | -0.0618 | -0.1118 | 0.2686 | 0.0064 | -0.1654 |
| 51 | 17.00 | -0.0906 | 0.0041 | -0.0145 | -0.0612 | -0.1103 | 0.2703 | 0.0066 | -0.1652 |
| 52 | 18.00 | -0.0893 | 0.0039 | -0.0140 | -0.0606 | -0.1089 | 0.2713 | 0.0067 | -0.1649 |
| 53 | 19.00 | -0.0881 | 0.0039 | -0.0135 | -0.0600 | -0.1075 | 0.2729 | 0.0068 | -0.1648 |
| 54 | 20.00 | -0.0869 | 0.0039 | -0.0131 | -0.0594 | -0.1063 | 0.2741 | 0.0070 | -0.1645 |

| | | | | | | | | | |
|----|--------|---------|--------|---------|---------|---------|--------|--------|---------|
| 55 | 22.00 | -0.0845 | 0.0040 | -0.0123 | -0.0583 | -0.1035 | 0.2760 | 0.0072 | -0.1640 |
| 56 | 24.00 | -0.0826 | 0.0041 | -0.0115 | -0.0574 | -0.1013 | 0.2774 | 0.0074 | -0.1634 |
| 57 | 26.00 | -0.0807 | 0.0039 | -0.0107 | -0.0565 | -0.0991 | 0.2780 | 0.0076 | -0.1627 |
| 58 | 28.00 | -0.0792 | 0.0039 | -0.0100 | -0.0556 | -0.0973 | 0.2785 | 0.0077 | -0.1620 |
| 59 | 30.00 | -0.0774 | 0.0039 | -0.0093 | -0.0547 | -0.0955 | 0.2787 | 0.0079 | -0.1611 |
| 60 | 32.00 | -0.0760 | 0.0039 | -0.0087 | -0.0539 | -0.0939 | 0.2786 | 0.0079 | -0.1603 |
| 61 | 34.00 | -0.0745 | 0.0039 | -0.0082 | -0.0531 | -0.0921 | 0.2779 | 0.0080 | -0.1592 |
| 62 | 36.00 | -0.0729 | 0.0040 | -0.0077 | -0.0523 | -0.0904 | 0.2773 | 0.0081 | -0.1582 |
| 63 | 38.00 | -0.0717 | 0.0040 | -0.0073 | -0.0516 | -0.0890 | 0.2764 | 0.0081 | -0.1571 |
| 64 | 40.00 | -0.0704 | 0.0040 | -0.0068 | -0.0508 | -0.0878 | 0.2750 | 0.0081 | -0.1559 |
| 65 | 45.00 | -0.0675 | 0.0039 | -0.0059 | -0.0491 | -0.0846 | 0.2711 | 0.0081 | -0.1528 |
| 66 | 50.00 | -0.0646 | 0.0039 | -0.0051 | -0.0474 | -0.0811 | 0.2663 | 0.0081 | -0.1494 |
| 67 | 55.00 | -0.0620 | 0.0039 | -0.0045 | -0.0458 | -0.0780 | 0.2611 | 0.0080 | -0.1459 |
| 68 | 60.00 | -0.0597 | 0.0036 | -0.0040 | -0.0442 | -0.0751 | 0.2550 | 0.0079 | -0.1421 |
| 69 | 65.00 | -0.0574 | 0.0034 | -0.0036 | -0.0427 | -0.0724 | 0.2486 | 0.0077 | -0.1383 |
| 70 | 70.00 | -0.0556 | 0.0033 | -0.0032 | -0.0413 | -0.0701 | 0.2421 | 0.0075 | -0.1345 |
| 71 | 75.00 | -0.0534 | 0.0032 | -0.0029 | -0.0399 | -0.0674 | 0.2354 | 0.0073 | -0.1305 |
| 72 | 80.00 | -0.0513 | 0.0031 | -0.0026 | -0.0386 | -0.0648 | 0.2286 | 0.0071 | -0.1266 |
| 73 | 85.00 | -0.0493 | 0.0030 | -0.0023 | -0.0372 | -0.0625 | 0.2221 | 0.0069 | -0.1228 |
| 74 | 90.00 | -0.0475 | 0.0029 | -0.0021 | -0.0359 | -0.0602 | 0.2155 | 0.0067 | -0.1191 |
| 75 | 95.00 | -0.0458 | 0.0028 | -0.0019 | -0.0347 | -0.0582 | 0.2094 | 0.0066 | -0.1155 |
| 76 | 100.00 | -0.0440 | 0.0028 | -0.0017 | -0.0335 | -0.0561 | 0.2031 | 0.0064 | -0.1120 |
| 77 | 110.00 | -0.0409 | 0.0026 | -0.0014 | -0.0313 | -0.0522 | 0.1909 | 0.0060 | -0.1051 |
| 78 | 120.00 | -0.0380 | 0.0024 | -0.0011 | -0.0292 | -0.0486 | 0.1794 | 0.0057 | -0.0986 |
| 79 | 130.00 | -0.0354 | 0.0022 | -0.0009 | -0.0272 | -0.0454 | 0.1685 | 0.0054 | -0.0925 |
| 80 | 140.00 | -0.0330 | 0.0020 | -0.0008 | -0.0254 | -0.0421 | 0.1581 | 0.0050 | -0.0867 |
| 81 | 150.00 | -0.0307 | 0.0019 | -0.0007 | -0.0237 | -0.0394 | 0.1485 | 0.0047 | -0.0813 |
| 82 | 160.00 | -0.0289 | 0.0018 | -0.0006 | -0.0221 | -0.0369 | 0.1392 | 0.0045 | -0.0762 |
| 83 | 170.00 | -0.0268 | 0.0017 | -0.0005 | -0.0207 | -0.0342 | 0.1305 | 0.0042 | -0.0713 |
| 84 | 180.00 | -0.0247 | 0.0015 | -0.0003 | -0.0192 | -0.0317 | 0.1225 | 0.0040 | -0.0668 |
| 85 | 190.00 | -0.0230 | 0.0014 | -0.0003 | -0.0180 | -0.0294 | 0.1148 | 0.0038 | -0.0626 |
| 86 | 200.00 | -0.0213 | 0.0013 | -0.0002 | -0.0168 | -0.0273 | 0.1076 | 0.0035 | -0.0587 |
| 87 | 220.00 | -0.0184 | 0.0011 | -0.0001 | -0.0147 | -0.0236 | 0.0947 | 0.0032 | -0.0515 |
| 88 | 240.00 | -0.0158 | 0.0010 | -0.0001 | -0.0128 | -0.0202 | 0.0833 | 0.0028 | -0.0451 |
| 89 | 260.00 | -0.0134 | 0.0010 | 0.0000 | -0.0111 | -0.0173 | 0.0732 | 0.0026 | -0.0396 |
| 90 | 280.00 | -0.0114 | 0.0009 | 0.0001 | -0.0098 | -0.0147 | 0.0642 | 0.0023 | -0.0347 |
| 91 | 300.00 | -0.0098 | 0.0006 | 0.0001 | -0.0084 | -0.0125 | 0.0563 | 0.0020 | -0.0303 |
| 92 | 350.00 | -0.0068 | 0.0003 | 0.0001 | -0.0059 | -0.0083 | 0.0405 | 0.0015 | -0.0216 |
| 93 | 400.00 | -0.0043 | 0.0001 | 0.0001 | -0.0040 | -0.0050 | 0.0292 | 0.0011 | -0.0154 |
| 94 | 450.00 | -0.0026 | 0.0001 | 0.0001 | -0.0027 | -0.0030 | 0.0213 | 0.0008 | -0.0110 |
| 95 | 500.00 | -0.0011 | 0.0000 | 0.0001 | -0.0018 | -0.0012 | 0.0154 | 0.0007 | -0.0078 |

表 2. 5 (2) 評価断面5の応力テンソル成分3、4

ステップ温度変化の基本解

断面5

| ステップ | 時間(S) | 応力成分3 | | | | 応力成分4 | | | |
|------|-------|---------|--------|---------|---------|---------|--------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.01 | -0.0142 | 0.0007 | -0.0002 | -0.0020 | -0.0045 | 0.0001 | 0.0000 | -0.0007 |
| 3 | 0.04 | -0.0764 | 0.0044 | -0.0008 | -0.0118 | -0.0271 | 0.0004 | -0.0002 | -0.0047 |
| 4 | 0.07 | -0.1097 | 0.0076 | -0.0009 | -0.0192 | -0.0419 | 0.0007 | -0.0002 | -0.0078 |
| 5 | 0.10 | -0.1333 | 0.0105 | -0.0010 | -0.0259 | -0.0523 | 0.0009 | -0.0003 | -0.0106 |
| 6 | 0.20 | -0.1785 | 0.0191 | -0.0014 | -0.0443 | -0.0740 | 0.0017 | -0.0005 | -0.0184 |
| 7 | 0.30 | -0.1984 | 0.0267 | -0.0015 | -0.0588 | -0.0859 | 0.0023 | -0.0008 | -0.0248 |
| 8 | 0.40 | -0.2110 | 0.0337 | -0.0014 | -0.0712 | -0.0944 | 0.0029 | -0.0011 | -0.0304 |
| 9 | 0.50 | -0.2198 | 0.0401 | -0.0015 | -0.0820 | -0.1007 | 0.0035 | -0.0014 | -0.0354 |
| 10 | 0.60 | -0.2264 | 0.0462 | -0.0014 | -0.0917 | -0.1054 | 0.0040 | -0.0017 | -0.0399 |
| 11 | 0.70 | -0.2314 | 0.0521 | -0.0014 | -0.1006 | -0.1094 | 0.0045 | -0.0019 | -0.0439 |
| 12 | 0.80 | -0.2359 | 0.0576 | -0.0013 | -0.1085 | -0.1126 | 0.0050 | -0.0022 | -0.0476 |
| 13 | 0.90 | -0.2392 | 0.0630 | -0.0013 | -0.1157 | -0.1153 | 0.0054 | -0.0025 | -0.0509 |
| 14 | 1.00 | -0.2423 | 0.0681 | -0.0012 | -0.1224 | -0.1175 | 0.0059 | -0.0027 | -0.0539 |
| 15 | 1.20 | -0.2465 | 0.0779 | -0.0011 | -0.1341 | -0.1207 | 0.0068 | -0.0032 | -0.0592 |
| 16 | 1.40 | -0.2493 | 0.0867 | -0.0010 | -0.1440 | -0.1230 | 0.0074 | -0.0036 | -0.0635 |
| 17 | 1.60 | -0.2510 | 0.0952 | -0.0008 | -0.1525 | -0.1245 | 0.0081 | -0.0041 | -0.0672 |
| 18 | 1.80 | -0.2521 | 0.1028 | -0.0007 | -0.1599 | -0.1257 | 0.0088 | -0.0044 | -0.0702 |
| 19 | 2.00 | -0.2526 | 0.1097 | -0.0005 | -0.1661 | -0.1263 | 0.0094 | -0.0048 | -0.0728 |
| 20 | 2.20 | -0.2528 | 0.1162 | -0.0003 | -0.1715 | -0.1268 | 0.0100 | -0.0051 | -0.0749 |
| 21 | 2.40 | -0.2528 | 0.1221 | 0.0000 | -0.1761 | -0.1272 | 0.0105 | -0.0054 | -0.0767 |
| 22 | 2.60 | -0.2525 | 0.1273 | 0.0002 | -0.1801 | -0.1273 | 0.0109 | -0.0057 | -0.0782 |
| 23 | 2.80 | -0.2519 | 0.1321 | 0.0003 | -0.1834 | -0.1271 | 0.0114 | -0.0060 | -0.0795 |
| 24 | 3.00 | -0.2509 | 0.1365 | 0.0005 | -0.1863 | -0.1268 | 0.0118 | -0.0063 | -0.0805 |
| 25 | 3.20 | -0.2502 | 0.1405 | 0.0007 | -0.1889 | -0.1266 | 0.0122 | -0.0065 | -0.0814 |
| 26 | 3.40 | -0.2489 | 0.1441 | 0.0010 | -0.1909 | -0.1263 | 0.0126 | -0.0067 | -0.0822 |
| 27 | 3.60 | -0.2478 | 0.1474 | 0.0013 | -0.1928 | -0.1259 | 0.0128 | -0.0070 | -0.0828 |
| 28 | 3.80 | -0.2463 | 0.1505 | 0.0016 | -0.1943 | -0.1254 | 0.0131 | -0.0072 | -0.0833 |
| 29 | 4.00 | -0.2450 | 0.1534 | 0.0019 | -0.1956 | -0.1251 | 0.0134 | -0.0074 | -0.0837 |
| 30 | 4.20 | -0.2437 | 0.1559 | 0.0022 | -0.1967 | -0.1247 | 0.0138 | -0.0075 | -0.0841 |
| 31 | 4.40 | -0.2421 | 0.1582 | 0.0026 | -0.1975 | -0.1241 | 0.0140 | -0.0077 | -0.0844 |
| 32 | 4.60 | -0.2406 | 0.1603 | 0.0029 | -0.1982 | -0.1236 | 0.0142 | -0.0079 | -0.0845 |
| 33 | 4.80 | -0.2392 | 0.1621 | 0.0031 | -0.1987 | -0.1231 | 0.0144 | -0.0080 | -0.0847 |
| 34 | 5.00 | -0.2378 | 0.1640 | 0.0035 | -0.1993 | -0.1226 | 0.0146 | -0.0082 | -0.0848 |
| 35 | 5.50 | -0.2337 | 0.1680 | 0.0044 | -0.1999 | -0.1212 | 0.0150 | -0.0085 | -0.0848 |
| 36 | 6.00 | -0.2298 | 0.1712 | 0.0053 | -0.2000 | -0.1199 | 0.0153 | -0.0089 | -0.0847 |
| 37 | 6.50 | -0.2261 | 0.1739 | 0.0062 | -0.1995 | -0.1187 | 0.0156 | -0.0091 | -0.0845 |
| 38 | 7.00 | -0.2222 | 0.1762 | 0.0071 | -0.1989 | -0.1175 | 0.0159 | -0.0094 | -0.0842 |
| 39 | 7.50 | -0.2188 | 0.1781 | 0.0081 | -0.1981 | -0.1164 | 0.0161 | -0.0096 | -0.0838 |
| 40 | 8.00 | -0.2151 | 0.1799 | 0.0090 | -0.1971 | -0.1152 | 0.0162 | -0.0098 | -0.0834 |
| 41 | 8.50 | -0.2117 | 0.1812 | 0.0100 | -0.1960 | -0.1143 | 0.0164 | -0.0100 | -0.0830 |
| 42 | 9.00 | -0.2080 | 0.1825 | 0.0109 | -0.1949 | -0.1130 | 0.0166 | -0.0102 | -0.0825 |
| 43 | 9.50 | -0.2046 | 0.1834 | 0.0118 | -0.1937 | -0.1119 | 0.0167 | -0.0104 | -0.0820 |
| 44 | 10.00 | -0.2014 | 0.1843 | 0.0127 | -0.1924 | -0.1110 | 0.0168 | -0.0106 | -0.0815 |
| 45 | 11.00 | -0.1951 | 0.1860 | 0.0144 | -0.1899 | -0.1091 | 0.0170 | -0.0108 | -0.0804 |
| 46 | 12.00 | -0.1890 | 0.1873 | 0.0159 | -0.1874 | -0.1071 | 0.0172 | -0.0111 | -0.0794 |
| 47 | 13.00 | -0.1835 | 0.1884 | 0.0174 | -0.1850 | -0.1053 | 0.0173 | -0.0113 | -0.0784 |
| 48 | 14.00 | -0.1781 | 0.1893 | 0.0189 | -0.1825 | -0.1036 | 0.0175 | -0.0115 | -0.0773 |
| 49 | 15.00 | -0.1733 | 0.1900 | 0.0202 | -0.1802 | -0.1020 | 0.0176 | -0.0117 | -0.0764 |
| 50 | 16.00 | -0.1685 | 0.1903 | 0.0214 | -0.1778 | -0.1005 | 0.0177 | -0.0118 | -0.0753 |
| 51 | 17.00 | -0.1641 | 0.1904 | 0.0225 | -0.1756 | -0.0989 | 0.0177 | -0.0119 | -0.0743 |
| 52 | 18.00 | -0.1601 | 0.1903 | 0.0235 | -0.1735 | -0.0976 | 0.0177 | -0.0121 | -0.0734 |
| 53 | 19.00 | -0.1562 | 0.1906 | 0.0246 | -0.1716 | -0.0964 | 0.0178 | -0.0122 | -0.0726 |
| 54 | 20.00 | -0.1524 | 0.1907 | 0.0255 | -0.1696 | -0.0951 | 0.0179 | -0.0123 | -0.0718 |

| | | | | | | | | | |
|----|--------|---------|--------|--------|---------|---------|--------|---------|---------|
| 55 | 22.00 | -0.1454 | 0.1904 | 0.0271 | -0.1659 | -0.0927 | 0.0179 | -0.0125 | -0.0702 |
| 56 | 24.00 | -0.1394 | 0.1901 | 0.0286 | -0.1625 | -0.0906 | 0.0179 | -0.0126 | -0.0687 |
| 57 | 26.00 | -0.1339 | 0.1892 | 0.0297 | -0.1594 | -0.0886 | 0.0179 | -0.0127 | -0.0673 |
| 58 | 28.00 | -0.1290 | 0.1883 | 0.0308 | -0.1564 | -0.0868 | 0.0178 | -0.0128 | -0.0660 |
| 59 | 30.00 | -0.1244 | 0.1873 | 0.0316 | -0.1534 | -0.0851 | 0.0177 | -0.0129 | -0.0648 |
| 60 | 32.00 | -0.1204 | 0.1862 | 0.0323 | -0.1507 | -0.0835 | 0.0177 | -0.0129 | -0.0636 |
| 61 | 34.00 | -0.1163 | 0.1847 | 0.0326 | -0.1480 | -0.0820 | 0.0176 | -0.0129 | -0.0626 |
| 62 | 36.00 | -0.1127 | 0.1834 | 0.0330 | -0.1455 | -0.0805 | 0.0176 | -0.0129 | -0.0616 |
| 63 | 38.00 | -0.1094 | 0.1819 | 0.0333 | -0.1431 | -0.0792 | 0.0175 | -0.0129 | -0.0606 |
| 64 | 40.00 | -0.1065 | 0.1803 | 0.0335 | -0.1407 | -0.0779 | 0.0174 | -0.0129 | -0.0596 |
| 65 | 45.00 | -0.0997 | 0.1757 | 0.0336 | -0.1350 | -0.0749 | 0.0170 | -0.0128 | -0.0573 |
| 66 | 50.00 | -0.0938 | 0.1710 | 0.0332 | -0.1298 | -0.0719 | 0.0167 | -0.0126 | -0.0552 |
| 67 | 55.00 | -0.0885 | 0.1662 | 0.0327 | -0.1248 | -0.0691 | 0.0164 | -0.0124 | -0.0532 |
| 68 | 60.00 | -0.0841 | 0.1610 | 0.0320 | -0.1201 | -0.0666 | 0.0160 | -0.0121 | -0.0512 |
| 69 | 65.00 | -0.0798 | 0.1557 | 0.0312 | -0.1156 | -0.0640 | 0.0156 | -0.0118 | -0.0494 |
| 70 | 70.00 | -0.0762 | 0.1507 | 0.0303 | -0.1112 | -0.0618 | 0.0152 | -0.0116 | -0.0476 |
| 71 | 75.00 | -0.0728 | 0.1456 | 0.0295 | -0.1071 | -0.0596 | 0.0148 | -0.0113 | -0.0460 |
| 72 | 80.00 | -0.0694 | 0.1405 | 0.0285 | -0.1031 | -0.0573 | 0.0144 | -0.0109 | -0.0443 |
| 73 | 85.00 | -0.0663 | 0.1357 | 0.0277 | -0.0993 | -0.0553 | 0.0140 | -0.0106 | -0.0428 |
| 74 | 90.00 | -0.0634 | 0.1310 | 0.0268 | -0.0956 | -0.0534 | 0.0135 | -0.0103 | -0.0413 |
| 75 | 95.00 | -0.0608 | 0.1267 | 0.0260 | -0.0922 | -0.0515 | 0.0131 | -0.0100 | -0.0399 |
| 76 | 100.00 | -0.0585 | 0.1225 | 0.0252 | -0.0889 | -0.0496 | 0.0128 | -0.0097 | -0.0385 |
| 77 | 110.00 | -0.0538 | 0.1144 | 0.0236 | -0.0826 | -0.0462 | 0.0120 | -0.0092 | -0.0359 |
| 78 | 120.00 | -0.0496 | 0.1070 | 0.0222 | -0.0769 | -0.0430 | 0.0113 | -0.0086 | -0.0335 |
| 79 | 130.00 | -0.0457 | 0.1000 | 0.0208 | -0.0716 | -0.0400 | 0.0106 | -0.0081 | -0.0312 |
| 80 | 140.00 | -0.0421 | 0.0933 | 0.0195 | -0.0666 | -0.0374 | 0.0100 | -0.0076 | -0.0291 |
| 81 | 150.00 | -0.0391 | 0.0871 | 0.0183 | -0.0620 | -0.0348 | 0.0094 | -0.0072 | -0.0272 |
| 82 | 160.00 | -0.0363 | 0.0814 | 0.0171 | -0.0577 | -0.0324 | 0.0088 | -0.0067 | -0.0254 |
| 83 | 170.00 | -0.0333 | 0.0760 | 0.0161 | -0.0538 | -0.0303 | 0.0083 | -0.0063 | -0.0237 |
| 84 | 180.00 | -0.0306 | 0.0709 | 0.0151 | -0.0501 | -0.0282 | 0.0078 | -0.0059 | -0.0222 |
| 85 | 190.00 | -0.0283 | 0.0663 | 0.0142 | -0.0467 | -0.0262 | 0.0073 | -0.0056 | -0.0207 |
| 86 | 200.00 | -0.0262 | 0.0618 | 0.0134 | -0.0436 | -0.0244 | 0.0068 | -0.0052 | -0.0194 |
| 87 | 220.00 | -0.0226 | 0.0539 | 0.0117 | -0.0380 | -0.0212 | 0.0060 | -0.0046 | -0.0169 |
| 88 | 240.00 | -0.0191 | 0.0473 | 0.0103 | -0.0331 | -0.0185 | 0.0053 | -0.0040 | -0.0148 |
| 89 | 260.00 | -0.0162 | 0.0414 | 0.0091 | -0.0288 | -0.0160 | 0.0048 | -0.0035 | -0.0130 |
| 90 | 280.00 | -0.0138 | 0.0362 | 0.0080 | -0.0252 | -0.0138 | 0.0042 | -0.0031 | -0.0114 |
| 91 | 300.00 | -0.0118 | 0.0315 | 0.0070 | -0.0219 | -0.0120 | 0.0037 | -0.0027 | -0.0100 |
| 92 | 350.00 | -0.0081 | 0.0223 | 0.0050 | -0.0155 | -0.0083 | 0.0027 | -0.0020 | -0.0070 |
| 93 | 400.00 | -0.0054 | 0.0156 | 0.0035 | -0.0110 | -0.0056 | 0.0020 | -0.0014 | -0.0050 |
| 94 | 450.00 | -0.0036 | 0.0110 | 0.0024 | -0.0078 | -0.0038 | 0.0015 | -0.0010 | -0.0036 |
| 95 | 500.00 | -0.0020 | 0.0076 | 0.0017 | -0.0055 | -0.0024 | 0.0012 | -0.0007 | -0.0026 |

表2. 6 (1) 評価断面6の応力テンソル成分1、2

ステップ温度変化の基本解

断面6

| ステップ | 時間(S) | 応力成分1 | | | | 応力成分2 | | | |
|------|-------|---------|---------|---------|---------|---------|---------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.01 | -0.0072 | 0.0000 | -0.0001 | -0.0003 | -0.0141 | -0.0001 | -0.0001 | -0.0004 |
| 3 | 0.04 | -0.0396 | 0.0000 | -0.0003 | -0.0017 | -0.0814 | -0.0007 | -0.0004 | -0.0025 |
| 4 | 0.07 | -0.0534 | 0.0000 | -0.0004 | -0.0024 | -0.1203 | -0.0012 | -0.0006 | -0.0042 |
| 5 | 0.10 | -0.0580 | 0.0000 | -0.0002 | -0.0026 | -0.1443 | -0.0018 | -0.0008 | -0.0056 |
| 6 | 0.20 | -0.0553 | 0.0000 | 0.0005 | -0.0025 | -0.1863 | -0.0033 | -0.0012 | -0.0094 |
| 7 | 0.30 | -0.0462 | 0.0000 | 0.0015 | -0.0018 | -0.2050 | -0.0046 | -0.0014 | -0.0123 |
| 8 | 0.40 | -0.0400 | -0.0001 | 0.0024 | -0.0010 | -0.2190 | -0.0058 | -0.0015 | -0.0148 |
| 9 | 0.50 | -0.0354 | -0.0001 | 0.0033 | -0.0003 | -0.2296 | -0.0070 | -0.0016 | -0.0169 |
| 10 | 0.60 | -0.0316 | -0.0001 | 0.0041 | 0.0004 | -0.2376 | -0.0081 | -0.0017 | -0.0189 |
| 11 | 0.70 | -0.0286 | -0.0001 | 0.0049 | 0.0010 | -0.2442 | -0.0092 | -0.0018 | -0.0207 |
| 12 | 0.80 | -0.0260 | -0.0001 | 0.0056 | 0.0016 | -0.2493 | -0.0102 | -0.0018 | -0.0223 |
| 13 | 0.90 | -0.0240 | -0.0001 | 0.0063 | 0.0020 | -0.2539 | -0.0111 | -0.0018 | -0.0238 |
| 14 | 1.00 | -0.0222 | -0.0001 | 0.0069 | 0.0024 | -0.2577 | -0.0121 | -0.0019 | -0.0252 |
| 15 | 1.20 | -0.0195 | -0.0001 | 0.0080 | 0.0030 | -0.2637 | -0.0139 | -0.0019 | -0.0279 |
| 16 | 1.40 | -0.0172 | -0.0001 | 0.0089 | 0.0034 | -0.2681 | -0.0155 | -0.0020 | -0.0302 |
| 17 | 1.60 | -0.0152 | -0.0001 | 0.0098 | 0.0037 | -0.2710 | -0.0171 | -0.0020 | -0.0324 |
| 18 | 1.80 | -0.0139 | -0.0002 | 0.0105 | 0.0039 | -0.2737 | -0.0186 | -0.0021 | -0.0344 |
| 19 | 2.00 | -0.0128 | -0.0002 | 0.0112 | 0.0040 | -0.2753 | -0.0201 | -0.0021 | -0.0362 |
| 20 | 2.20 | -0.0122 | -0.0002 | 0.0118 | 0.0040 | -0.2767 | -0.0215 | -0.0021 | -0.0378 |
| 21 | 2.40 | -0.0113 | -0.0002 | 0.0124 | 0.0040 | -0.2771 | -0.0228 | -0.0022 | -0.0393 |
| 22 | 2.60 | -0.0104 | -0.0002 | 0.0130 | 0.0040 | -0.2771 | -0.0241 | -0.0022 | -0.0407 |
| 23 | 2.80 | -0.0095 | -0.0002 | 0.0135 | 0.0040 | -0.2768 | -0.0255 | -0.0022 | -0.0420 |
| 24 | 3.00 | -0.0092 | -0.0002 | 0.0140 | 0.0039 | -0.2768 | -0.0267 | -0.0022 | -0.0432 |
| 25 | 3.20 | -0.0089 | -0.0002 | 0.0145 | 0.0038 | -0.2762 | -0.0279 | -0.0022 | -0.0443 |
| 26 | 3.40 | -0.0088 | -0.0002 | 0.0149 | 0.0037 | -0.2759 | -0.0291 | -0.0022 | -0.0454 |
| 27 | 3.60 | -0.0083 | -0.0003 | 0.0153 | 0.0036 | -0.2751 | -0.0303 | -0.0023 | -0.0464 |
| 28 | 3.80 | -0.0079 | -0.0003 | 0.0157 | 0.0034 | -0.2743 | -0.0314 | -0.0023 | -0.0473 |
| 29 | 4.00 | -0.0077 | -0.0003 | 0.0161 | 0.0033 | -0.2731 | -0.0326 | -0.0023 | -0.0481 |
| 30 | 4.20 | -0.0074 | -0.0004 | 0.0164 | 0.0031 | -0.2721 | -0.0337 | -0.0023 | -0.0490 |
| 31 | 4.40 | -0.0072 | -0.0004 | 0.0168 | 0.0030 | -0.2711 | -0.0349 | -0.0023 | -0.0497 |
| 32 | 4.60 | -0.0068 | -0.0004 | 0.0171 | 0.0028 | -0.2697 | -0.0361 | -0.0024 | -0.0504 |
| 33 | 4.80 | -0.0066 | -0.0005 | 0.0174 | 0.0026 | -0.2684 | -0.0373 | -0.0024 | -0.0510 |
| 34 | 5.00 | -0.0065 | -0.0005 | 0.0177 | 0.0024 | -0.2672 | -0.0383 | -0.0025 | -0.0517 |
| 35 | 5.50 | -0.0061 | -0.0006 | 0.0182 | 0.0020 | -0.2640 | -0.0406 | -0.0026 | -0.0532 |
| 36 | 6.00 | -0.0059 | -0.0007 | 0.0187 | 0.0016 | -0.2606 | -0.0426 | -0.0026 | -0.0545 |
| 37 | 6.50 | -0.0056 | -0.0007 | 0.0190 | 0.0010 | -0.2569 | -0.0443 | -0.0027 | -0.0557 |
| 38 | 7.00 | -0.0053 | -0.0006 | 0.0193 | 0.0005 | -0.2530 | -0.0458 | -0.0027 | -0.0568 |
| 39 | 7.50 | -0.0050 | -0.0006 | 0.0196 | 0.0001 | -0.2494 | -0.0471 | -0.0028 | -0.0577 |
| 40 | 8.00 | -0.0046 | -0.0007 | 0.0197 | -0.0004 | -0.2456 | -0.0483 | -0.0029 | -0.0585 |
| 41 | 8.50 | -0.0044 | -0.0007 | 0.0198 | -0.0008 | -0.2421 | -0.0494 | -0.0030 | -0.0593 |
| 42 | 9.00 | -0.0045 | -0.0007 | 0.0199 | -0.0012 | -0.2389 | -0.0502 | -0.0030 | -0.0600 |
| 43 | 9.50 | -0.0043 | -0.0007 | 0.0199 | -0.0016 | -0.2353 | -0.0507 | -0.0031 | -0.0606 |
| 44 | 10.00 | -0.0043 | -0.0007 | 0.0198 | -0.0019 | -0.2321 | -0.0510 | -0.0031 | -0.0612 |
| 45 | 11.00 | -0.0040 | -0.0010 | 0.0197 | -0.0026 | -0.2255 | -0.0520 | -0.0033 | -0.0622 |
| 46 | 12.00 | -0.0039 | -0.0010 | 0.0195 | -0.0031 | -0.2192 | -0.0518 | -0.0034 | -0.0630 |
| 47 | 13.00 | -0.0038 | -0.0009 | 0.0191 | -0.0036 | -0.2134 | -0.0513 | -0.0035 | -0.0637 |
| 48 | 14.00 | -0.0037 | -0.0009 | 0.0188 | -0.0040 | -0.2078 | -0.0504 | -0.0035 | -0.0643 |
| 49 | 15.00 | -0.0037 | -0.0009 | 0.0184 | -0.0043 | -0.2025 | -0.0493 | -0.0036 | -0.0648 |
| 50 | 16.00 | -0.0035 | -0.0008 | 0.0180 | -0.0046 | -0.1972 | -0.0482 | -0.0037 | -0.0651 |
| 51 | 17.00 | -0.0034 | -0.0008 | 0.0176 | -0.0049 | -0.1923 | -0.0469 | -0.0038 | -0.0655 |
| 52 | 18.00 | -0.0033 | -0.0008 | 0.0172 | -0.0052 | -0.1875 | -0.0451 | -0.0039 | -0.0657 |
| 53 | 19.00 | -0.0031 | -0.0007 | 0.0168 | -0.0054 | -0.1829 | -0.0431 | -0.0039 | -0.0660 |
| 54 | 20.00 | -0.0031 | -0.0006 | 0.0163 | -0.0056 | -0.1789 | -0.0411 | -0.0039 | -0.0662 |

| | | | | | | | | | |
|----|--------|---------|---------|--------|---------|---------|---------|---------|---------|
| 55 | 22.00 | -0.0029 | -0.0004 | 0.0155 | -0.0059 | -0.1710 | -0.0373 | -0.0040 | -0.0664 |
| 56 | 24.00 | -0.0026 | -0.0004 | 0.0148 | -0.0059 | -0.1638 | -0.0335 | -0.0041 | -0.0664 |
| 57 | 26.00 | -0.0023 | -0.0004 | 0.0141 | -0.0060 | -0.1572 | -0.0297 | -0.0042 | -0.0663 |
| 58 | 28.00 | -0.0022 | -0.0002 | 0.0134 | -0.0061 | -0.1512 | -0.0261 | -0.0042 | -0.0662 |
| 59 | 30.00 | -0.0021 | -0.0002 | 0.0128 | -0.0061 | -0.1458 | -0.0226 | -0.0043 | -0.0659 |
| 60 | 32.00 | -0.0018 | -0.0001 | 0.0122 | -0.0062 | -0.1407 | -0.0192 | -0.0043 | -0.0656 |
| 61 | 34.00 | -0.0018 | 0.0000 | 0.0116 | -0.0063 | -0.1363 | -0.0161 | -0.0044 | -0.0653 |
| 62 | 36.00 | -0.0018 | 0.0000 | 0.0111 | -0.0063 | -0.1322 | -0.0134 | -0.0044 | -0.0649 |
| 63 | 38.00 | -0.0017 | 0.0001 | 0.0106 | -0.0063 | -0.1284 | -0.0105 | -0.0045 | -0.0645 |
| 64 | 40.00 | -0.0017 | 0.0001 | 0.0102 | -0.0062 | -0.1246 | -0.0080 | -0.0045 | -0.0639 |
| 65 | 45.00 | -0.0015 | 0.0001 | 0.0093 | -0.0061 | -0.1164 | -0.0025 | -0.0046 | -0.0625 |
| 66 | 50.00 | -0.0015 | 0.0001 | 0.0085 | -0.0059 | -0.1096 | 0.0021 | -0.0046 | -0.0609 |
| 67 | 55.00 | -0.0013 | 0.0000 | 0.0078 | -0.0057 | -0.1032 | 0.0058 | -0.0046 | -0.0592 |
| 68 | 60.00 | -0.0011 | 0.0000 | 0.0073 | -0.0055 | -0.0972 | 0.0089 | -0.0046 | -0.0575 |
| 69 | 65.00 | -0.0010 | -0.0001 | 0.0067 | -0.0054 | -0.0921 | 0.0113 | -0.0046 | -0.0557 |
| 70 | 70.00 | -0.0007 | -0.0001 | 0.0062 | -0.0052 | -0.0872 | 0.0131 | -0.0045 | -0.0540 |
| 71 | 75.00 | -0.0006 | -0.0001 | 0.0058 | -0.0051 | -0.0828 | 0.0147 | -0.0045 | -0.0523 |
| 72 | 80.00 | -0.0004 | -0.0002 | 0.0054 | -0.0049 | -0.0787 | 0.0158 | -0.0044 | -0.0506 |
| 73 | 85.00 | -0.0005 | -0.0002 | 0.0051 | -0.0047 | -0.0753 | 0.0166 | -0.0044 | -0.0489 |
| 74 | 90.00 | -0.0006 | -0.0001 | 0.0049 | -0.0045 | -0.0720 | 0.0173 | -0.0043 | -0.0474 |
| 75 | 95.00 | -0.0006 | -0.0002 | 0.0046 | -0.0044 | -0.0688 | 0.0177 | -0.0042 | -0.0458 |
| 76 | 100.00 | -0.0004 | 0.0000 | 0.0044 | -0.0042 | -0.0656 | 0.0183 | -0.0041 | -0.0442 |
| 77 | 110.00 | -0.0004 | 0.0000 | 0.0040 | -0.0039 | -0.0600 | 0.0187 | -0.0040 | -0.0413 |
| 78 | 120.00 | -0.0004 | -0.0001 | 0.0036 | -0.0036 | -0.0551 | 0.0185 | -0.0038 | -0.0385 |
| 79 | 130.00 | -0.0003 | -0.0001 | 0.0033 | -0.0034 | -0.0506 | 0.0183 | -0.0036 | -0.0360 |
| 80 | 140.00 | -0.0004 | -0.0001 | 0.0030 | -0.0032 | -0.0468 | 0.0177 | -0.0034 | -0.0337 |
| 81 | 150.00 | -0.0003 | -0.0002 | 0.0028 | -0.0029 | -0.0432 | 0.0172 | -0.0033 | -0.0314 |
| 82 | 160.00 | -0.0001 | -0.0002 | 0.0026 | -0.0027 | -0.0397 | 0.0166 | -0.0031 | -0.0294 |
| 83 | 170.00 | -0.0002 | -0.0003 | 0.0024 | -0.0025 | -0.0368 | 0.0158 | -0.0029 | -0.0274 |
| 84 | 180.00 | -0.0001 | -0.0003 | 0.0022 | -0.0023 | -0.0340 | 0.0150 | -0.0027 | -0.0256 |
| 85 | 190.00 | 0.0000 | -0.0004 | 0.0020 | -0.0021 | -0.0314 | 0.0144 | -0.0026 | -0.0239 |
| 86 | 200.00 | 0.0000 | -0.0004 | 0.0018 | -0.0020 | -0.0291 | 0.0137 | -0.0024 | -0.0224 |
| 87 | 220.00 | 0.0000 | -0.0005 | 0.0015 | -0.0017 | -0.0251 | 0.0123 | -0.0021 | -0.0195 |
| 88 | 240.00 | 0.0002 | -0.0005 | 0.0013 | -0.0015 | -0.0213 | 0.0108 | -0.0019 | -0.0170 |
| 89 | 260.00 | 0.0003 | -0.0005 | 0.0011 | -0.0012 | -0.0181 | 0.0095 | -0.0016 | -0.0148 |
| 90 | 280.00 | 0.0004 | -0.0005 | 0.0010 | -0.0009 | -0.0154 | 0.0083 | -0.0014 | -0.0129 |
| 91 | 300.00 | 0.0005 | -0.0005 | 0.0008 | -0.0008 | -0.0130 | 0.0074 | -0.0012 | -0.0112 |
| 92 | 350.00 | 0.0007 | -0.0005 | 0.0005 | -0.0005 | -0.0085 | 0.0050 | -0.0009 | -0.0078 |
| 93 | 400.00 | 0.0007 | -0.0005 | 0.0004 | -0.0003 | -0.0053 | 0.0031 | -0.0007 | -0.0054 |
| 94 | 450.00 | 0.0006 | -0.0006 | 0.0002 | -0.0001 | -0.0033 | 0.0017 | -0.0004 | -0.0037 |
| 95 | 500.00 | 0.0009 | -0.0005 | 0.0001 | 0.0000 | -0.0017 | 0.0010 | -0.0003 | -0.0025 |

表 2. 6 (2) 評価断面6の応力テンソル成分3、4

ステップ温度変化の基本解

断面6

| ステップ | 時間(S) | 応力成分3 | | | | 応力成分4 | | | |
|------|-------|---------|--------|--------|---------|---------|---------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.01 | -0.0145 | 0.0003 | 0.0000 | -0.0008 | -0.0006 | 0.0000 | 0.0000 | -0.0001 |
| 3 | 0.04 | -0.0833 | 0.0019 | 0.0001 | -0.0044 | -0.0041 | -0.0001 | 0.0000 | -0.0003 |
| 4 | 0.07 | -0.1233 | 0.0032 | 0.0002 | -0.0074 | -0.0066 | -0.0001 | 0.0000 | -0.0006 |
| 5 | 0.10 | -0.1481 | 0.0044 | 0.0004 | -0.0100 | -0.0086 | -0.0002 | 0.0000 | -0.0009 |
| 6 | 0.20 | -0.1924 | 0.0081 | 0.0009 | -0.0174 | -0.0129 | -0.0003 | 0.0000 | -0.0017 |
| 7 | 0.30 | -0.2128 | 0.0112 | 0.0016 | -0.0234 | -0.0153 | -0.0005 | 0.0000 | -0.0024 |
| 8 | 0.40 | -0.2284 | 0.0142 | 0.0022 | -0.0288 | -0.0171 | -0.0006 | 0.0000 | -0.0031 |
| 9 | 0.50 | -0.2405 | 0.0169 | 0.0029 | -0.0337 | -0.0184 | -0.0007 | -0.0001 | -0.0037 |
| 10 | 0.60 | -0.2502 | 0.0194 | 0.0035 | -0.0381 | -0.0196 | -0.0008 | -0.0001 | -0.0043 |
| 11 | 0.70 | -0.2581 | 0.0219 | 0.0041 | -0.0423 | -0.0204 | -0.0009 | -0.0001 | -0.0048 |
| 12 | 0.80 | -0.2651 | 0.0243 | 0.0047 | -0.0463 | -0.0211 | -0.0010 | -0.0001 | -0.0053 |
| 13 | 0.90 | -0.2713 | 0.0265 | 0.0052 | -0.0502 | -0.0216 | -0.0011 | -0.0001 | -0.0057 |
| 14 | 1.00 | -0.2767 | 0.0287 | 0.0057 | -0.0538 | -0.0222 | -0.0012 | -0.0001 | -0.0062 |
| 15 | 1.20 | -0.2859 | 0.0329 | 0.0067 | -0.0608 | -0.0230 | -0.0013 | -0.0001 | -0.0070 |
| 16 | 1.40 | -0.2934 | 0.0368 | 0.0076 | -0.0672 | -0.0236 | -0.0015 | -0.0001 | -0.0078 |
| 17 | 1.60 | -0.2995 | 0.0406 | 0.0085 | -0.0733 | -0.0240 | -0.0017 | -0.0001 | -0.0086 |
| 18 | 1.80 | -0.3050 | 0.0443 | 0.0094 | -0.0790 | -0.0244 | -0.0018 | -0.0001 | -0.0093 |
| 19 | 2.00 | -0.3096 | 0.0477 | 0.0102 | -0.0846 | -0.0247 | -0.0020 | -0.0001 | -0.0099 |
| 20 | 2.20 | -0.3138 | 0.0511 | 0.0109 | -0.0898 | -0.0250 | -0.0021 | -0.0001 | -0.0105 |
| 21 | 2.40 | -0.3171 | 0.0543 | 0.0117 | -0.0948 | -0.0250 | -0.0022 | -0.0001 | -0.0111 |
| 22 | 2.60 | -0.3200 | 0.0575 | 0.0123 | -0.0996 | -0.0252 | -0.0024 | -0.0001 | -0.0117 |
| 23 | 2.80 | -0.3224 | 0.0605 | 0.0130 | -0.1042 | -0.0253 | -0.0025 | -0.0001 | -0.0123 |
| 24 | 3.00 | -0.3250 | 0.0634 | 0.0137 | -0.1086 | -0.0253 | -0.0026 | 0.0000 | -0.0128 |
| 25 | 3.20 | -0.3271 | 0.0663 | 0.0143 | -0.1128 | -0.0253 | -0.0027 | 0.0000 | -0.0133 |
| 26 | 3.40 | -0.3292 | 0.0691 | 0.0149 | -0.1170 | -0.0253 | -0.0029 | 0.0000 | -0.0138 |
| 27 | 3.60 | -0.3309 | 0.0719 | 0.0155 | -0.1210 | -0.0252 | -0.0030 | 0.0000 | -0.0143 |
| 28 | 3.80 | -0.3326 | 0.0745 | 0.0161 | -0.1248 | -0.0252 | -0.0031 | 0.0000 | -0.0148 |
| 29 | 4.00 | -0.3338 | 0.0771 | 0.0166 | -0.1286 | -0.0251 | -0.0032 | 0.0000 | -0.0152 |
| 30 | 4.20 | -0.3350 | 0.0797 | 0.0171 | -0.1323 | -0.0251 | -0.0033 | 0.0000 | -0.0157 |
| 31 | 4.40 | -0.3363 | 0.0822 | 0.0176 | -0.1358 | -0.0250 | -0.0034 | 0.0000 | -0.0161 |
| 32 | 4.60 | -0.3372 | 0.0846 | 0.0180 | -0.1393 | -0.0249 | -0.0036 | 0.0000 | -0.0165 |
| 33 | 4.80 | -0.3380 | 0.0868 | 0.0184 | -0.1426 | -0.0249 | -0.0037 | 0.0000 | -0.0169 |
| 34 | 5.00 | -0.3389 | 0.0892 | 0.0188 | -0.1460 | -0.0248 | -0.0038 | 0.0000 | -0.0173 |
| 35 | 5.50 | -0.3408 | 0.0947 | 0.0197 | -0.1536 | -0.0246 | -0.0040 | 0.0001 | -0.0182 |
| 36 | 6.00 | -0.3422 | 0.1000 | 0.0204 | -0.1608 | -0.0244 | -0.0042 | 0.0001 | -0.0192 |
| 37 | 6.50 | -0.3433 | 0.1050 | 0.0210 | -0.1676 | -0.0241 | -0.0044 | 0.0001 | -0.0200 |
| 38 | 7.00 | -0.3439 | 0.1099 | 0.0215 | -0.1739 | -0.0238 | -0.0045 | 0.0001 | -0.0208 |
| 39 | 7.50 | -0.3446 | 0.1144 | 0.0219 | -0.1798 | -0.0236 | -0.0047 | 0.0001 | -0.0215 |
| 40 | 8.00 | -0.3449 | 0.1186 | 0.0221 | -0.1853 | -0.0232 | -0.0047 | 0.0001 | -0.0222 |
| 41 | 8.50 | -0.3453 | 0.1228 | 0.0223 | -0.1905 | -0.0229 | -0.0048 | 0.0002 | -0.0229 |
| 42 | 9.00 | -0.3457 | 0.1267 | 0.0224 | -0.1953 | -0.0227 | -0.0048 | 0.0002 | -0.0234 |
| 43 | 9.50 | -0.3456 | 0.1303 | 0.0224 | -0.1998 | -0.0223 | -0.0049 | 0.0002 | -0.0240 |
| 44 | 10.00 | -0.3457 | 0.1338 | 0.0224 | -0.2039 | -0.0220 | -0.0049 | 0.0002 | -0.0244 |
| 45 | 11.00 | -0.3452 | 0.1400 | 0.0222 | -0.2115 | -0.0214 | -0.0049 | 0.0002 | -0.0253 |
| 46 | 12.00 | -0.3445 | 0.1458 | 0.0217 | -0.2180 | -0.0209 | -0.0049 | 0.0002 | -0.0260 |
| 47 | 13.00 | -0.3438 | 0.1509 | 0.0211 | -0.2236 | -0.0204 | -0.0048 | 0.0002 | -0.0266 |
| 48 | 14.00 | -0.3428 | 0.1556 | 0.0204 | -0.2286 | -0.0199 | -0.0047 | 0.0002 | -0.0271 |
| 49 | 15.00 | -0.3418 | 0.1597 | 0.0196 | -0.2328 | -0.0195 | -0.0046 | 0.0003 | -0.0275 |
| 50 | 16.00 | -0.3404 | 0.1632 | 0.0187 | -0.2364 | -0.0190 | -0.0045 | 0.0003 | -0.0278 |
| 51 | 17.00 | -0.3390 | 0.1661 | 0.0177 | -0.2395 | -0.0186 | -0.0043 | 0.0003 | -0.0281 |
| 52 | 18.00 | -0.3374 | 0.1689 | 0.0167 | -0.2420 | -0.0181 | -0.0041 | 0.0003 | -0.0283 |
| 53 | 19.00 | -0.3358 | 0.1715 | 0.0158 | -0.2442 | -0.0176 | -0.0039 | 0.0003 | -0.0284 |
| 54 | 20.00 | -0.3342 | 0.1737 | 0.0147 | -0.2460 | -0.0172 | -0.0037 | 0.0003 | -0.0285 |

| | | | | | | | | | |
|----|--------|---------|--------|---------|---------|---------|---------|--------|---------|
| 55 | 22.00 | -0.3307 | 0.1769 | 0.0127 | -0.2486 | -0.0166 | -0.0034 | 0.0003 | -0.0285 |
| 56 | 24.00 | -0.3273 | 0.1792 | 0.0107 | -0.2500 | -0.0159 | -0.0030 | 0.0003 | -0.0284 |
| 57 | 26.00 | -0.3236 | 0.1807 | 0.0087 | -0.2506 | -0.0154 | -0.0027 | 0.0003 | -0.0283 |
| 58 | 28.00 | -0.3199 | 0.1814 | 0.0067 | -0.2504 | -0.0149 | -0.0024 | 0.0003 | -0.0281 |
| 59 | 30.00 | -0.3161 | 0.1817 | 0.0049 | -0.2497 | -0.0144 | -0.0020 | 0.0003 | -0.0279 |
| 60 | 32.00 | -0.3122 | 0.1814 | 0.0031 | -0.2486 | -0.0140 | -0.0017 | 0.0003 | -0.0276 |
| 61 | 34.00 | -0.3086 | 0.1807 | 0.0014 | -0.2470 | -0.0136 | -0.0014 | 0.0003 | -0.0273 |
| 62 | 36.00 | -0.3049 | 0.1796 | -0.0002 | -0.2451 | -0.0131 | -0.0012 | 0.0003 | -0.0270 |
| 63 | 38.00 | -0.3011 | 0.1785 | -0.0017 | -0.2429 | -0.0128 | -0.0009 | 0.0003 | -0.0266 |
| 64 | 40.00 | -0.2970 | 0.1769 | -0.0030 | -0.2404 | -0.0125 | -0.0007 | 0.0003 | -0.0263 |
| 65 | 45.00 | -0.2876 | 0.1720 | -0.0062 | -0.2338 | -0.0117 | -0.0002 | 0.0003 | -0.0254 |
| 66 | 50.00 | -0.2783 | 0.1664 | -0.0088 | -0.2265 | -0.0110 | 0.0002 | 0.0003 | -0.0245 |
| 67 | 55.00 | -0.2689 | 0.1608 | -0.0111 | -0.2190 | -0.0104 | 0.0005 | 0.0003 | -0.0236 |
| 68 | 60.00 | -0.2598 | 0.1547 | -0.0130 | -0.2114 | -0.0099 | 0.0007 | 0.0003 | -0.0227 |
| 69 | 65.00 | -0.2512 | 0.1487 | -0.0146 | -0.2040 | -0.0094 | 0.0010 | 0.0003 | -0.0218 |
| 70 | 70.00 | -0.2425 | 0.1427 | -0.0159 | -0.1966 | -0.0089 | 0.0011 | 0.0003 | -0.0210 |
| 71 | 75.00 | -0.2342 | 0.1369 | -0.0170 | -0.1895 | -0.0086 | 0.0013 | 0.0003 | -0.0202 |
| 72 | 80.00 | -0.2261 | 0.1312 | -0.0179 | -0.1826 | -0.0081 | 0.0014 | 0.0003 | -0.0194 |
| 73 | 85.00 | -0.2185 | 0.1258 | -0.0185 | -0.1759 | -0.0078 | 0.0014 | 0.0003 | -0.0186 |
| 74 | 90.00 | -0.2113 | 0.1208 | -0.0190 | -0.1694 | -0.0075 | 0.0015 | 0.0003 | -0.0179 |
| 75 | 95.00 | -0.2042 | 0.1159 | -0.0194 | -0.1633 | -0.0072 | 0.0015 | 0.0002 | -0.0172 |
| 76 | 100.00 | -0.1971 | 0.1114 | -0.0196 | -0.1573 | -0.0069 | 0.0015 | 0.0002 | -0.0166 |
| 77 | 110.00 | -0.1840 | 0.1025 | -0.0199 | -0.1461 | -0.0063 | 0.0015 | 0.0002 | -0.0154 |
| 78 | 120.00 | -0.1716 | 0.0944 | -0.0198 | -0.1357 | -0.0059 | 0.0015 | 0.0002 | -0.0142 |
| 79 | 130.00 | -0.1602 | 0.0872 | -0.0195 | -0.1263 | -0.0054 | 0.0014 | 0.0002 | -0.0132 |
| 80 | 140.00 | -0.1496 | 0.0806 | -0.0191 | -0.1175 | -0.0051 | 0.0014 | 0.0002 | -0.0122 |
| 81 | 150.00 | -0.1397 | 0.0745 | -0.0185 | -0.1093 | -0.0048 | 0.0014 | 0.0002 | -0.0113 |
| 82 | 160.00 | -0.1303 | 0.0688 | -0.0179 | -0.1017 | -0.0045 | 0.0013 | 0.0002 | -0.0105 |
| 83 | 170.00 | -0.1215 | 0.0636 | -0.0172 | -0.0946 | -0.0041 | 0.0012 | 0.0001 | -0.0097 |
| 84 | 180.00 | -0.1133 | 0.0590 | -0.0165 | -0.0881 | -0.0039 | 0.0012 | 0.0001 | -0.0090 |
| 85 | 190.00 | -0.1058 | 0.0546 | -0.0158 | -0.0821 | -0.0037 | 0.0012 | 0.0001 | -0.0084 |
| 86 | 200.00 | -0.0987 | 0.0508 | -0.0150 | -0.0766 | -0.0034 | 0.0011 | 0.0001 | -0.0078 |
| 87 | 220.00 | -0.0861 | 0.0435 | -0.0136 | -0.0665 | -0.0030 | 0.0010 | 0.0001 | -0.0067 |
| 88 | 240.00 | -0.0749 | 0.0374 | -0.0123 | -0.0579 | -0.0027 | 0.0009 | 0.0001 | -0.0058 |
| 89 | 260.00 | -0.0651 | 0.0322 | -0.0110 | -0.0503 | -0.0023 | 0.0008 | 0.0001 | -0.0050 |
| 90 | 280.00 | -0.0566 | 0.0276 | -0.0098 | -0.0437 | -0.0021 | 0.0007 | 0.0001 | -0.0043 |
| 91 | 300.00 | -0.0493 | 0.0236 | -0.0088 | -0.0380 | -0.0019 | 0.0006 | 0.0000 | -0.0037 |
| 92 | 350.00 | -0.0348 | 0.0161 | -0.0065 | -0.0268 | -0.0015 | 0.0004 | 0.0000 | -0.0026 |
| 93 | 400.00 | -0.0243 | 0.0109 | -0.0048 | -0.0190 | -0.0012 | 0.0002 | 0.0000 | -0.0018 |
| 94 | 450.00 | -0.0171 | 0.0072 | -0.0035 | -0.0134 | -0.0010 | 0.0001 | 0.0000 | -0.0012 |
| 95 | 500.00 | -0.0117 | 0.0047 | -0.0026 | -0.0095 | -0.0009 | 0.0000 | 0.0000 | -0.0008 |

表2. 7(1) 評価断面7の応力テンソル成分1、2

ステップ温度変化の基本解

断面7

| ステップ | 時間(S) | 応力成分1 | | | | 応力成分2 | | | |
|------|-------|---------|---------|---------|---------|---------|--------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.01 | -0.0063 | 0.0000 | -0.0002 | -0.0006 | -0.0124 | 0.0001 | -0.0003 | -0.0011 |
| 3 | 0.04 | -0.0360 | 0.0000 | -0.0013 | -0.0034 | -0.0738 | 0.0007 | -0.0015 | -0.0067 |
| 4 | 0.07 | -0.0521 | 0.0000 | -0.0018 | -0.0049 | -0.1143 | 0.0012 | -0.0023 | -0.0106 |
| 5 | 0.10 | -0.0601 | 0.0000 | -0.0021 | -0.0056 | -0.1415 | 0.0016 | -0.0028 | -0.0135 |
| 6 | 0.20 | -0.0653 | 0.0000 | -0.0023 | -0.0060 | -0.1916 | 0.0030 | -0.0035 | -0.0201 |
| 7 | 0.30 | -0.0576 | 0.0000 | -0.0021 | -0.0053 | -0.2124 | 0.0042 | -0.0037 | -0.0246 |
| 8 | 0.40 | -0.0506 | 0.0000 | -0.0020 | -0.0049 | -0.2264 | 0.0053 | -0.0039 | -0.0287 |
| 9 | 0.50 | -0.0448 | 0.0000 | -0.0020 | -0.0046 | -0.2371 | 0.0063 | -0.0042 | -0.0325 |
| 10 | 0.60 | -0.0403 | 0.0000 | -0.0021 | -0.0045 | -0.2459 | 0.0072 | -0.0045 | -0.0361 |
| 11 | 0.70 | -0.0364 | 0.0000 | -0.0022 | -0.0045 | -0.2529 | 0.0082 | -0.0048 | -0.0395 |
| 12 | 0.80 | -0.0333 | 0.0000 | -0.0023 | -0.0045 | -0.2588 | 0.0090 | -0.0050 | -0.0426 |
| 13 | 0.90 | -0.0308 | 0.0000 | -0.0024 | -0.0045 | -0.2638 | 0.0099 | -0.0052 | -0.0456 |
| 14 | 1.00 | -0.0286 | 0.0000 | -0.0025 | -0.0045 | -0.2681 | 0.0106 | -0.0054 | -0.0484 |
| 15 | 1.20 | -0.0249 | 0.0000 | -0.0027 | -0.0046 | -0.2755 | 0.0122 | -0.0057 | -0.0536 |
| 16 | 1.40 | -0.0220 | 0.0000 | -0.0028 | -0.0047 | -0.2814 | 0.0136 | -0.0059 | -0.0582 |
| 17 | 1.60 | -0.0197 | 0.0000 | -0.0029 | -0.0047 | -0.2860 | 0.0150 | -0.0060 | -0.0625 |
| 18 | 1.80 | -0.0178 | 0.0000 | -0.0030 | -0.0047 | -0.2899 | 0.0163 | -0.0061 | -0.0664 |
| 19 | 2.00 | -0.0162 | 0.0000 | -0.0031 | -0.0047 | -0.2934 | 0.0176 | -0.0062 | -0.0700 |
| 20 | 2.20 | -0.0149 | 0.0000 | -0.0032 | -0.0047 | -0.2962 | 0.0188 | -0.0062 | -0.0734 |
| 21 | 2.40 | -0.0136 | 0.0000 | -0.0033 | -0.0047 | -0.2986 | 0.0199 | -0.0062 | -0.0766 |
| 22 | 2.60 | -0.0126 | 0.0000 | -0.0033 | -0.0046 | -0.3007 | 0.0211 | -0.0062 | -0.0795 |
| 23 | 2.80 | -0.0117 | 0.0000 | -0.0034 | -0.0046 | -0.3023 | 0.0221 | -0.0061 | -0.0822 |
| 24 | 3.00 | -0.0109 | 0.0000 | -0.0034 | -0.0045 | -0.3038 | 0.0231 | -0.0061 | -0.0848 |
| 25 | 3.20 | -0.0105 | 0.0000 | -0.0035 | -0.0045 | -0.3052 | 0.0241 | -0.0061 | -0.0873 |
| 26 | 3.40 | -0.0097 | -0.0001 | -0.0035 | -0.0044 | -0.3060 | 0.0251 | -0.0060 | -0.0897 |
| 27 | 3.60 | -0.0091 | -0.0001 | -0.0035 | -0.0044 | -0.3070 | 0.0261 | -0.0059 | -0.0920 |
| 28 | 3.80 | -0.0086 | -0.0001 | -0.0036 | -0.0043 | -0.3076 | 0.0270 | -0.0059 | -0.0942 |
| 29 | 4.00 | -0.0084 | -0.0001 | -0.0036 | -0.0043 | -0.3082 | 0.0279 | -0.0058 | -0.0962 |
| 30 | 4.20 | -0.0080 | -0.0001 | -0.0036 | -0.0042 | -0.3088 | 0.0288 | -0.0057 | -0.0983 |
| 31 | 4.40 | -0.0077 | -0.0001 | -0.0036 | -0.0042 | -0.3091 | 0.0297 | -0.0056 | -0.1001 |
| 32 | 4.60 | -0.0073 | -0.0001 | -0.0037 | -0.0041 | -0.3094 | 0.0305 | -0.0056 | -0.1020 |
| 33 | 4.80 | -0.0071 | -0.0001 | -0.0037 | -0.0041 | -0.3099 | 0.0313 | -0.0055 | -0.1037 |
| 34 | 5.00 | -0.0069 | -0.0001 | -0.0037 | -0.0041 | -0.3101 | 0.0322 | -0.0054 | -0.1055 |
| 35 | 5.50 | -0.0061 | -0.0001 | -0.0037 | -0.0039 | -0.3102 | 0.0342 | -0.0052 | -0.1095 |
| 36 | 6.00 | -0.0057 | -0.0001 | -0.0037 | -0.0038 | -0.3100 | 0.0361 | -0.0050 | -0.1132 |
| 37 | 6.50 | -0.0054 | -0.0001 | -0.0038 | -0.0037 | -0.3100 | 0.0379 | -0.0048 | -0.1167 |
| 38 | 7.00 | -0.0051 | -0.0001 | -0.0038 | -0.0036 | -0.3096 | 0.0398 | -0.0046 | -0.1199 |
| 39 | 7.50 | -0.0049 | -0.0001 | -0.0038 | -0.0035 | -0.3089 | 0.0416 | -0.0045 | -0.1230 |
| 40 | 8.00 | -0.0045 | -0.0001 | -0.0039 | -0.0034 | -0.3083 | 0.0433 | -0.0043 | -0.1259 |
| 41 | 8.50 | -0.0044 | -0.0001 | -0.0039 | -0.0033 | -0.3077 | 0.0450 | -0.0042 | -0.1286 |
| 42 | 9.00 | -0.0042 | -0.0001 | -0.0039 | -0.0032 | -0.3068 | 0.0466 | -0.0041 | -0.1311 |
| 43 | 9.50 | -0.0038 | -0.0001 | -0.0039 | -0.0031 | -0.3059 | 0.0482 | -0.0039 | -0.1335 |
| 44 | 10.00 | -0.0038 | -0.0001 | -0.0040 | -0.0031 | -0.3050 | 0.0498 | -0.0038 | -0.1358 |
| 45 | 11.00 | -0.0034 | -0.0001 | -0.0040 | -0.0029 | -0.3026 | 0.0528 | -0.0036 | -0.1399 |
| 46 | 12.00 | -0.0034 | -0.0001 | -0.0040 | -0.0028 | -0.3006 | 0.0558 | -0.0034 | -0.1436 |
| 47 | 13.00 | -0.0032 | -0.0001 | -0.0041 | -0.0026 | -0.2983 | 0.0588 | -0.0031 | -0.1469 |
| 48 | 14.00 | -0.0033 | 0.0000 | -0.0041 | -0.0025 | -0.2961 | 0.0617 | -0.0030 | -0.1499 |
| 49 | 15.00 | -0.0033 | -0.0002 | -0.0041 | -0.0024 | -0.2938 | 0.0643 | -0.0028 | -0.1525 |
| 50 | 16.00 | -0.0034 | -0.0002 | -0.0041 | -0.0023 | -0.2916 | 0.0667 | -0.0027 | -0.1547 |
| 51 | 17.00 | -0.0032 | -0.0002 | -0.0042 | -0.0022 | -0.2891 | 0.0689 | -0.0025 | -0.1567 |
| 52 | 18.00 | -0.0032 | -0.0002 | -0.0042 | -0.0022 | -0.2867 | 0.0711 | -0.0024 | -0.1585 |
| 53 | 19.00 | -0.0030 | -0.0002 | -0.0042 | -0.0021 | -0.2844 | 0.0732 | -0.0023 | -0.1602 |
| 54 | 20.00 | -0.0032 | -0.0004 | -0.0042 | -0.0020 | -0.2822 | 0.0751 | -0.0022 | -0.1617 |

| | | | | | | | | | |
|----|--------|---------|---------|---------|---------|---------|--------|---------|---------|
| 55 | 22.00 | -0.0030 | -0.0006 | -0.0042 | -0.0018 | -0.2775 | 0.0789 | -0.0019 | -0.1640 |
| 56 | 24.00 | -0.0029 | -0.0006 | -0.0042 | -0.0017 | -0.2730 | 0.0819 | -0.0017 | -0.1657 |
| 57 | 26.00 | -0.0027 | -0.0006 | -0.0042 | -0.0016 | -0.2685 | 0.0844 | -0.0015 | -0.1669 |
| 58 | 28.00 | -0.0025 | -0.0008 | -0.0042 | -0.0014 | -0.2641 | 0.0867 | -0.0014 | -0.1677 |
| 59 | 30.00 | -0.0025 | -0.0008 | -0.0042 | -0.0014 | -0.2598 | 0.0884 | -0.0013 | -0.1680 |
| 60 | 32.00 | -0.0023 | -0.0008 | -0.0041 | -0.0013 | -0.2557 | 0.0896 | -0.0012 | -0.1680 |
| 61 | 34.00 | -0.0024 | -0.0009 | -0.0041 | -0.0012 | -0.2519 | 0.0907 | -0.0011 | -0.1677 |
| 62 | 36.00 | -0.0022 | -0.0009 | -0.0040 | -0.0012 | -0.2479 | 0.0915 | -0.0010 | -0.1672 |
| 63 | 38.00 | -0.0022 | -0.0008 | -0.0040 | -0.0011 | -0.2439 | 0.0922 | -0.0008 | -0.1665 |
| 64 | 40.00 | -0.0022 | -0.0010 | -0.0039 | -0.0011 | -0.2401 | 0.0925 | -0.0008 | -0.1655 |
| 65 | 45.00 | -0.0019 | -0.0011 | -0.0038 | -0.0009 | -0.2309 | 0.0926 | -0.0006 | -0.1625 |
| 66 | 50.00 | -0.0017 | -0.0009 | -0.0037 | -0.0008 | -0.2223 | 0.0919 | -0.0005 | -0.1588 |
| 67 | 55.00 | -0.0015 | -0.0010 | -0.0036 | -0.0008 | -0.2140 | 0.0904 | -0.0004 | -0.1547 |
| 68 | 60.00 | -0.0015 | -0.0010 | -0.0035 | -0.0007 | -0.2063 | 0.0883 | -0.0003 | -0.1503 |
| 69 | 65.00 | -0.0017 | -0.0010 | -0.0034 | -0.0007 | -0.1991 | 0.0857 | -0.0003 | -0.1457 |
| 70 | 70.00 | -0.0015 | -0.0008 | -0.0032 | -0.0006 | -0.1917 | 0.0832 | -0.0003 | -0.1411 |
| 71 | 75.00 | -0.0013 | -0.0008 | -0.0031 | -0.0006 | -0.1846 | 0.0808 | -0.0002 | -0.1365 |
| 72 | 80.00 | -0.0012 | -0.0008 | -0.0030 | -0.0005 | -0.1780 | 0.0780 | -0.0002 | -0.1319 |
| 73 | 85.00 | -0.0012 | -0.0008 | -0.0029 | -0.0005 | -0.1717 | 0.0754 | -0.0002 | -0.1274 |
| 74 | 90.00 | -0.0012 | -0.0006 | -0.0028 | -0.0005 | -0.1657 | 0.0724 | -0.0002 | -0.1230 |
| 75 | 95.00 | -0.0010 | -0.0006 | -0.0027 | -0.0004 | -0.1599 | 0.0699 | -0.0002 | -0.1188 |
| 76 | 100.00 | -0.0012 | -0.0006 | -0.0026 | -0.0004 | -0.1545 | 0.0675 | -0.0001 | -0.1146 |
| 77 | 110.00 | -0.0009 | -0.0006 | -0.0024 | -0.0004 | -0.1438 | 0.0626 | -0.0001 | -0.1067 |
| 78 | 120.00 | -0.0009 | -0.0004 | -0.0022 | -0.0003 | -0.1339 | 0.0579 | -0.0001 | -0.0994 |
| 79 | 130.00 | -0.0007 | -0.0004 | -0.0021 | -0.0003 | -0.1249 | 0.0537 | -0.0001 | -0.0925 |
| 80 | 140.00 | -0.0010 | -0.0004 | -0.0019 | -0.0003 | -0.1166 | 0.0498 | -0.0001 | -0.0861 |
| 81 | 150.00 | -0.0007 | -0.0004 | -0.0017 | -0.0002 | -0.1085 | 0.0464 | 0.0000 | -0.0802 |
| 82 | 160.00 | -0.0005 | -0.0005 | -0.0016 | -0.0002 | -0.1010 | 0.0430 | 0.0000 | -0.0746 |
| 83 | 170.00 | -0.0005 | -0.0005 | -0.0014 | -0.0001 | -0.0940 | 0.0399 | 0.0001 | -0.0694 |
| 84 | 180.00 | -0.0005 | -0.0005 | -0.0013 | -0.0001 | -0.0876 | 0.0371 | 0.0001 | -0.0646 |
| 85 | 190.00 | -0.0004 | -0.0002 | -0.0012 | -0.0001 | -0.0818 | 0.0344 | 0.0001 | -0.0602 |
| 86 | 200.00 | -0.0002 | -0.0002 | -0.0011 | -0.0001 | -0.0763 | 0.0319 | 0.0001 | -0.0561 |
| 87 | 220.00 | -0.0003 | 0.0000 | -0.0009 | 0.0000 | -0.0662 | 0.0274 | 0.0002 | -0.0486 |
| 88 | 240.00 | -0.0001 | 0.0002 | -0.0007 | 0.0000 | -0.0576 | 0.0235 | 0.0002 | -0.0422 |
| 89 | 260.00 | 0.0001 | 0.0002 | -0.0006 | 0.0000 | -0.0499 | 0.0203 | 0.0003 | -0.0366 |
| 90 | 280.00 | 0.0001 | 0.0002 | -0.0005 | 0.0001 | -0.0432 | 0.0175 | 0.0003 | -0.0317 |
| 91 | 300.00 | 0.0002 | 0.0003 | -0.0004 | 0.0000 | -0.0377 | 0.0151 | 0.0003 | -0.0276 |
| 92 | 350.00 | 0.0003 | 0.0006 | -0.0001 | 0.0001 | -0.0264 | 0.0103 | 0.0003 | -0.0192 |
| 93 | 400.00 | 0.0002 | 0.0008 | 0.0000 | 0.0001 | -0.0187 | 0.0069 | 0.0004 | -0.0134 |
| 94 | 450.00 | 0.0002 | 0.0010 | 0.0001 | 0.0001 | -0.0131 | 0.0045 | 0.0004 | -0.0094 |
| 95 | 500.00 | 0.0004 | 0.0010 | 0.0002 | 0.0002 | -0.0089 | 0.0033 | 0.0005 | -0.0066 |

表 2. 7 (2) 評価断面7の応力テンソル成分3、4

ステップ温度変化の基本解

断面7

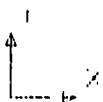
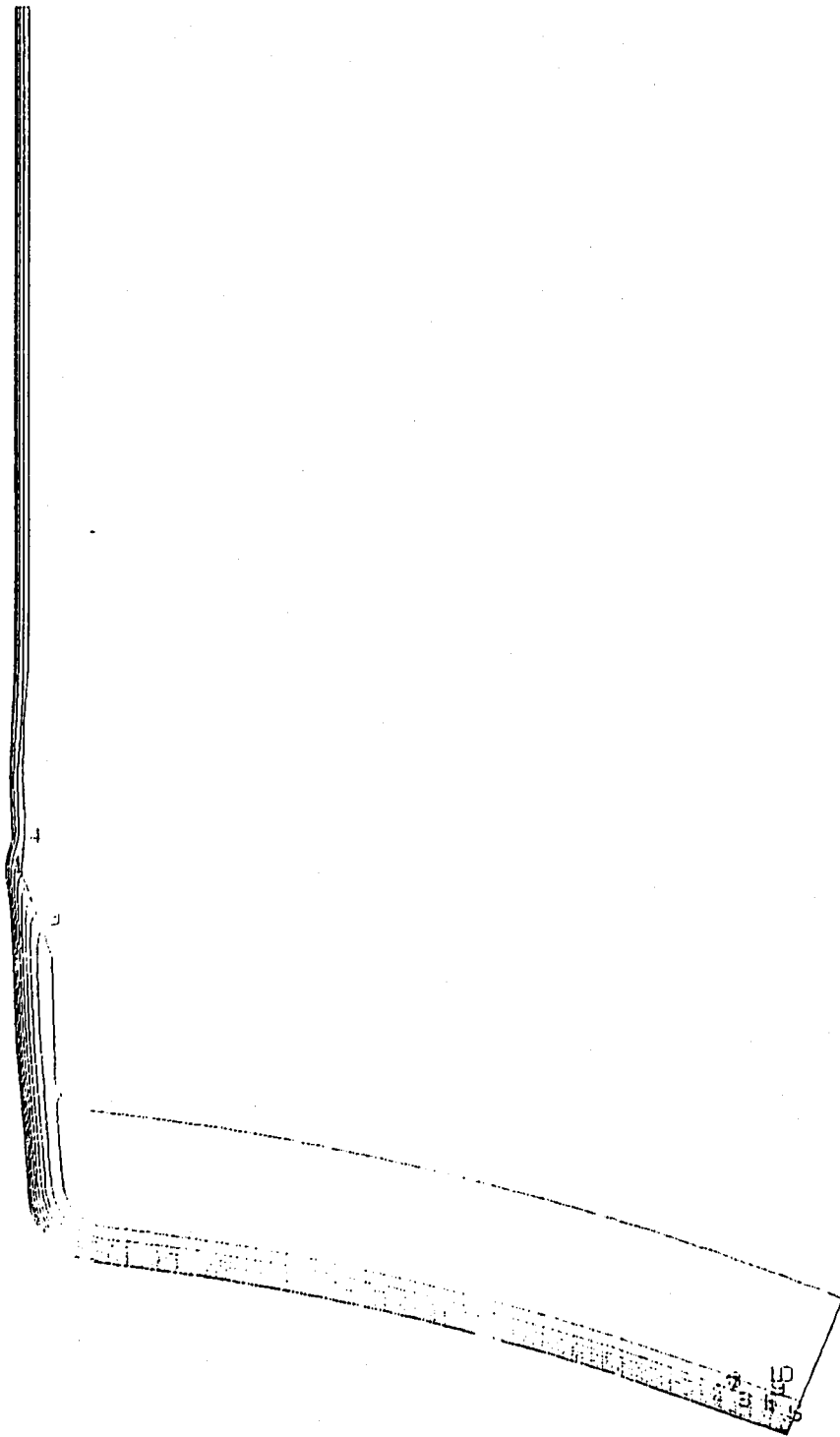
| ステップ | 時間(S) | 応力成分3 | | | | 応力成分4 | | | |
|------|-------|---------|--------|---------|---------|--------|---------|---------|------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.00 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | |
| 2 | 0.01 | -0.0124 | 0.0001 | -0.0003 | -0.0012 | 0.0001 | 0.0000 | 0.0000 | |
| 3 | 0.04 | -0.0740 | 0.0008 | -0.0016 | -0.0069 | 0.0009 | 0.0000 | 0.0001 | |
| 4 | 0.07 | -0.1147 | 0.0013 | -0.0025 | -0.0109 | 0.0014 | 0.0000 | 0.0001 | |
| 5 | 0.10 | -0.1421 | 0.0018 | -0.0030 | -0.0139 | 0.0018 | 0.0000 | 0.0002 | |
| 6 | 0.20 | -0.1927 | 0.0033 | -0.0039 | -0.0209 | 0.0028 | 0.0000 | 0.0003 | |
| 7 | 0.30 | -0.2138 | 0.0047 | -0.0043 | -0.0257 | 0.0033 | -0.0001 | 0.0004 | |
| 8 | 0.40 | -0.2282 | 0.0059 | -0.0046 | -0.0301 | 0.0037 | -0.0001 | 0.0005 | |
| 9 | 0.50 | -0.2393 | 0.0070 | -0.0051 | -0.0342 | 0.0040 | -0.0001 | 0.0005 | |
| 10 | 0.60 | -0.2484 | 0.0081 | -0.0055 | -0.0380 | 0.0043 | -0.0001 | 0.0006 | |
| 11 | 0.70 | -0.2557 | 0.0091 | -0.0058 | -0.0416 | 0.0045 | -0.0001 | 0.0007 | |
| 12 | 0.80 | -0.2619 | 0.0101 | -0.0062 | -0.0450 | 0.0047 | -0.0001 | 0.0007 | |
| 13 | 0.90 | -0.2672 | 0.0110 | -0.0065 | -0.0482 | 0.0048 | -0.0001 | 0.0008 | |
| 14 | 1.00 | -0.2718 | 0.0119 | -0.0068 | -0.0511 | 0.0049 | -0.0002 | 0.0009 | |
| 15 | 1.20 | -0.2797 | 0.0136 | -0.0073 | -0.0567 | 0.0051 | -0.0002 | 0.0009 | |
| 16 | 1.40 | -0.2861 | 0.0152 | -0.0077 | -0.0618 | 0.0052 | -0.0002 | 0.0010 | |
| 17 | 1.60 | -0.2912 | 0.0168 | -0.0080 | -0.0664 | 0.0052 | -0.0002 | 0.0011 | |
| 18 | 1.80 | -0.2956 | 0.0183 | -0.0083 | -0.0707 | 0.0052 | -0.0002 | 0.0011 | |
| 19 | 2.00 | -0.2996 | 0.0197 | -0.0085 | -0.0746 | 0.0053 | -0.0003 | 0.0012 | |
| 20 | 2.20 | -0.3028 | 0.0210 | -0.0087 | -0.0783 | 0.0053 | -0.0003 | 0.0013 | |
| 21 | 2.40 | -0.3057 | 0.0223 | -0.0089 | -0.0818 | 0.0053 | -0.0003 | 0.0013 | |
| 22 | 2.60 | -0.3081 | 0.0236 | -0.0090 | -0.0851 | 0.0053 | -0.0003 | 0.0014 | |
| 23 | 2.80 | -0.3102 | 0.0248 | -0.0091 | -0.0881 | 0.0052 | -0.0003 | 0.0014 | |
| 24 | 3.00 | -0.3120 | 0.0259 | -0.0092 | -0.0910 | 0.0051 | -0.0003 | -0.0001 | |
| 25 | 3.20 | -0.3138 | 0.0270 | -0.0093 | -0.0938 | 0.0051 | -0.0003 | -0.0001 | |
| 26 | 3.40 | -0.3150 | 0.0282 | -0.0094 | -0.0964 | 0.0050 | -0.0003 | -0.0001 | |
| 27 | 3.60 | -0.3164 | 0.0293 | -0.0095 | -0.0990 | 0.0050 | -0.0004 | -0.0001 | |
| 28 | 3.80 | -0.3173 | 0.0303 | -0.0095 | -0.1015 | 0.0050 | -0.0004 | -0.0001 | |
| 29 | 4.00 | -0.3183 | 0.0314 | -0.0096 | -0.1038 | 0.0049 | -0.0004 | -0.0001 | |
| 30 | 4.20 | -0.3193 | 0.0324 | -0.0097 | -0.1061 | 0.0049 | -0.0004 | -0.0001 | |
| 31 | 4.40 | -0.3199 | 0.0334 | -0.0097 | -0.1082 | 0.0049 | -0.0004 | -0.0001 | |
| 32 | 4.60 | -0.3206 | 0.0343 | -0.0098 | -0.1103 | 0.0049 | -0.0004 | -0.0001 | |
| 33 | 4.80 | -0.3213 | 0.0352 | -0.0098 | -0.1122 | 0.0049 | -0.0004 | -0.0001 | |
| 34 | 5.00 | -0.3220 | 0.0362 | -0.0098 | -0.1142 | 0.0048 | -0.0004 | -0.0001 | |
| 35 | 5.50 | -0.3229 | 0.0385 | -0.0099 | -0.1188 | 0.0046 | -0.0004 | -0.0001 | |
| 36 | 6.00 | -0.3234 | 0.0406 | -0.0099 | -0.1231 | 0.0044 | -0.0005 | -0.0002 | |
| 37 | 6.50 | -0.3240 | 0.0427 | -0.0100 | -0.1271 | 0.0044 | -0.0005 | -0.0002 | |
| 38 | 7.00 | -0.3242 | 0.0449 | -0.0101 | -0.1308 | 0.0043 | -0.0005 | -0.0002 | |
| 39 | 7.50 | -0.3241 | 0.0469 | -0.0101 | -0.1343 | 0.0041 | -0.0005 | -0.0002 | |
| 40 | 8.00 | -0.3241 | 0.0488 | -0.0101 | -0.1376 | 0.0041 | -0.0005 | -0.0002 | |
| 41 | 8.50 | -0.3241 | 0.0508 | -0.0102 | -0.1407 | 0.0040 | -0.0005 | -0.0002 | |
| 42 | 9.00 | -0.3237 | 0.0526 | -0.0102 | -0.1437 | 0.0040 | -0.0006 | -0.0002 | |
| 43 | 9.50 | -0.3233 | 0.0544 | -0.0102 | -0.1465 | 0.0039 | -0.0006 | -0.0002 | |
| 44 | 10.00 | -0.3230 | 0.0562 | -0.0103 | -0.1491 | 0.0038 | -0.0006 | -0.0002 | |
| 45 | 11.00 | -0.3216 | 0.0597 | -0.0103 | -0.1540 | 0.0037 | -0.0006 | -0.0002 | |
| 46 | 12.00 | -0.3204 | 0.0631 | -0.0103 | -0.1583 | 0.0036 | -0.0006 | -0.0003 | |
| 47 | 13.00 | -0.3189 | 0.0664 | -0.0103 | -0.1622 | 0.0034 | -0.0006 | -0.0003 | |
| 48 | 14.00 | -0.3174 | 0.0696 | -0.0104 | -0.1657 | 0.0033 | -0.0007 | -0.0003 | |
| 49 | 15.00 | -0.3158 | 0.0727 | -0.0104 | -0.1689 | 0.0032 | -0.0007 | -0.0003 | |
| 50 | 16.00 | -0.3142 | 0.0753 | -0.0104 | -0.1716 | 0.0031 | -0.0007 | -0.0003 | |
| 51 | 17.00 | -0.3122 | 0.0778 | -0.0104 | -0.1740 | 0.0030 | -0.0007 | -0.0003 | |
| 52 | 18.00 | -0.3103 | 0.0802 | -0.0104 | -0.1763 | 0.0029 | -0.0007 | -0.0003 | |
| 53 | 19.00 | -0.3085 | 0.0826 | -0.0104 | -0.1783 | 0.0028 | -0.0007 | -0.0003 | |
| 54 | 20.00 | -0.3068 | 0.0848 | -0.0104 | -0.1802 | 0.0028 | -0.0007 | -0.0003 | |

| | | | | | | | | | |
|----|--------|---------|--------|---------|---------|---------|---------|---------|---------|
| 55 | 22.00 | -0.3030 | 0.0890 | -0.0103 | -0.1832 | 0.0026 | -0.0007 | -0.0003 | 0.0020 |
| 56 | 24.00 | -0.2991 | 0.0924 | -0.0102 | -0.1854 | 0.0025 | -0.0008 | -0.0003 | 0.0020 |
| 57 | 26.00 | -0.2953 | 0.0953 | -0.0102 | -0.1871 | 0.0023 | -0.0008 | -0.0004 | 0.0020 |
| 58 | 28.00 | -0.2913 | 0.0979 | -0.0101 | -0.1883 | 0.0022 | -0.0008 | -0.0004 | 0.0020 |
| 59 | 30.00 | -0.2874 | 0.1000 | -0.0100 | -0.1891 | 0.0021 | -0.0008 | -0.0004 | 0.0020 |
| 60 | 32.00 | -0.2837 | 0.1015 | -0.0099 | -0.1894 | 0.0020 | -0.0008 | -0.0004 | 0.0020 |
| 61 | 34.00 | -0.2801 | 0.1030 | -0.0097 | -0.1894 | 0.0019 | -0.0008 | -0.0004 | 0.0019 |
| 62 | 36.00 | -0.2762 | 0.1039 | -0.0096 | -0.1890 | 0.0019 | -0.0007 | -0.0004 | 0.0019 |
| 63 | 38.00 | -0.2724 | 0.1048 | -0.0094 | -0.1885 | 0.0018 | -0.0007 | -0.0004 | 0.0019 |
| 64 | 40.00 | -0.2687 | 0.1055 | -0.0092 | -0.1877 | 0.0017 | -0.0007 | -0.0004 | 0.0018 |
| 65 | 45.00 | -0.2596 | 0.1061 | -0.0089 | -0.1850 | 0.0016 | -0.0007 | -0.0004 | 0.0018 |
| 66 | 50.00 | -0.2510 | 0.1057 | -0.0085 | -0.1814 | 0.0014 | -0.0006 | -0.0004 | 0.0017 |
| 67 | 55.00 | -0.2424 | 0.1046 | -0.0081 | -0.1773 | 0.0013 | -0.0006 | -0.0003 | 0.0016 |
| 68 | 60.00 | -0.2343 | 0.1026 | -0.0078 | -0.1727 | 0.0012 | -0.0005 | -0.0003 | 0.0015 |
| 69 | 65.00 | -0.2267 | 0.1002 | -0.0074 | -0.1680 | 0.0011 | -0.0005 | -0.0003 | 0.0015 |
| 70 | 70.00 | -0.2188 | 0.0980 | -0.0070 | -0.1633 | 0.0011 | -0.0005 | -0.0003 | 0.0014 |
| 71 | 75.00 | -0.2113 | 0.0955 | -0.0067 | -0.1585 | 0.0010 | -0.0004 | -0.0003 | 0.0014 |
| 72 | 80.00 | -0.2042 | 0.0928 | -0.0063 | -0.1536 | 0.0009 | -0.0004 | -0.0003 | 0.0013 |
| 73 | 85.00 | -0.1973 | 0.0902 | -0.0060 | -0.1488 | 0.0008 | -0.0004 | -0.0003 | 0.0012 |
| 74 | 90.00 | -0.1908 | 0.0873 | -0.0057 | -0.1441 | 0.0008 | -0.0004 | -0.0003 | 0.0012 |
| 75 | 95.00 | -0.1844 | 0.0846 | -0.0054 | -0.1395 | 0.0007 | -0.0004 | -0.0003 | 0.0011 |
| 76 | 100.00 | -0.1785 | 0.0822 | -0.0051 | -0.1350 | 0.0006 | -0.0004 | -0.0003 | 0.0011 |
| 77 | 110.00 | -0.1666 | 0.0771 | -0.0046 | -0.1264 | 0.0006 | -0.0003 | -0.0002 | 0.0010 |
| 78 | 120.00 | -0.1556 | 0.0721 | -0.0041 | -0.1183 | 0.0005 | -0.0003 | -0.0002 | 0.0009 |
| 79 | 130.00 | -0.1455 | 0.0677 | -0.0036 | -0.1107 | 0.0004 | -0.0002 | -0.0002 | 0.0008 |
| 80 | 140.00 | -0.1361 | 0.0635 | -0.0032 | -0.1035 | 0.0004 | -0.0002 | -0.0002 | 0.0007 |
| 81 | 150.00 | -0.1269 | 0.0595 | -0.0029 | -0.0967 | 0.0003 | -0.0002 | -0.0002 | 0.0006 |
| 82 | 160.00 | -0.1184 | 0.0557 | -0.0025 | -0.0904 | 0.0002 | -0.0001 | -0.0002 | 0.0005 |
| 83 | 170.00 | -0.1105 | 0.0522 | -0.0022 | -0.0845 | 0.0001 | -0.0001 | -0.0002 | 0.0005 |
| 84 | 180.00 | -0.1032 | 0.0490 | -0.0019 | -0.0790 | 0.0000 | 0.0000 | -0.0002 | 0.0004 |
| 85 | 190.00 | -0.0965 | 0.0457 | -0.0017 | -0.0739 | 0.0000 | 0.0000 | -0.0002 | 0.0004 |
| 86 | 200.00 | -0.0902 | 0.0429 | -0.0015 | -0.0692 | 0.0000 | 0.0000 | -0.0001 | 0.0003 |
| 87 | 220.00 | -0.0786 | 0.0376 | -0.0011 | -0.0605 | -0.0001 | 0.0000 | -0.0001 | 0.0002 |
| 88 | 240.00 | -0.0687 | 0.0328 | -0.0008 | -0.0529 | -0.0001 | 0.0001 | -0.0001 | 0.0002 |
| 89 | 260.00 | -0.0597 | 0.0288 | -0.0005 | -0.0462 | -0.0002 | 0.0001 | -0.0001 | 0.0001 |
| 90 | 280.00 | -0.0520 | 0.0253 | -0.0003 | -0.0404 | -0.0003 | 0.0001 | -0.0001 | 0.0000 |
| 91 | 300.00 | -0.0454 | 0.0221 | -0.0001 | -0.0353 | -0.0002 | 0.0001 | -0.0001 | 0.0000 |
| 92 | 350.00 | -0.0323 | 0.0158 | 0.0002 | -0.0252 | -0.0003 | 0.0002 | -0.0001 | -0.0001 |
| 93 | 400.00 | -0.0230 | 0.0111 | 0.0003 | -0.0179 | -0.0004 | 0.0002 | 0.0000 | -0.0001 |
| 94 | 450.00 | -0.0163 | 0.0077 | 0.0004 | -0.0127 | -0.0005 | 0.0002 | 0.0000 | -0.0002 |
| 95 | 500.00 | -0.0113 | 0.0056 | 0.0004 | -0.0091 | -0.0006 | 0.0002 | 0.0000 | -0.0003 |

FIFTH
TEMPERATURE

CONTOUR VALUES

- 1 563.6495
- 2 567.4993
- 3 571.2991
- 4 575.0988
- 5 578.8987
- 6 582.6985
- 7 586.4983
- 8 590.2981
- 9 594.0979
- 10 597.8977



GRAPH. SCALE 1 50.0000

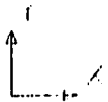
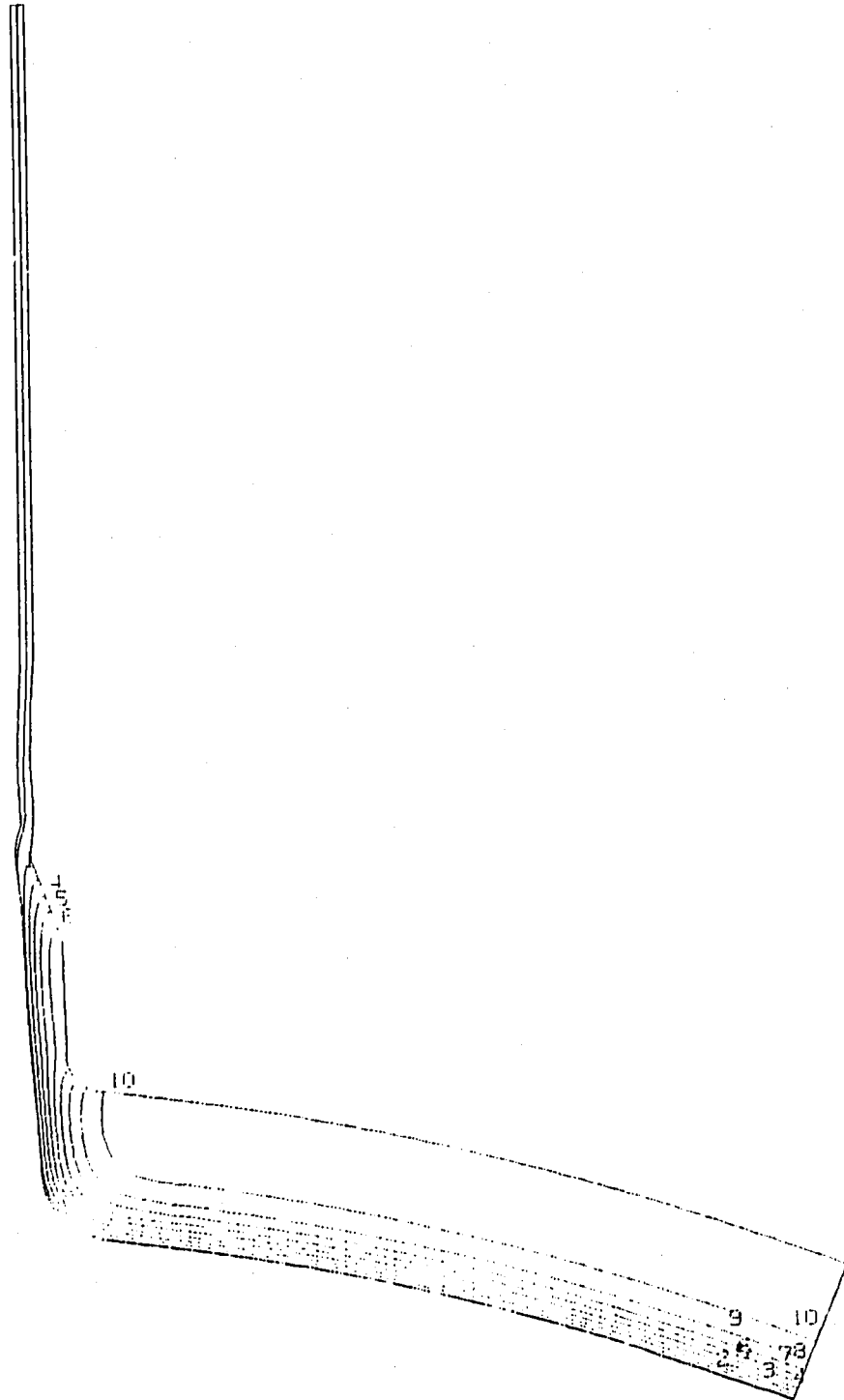
STEP NO. 10

図10.1 温度コンター t=5 sec

FILMS
TEMPERATURE

CONTOUR VALUES

- 1 511.1994
- 2 520.4993
- 3 529.7990
- 4 539.0989
- 5 548.3985
- 6 557.6985
- 7 566.9980
- 8 576.2981
- 9 585.5979
- 10 594.8977



GEOM. SCALE 50.0000

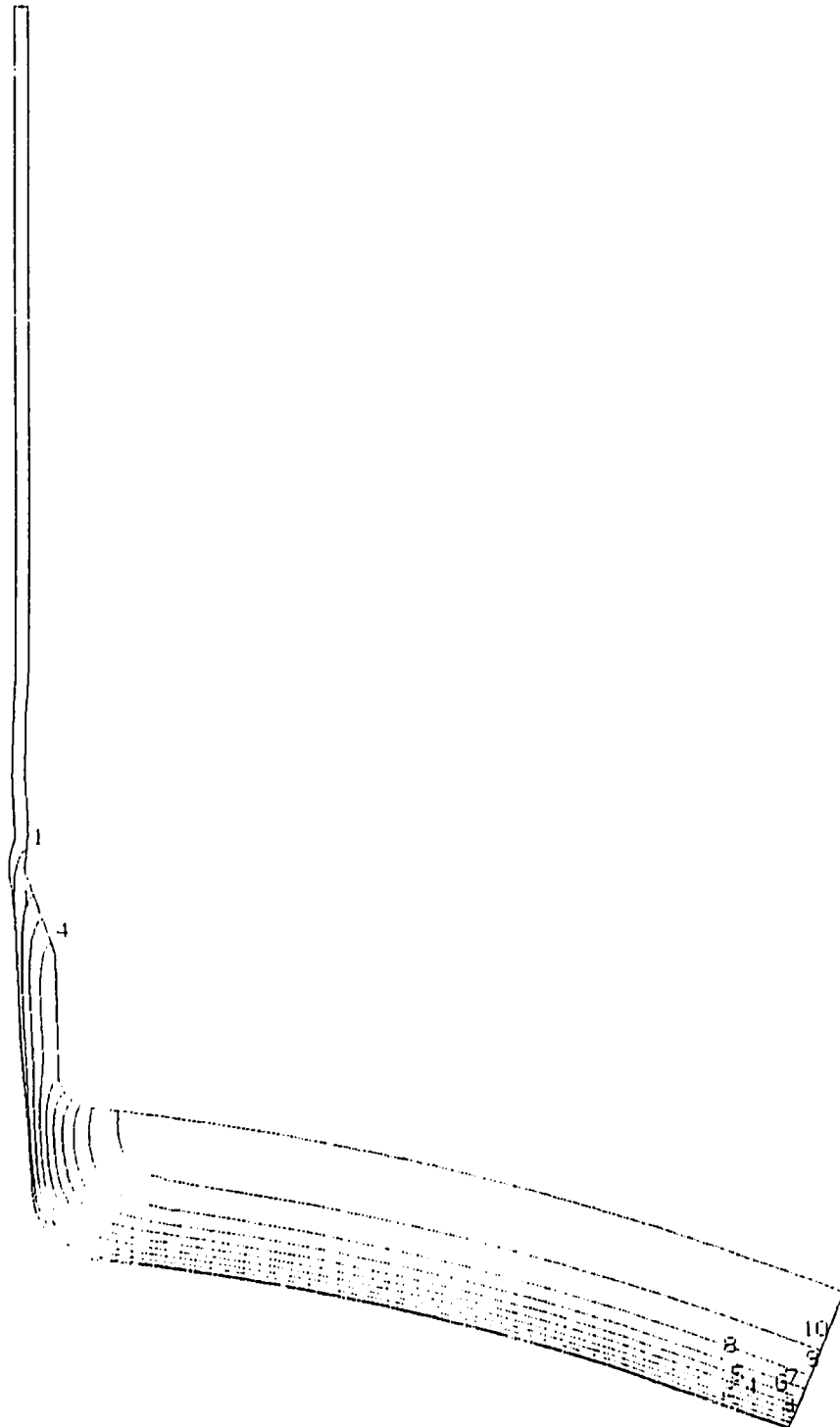
STEP NO. 20

図10. 2 温度コンター t = 15 sec

F I I I A S
T E M P E R A T U R E

C O N T O U R V A L U E S

- 1 476.0000
- 2 489.0000
- 3 502.0000
- 4 515.0000
- 5 528.0000
- 6 541.0000
- 7 553.9999
- 8 567.0000
- 9 580.0000
- 10 593.0000



STEP NO. 30

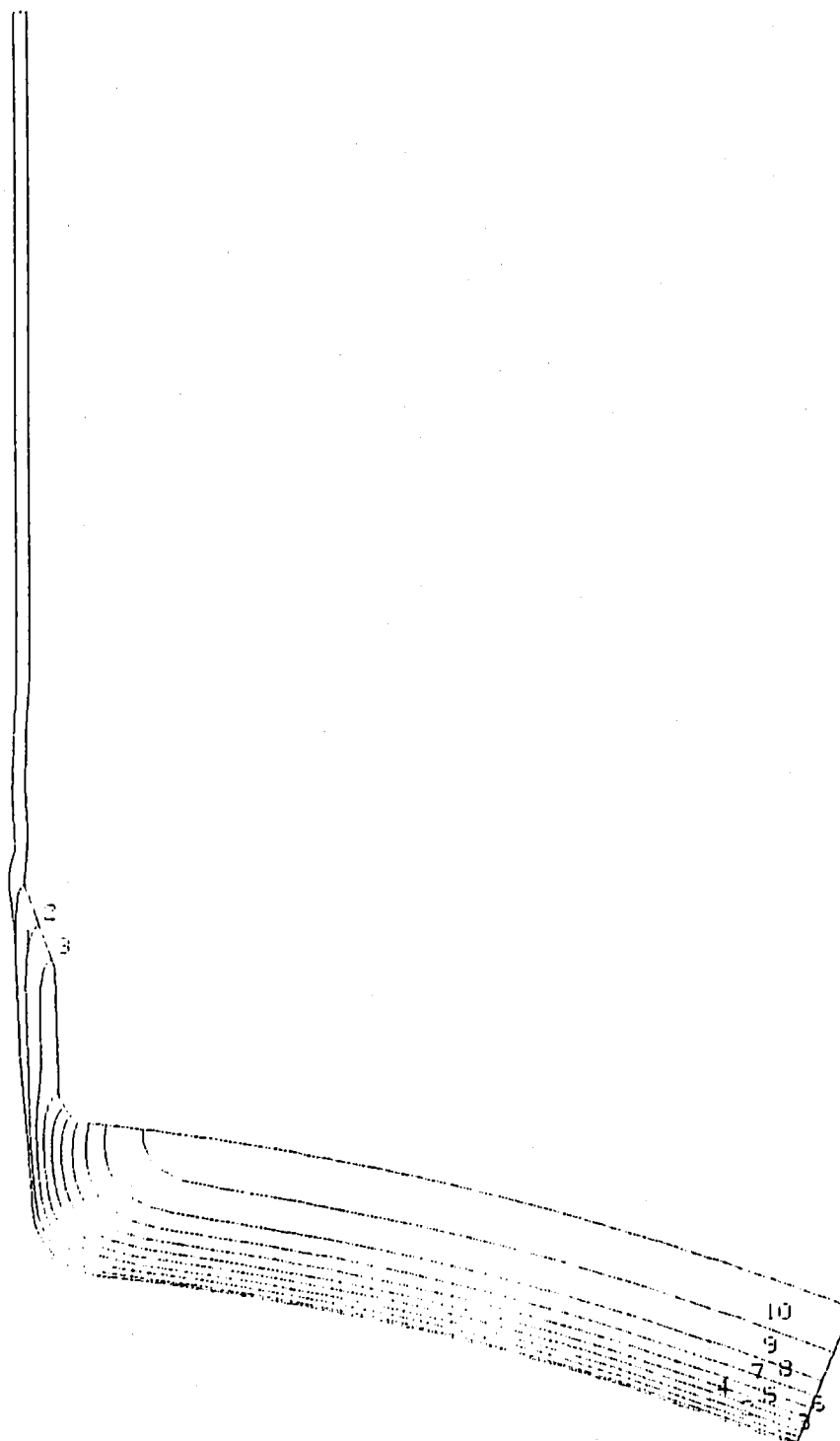
GEOM. SCALE 50.0000

図10.3 温度コンター t=25 sec

FINNS
TEMPERATURE

CONTOUR VALUES

- 1 447.0000
- 2 463.0000
- 3 478.9999
- 4 495.0000
- 5 511.0000
- 6 527.0000
- 7 543.0000
- 8 559.0000
- 9 575.0000
- 10 591.0000



LEN. SCALE 50.0000

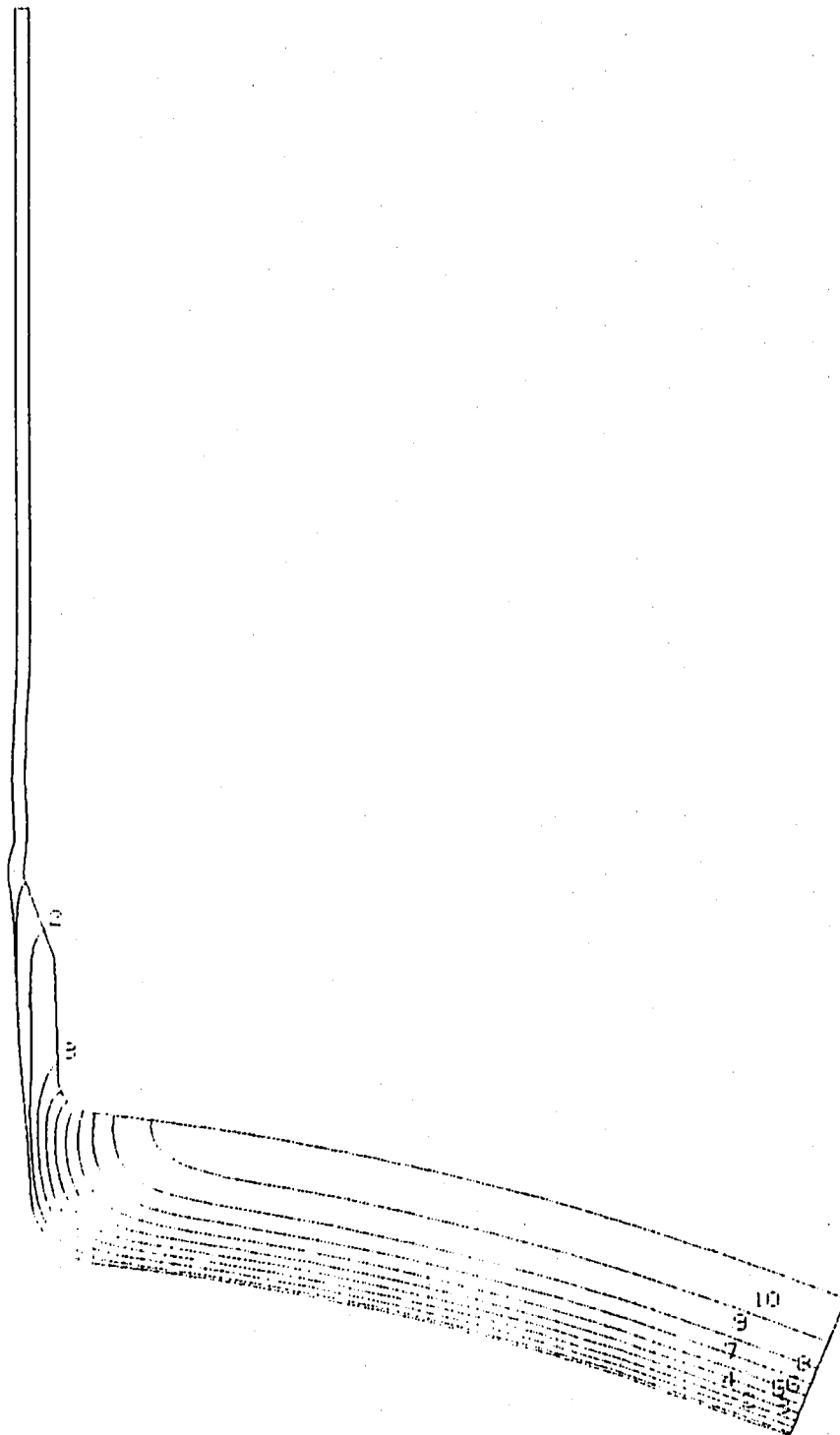
STEP NO. 40

図10.4 温度コンター t=35 sec

FINR5
TEMPERATURE

CONTOUR VALUES

- 1 422.0000
- 2 440.0000
- 3 457.9109
- 4 476.0000
- 5 494.0000
- 6 512.0000
- 7 530.0000
- 8 548.0000
- 9 566.0000
- 10 584.0000



STEP NO. 45

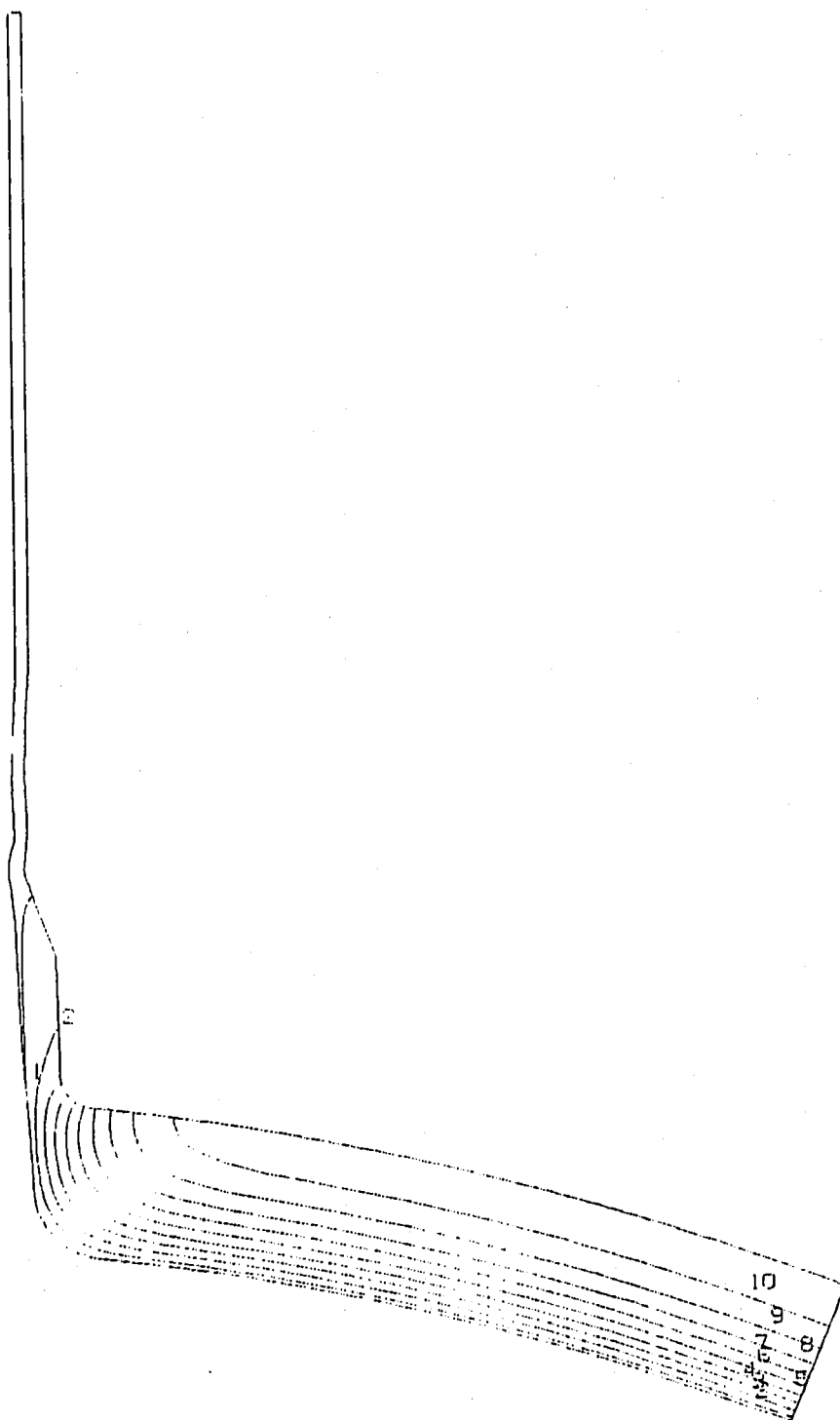
GRAPH. SCALE 50.0000

図10.5 温度コンター t=45 sec

FTHAS
TEMPERATURE

CONTOUR VALUES

- 1 378.0000
- 2 394.0000
- 3 415.0000
- 4 436.0000
- 5 457.0000
- 6 478.0000
- 7 499.0000
- 8 520.0000
- 9 541.0000
- 10 562.0000



COND. SCALE 50.0000

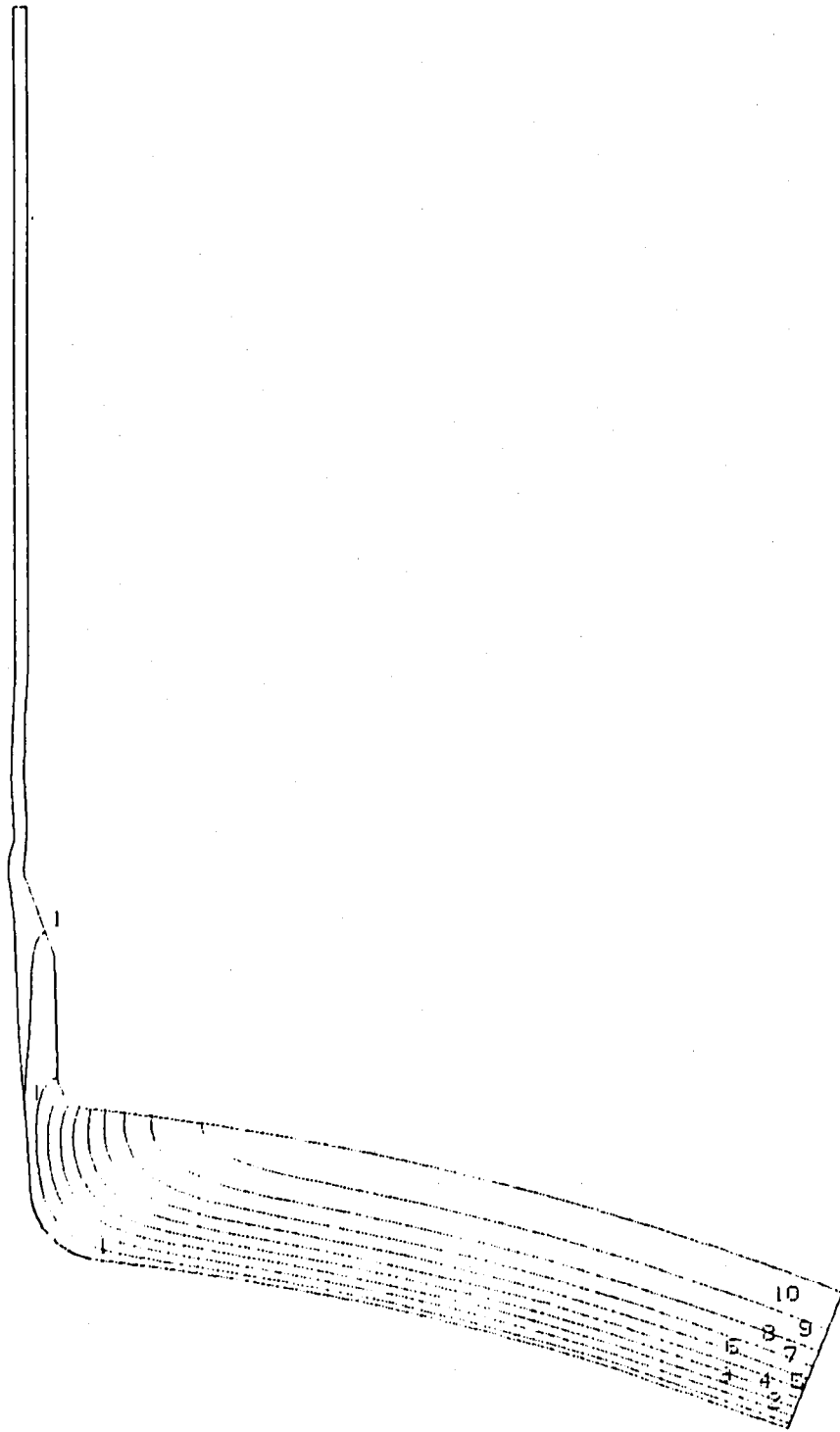
STEP NO. 55

図10.6 温度コンター t=70 sec

F11135
TEMPERATURE

CONTOUR VALUES

| | |
|----|----------|
| 1 | 342.0000 |
| 2 | 363.0000 |
| 3 | 384.0000 |
| 4 | 405.0000 |
| 5 | 426.0000 |
| 6 | 447.0000 |
| 7 | 468.0000 |
| 8 | 489.0000 |
| 9 | 510.0000 |
| 10 | 531.0000 |



GRAPH. SCALE 1 50.0000

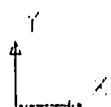
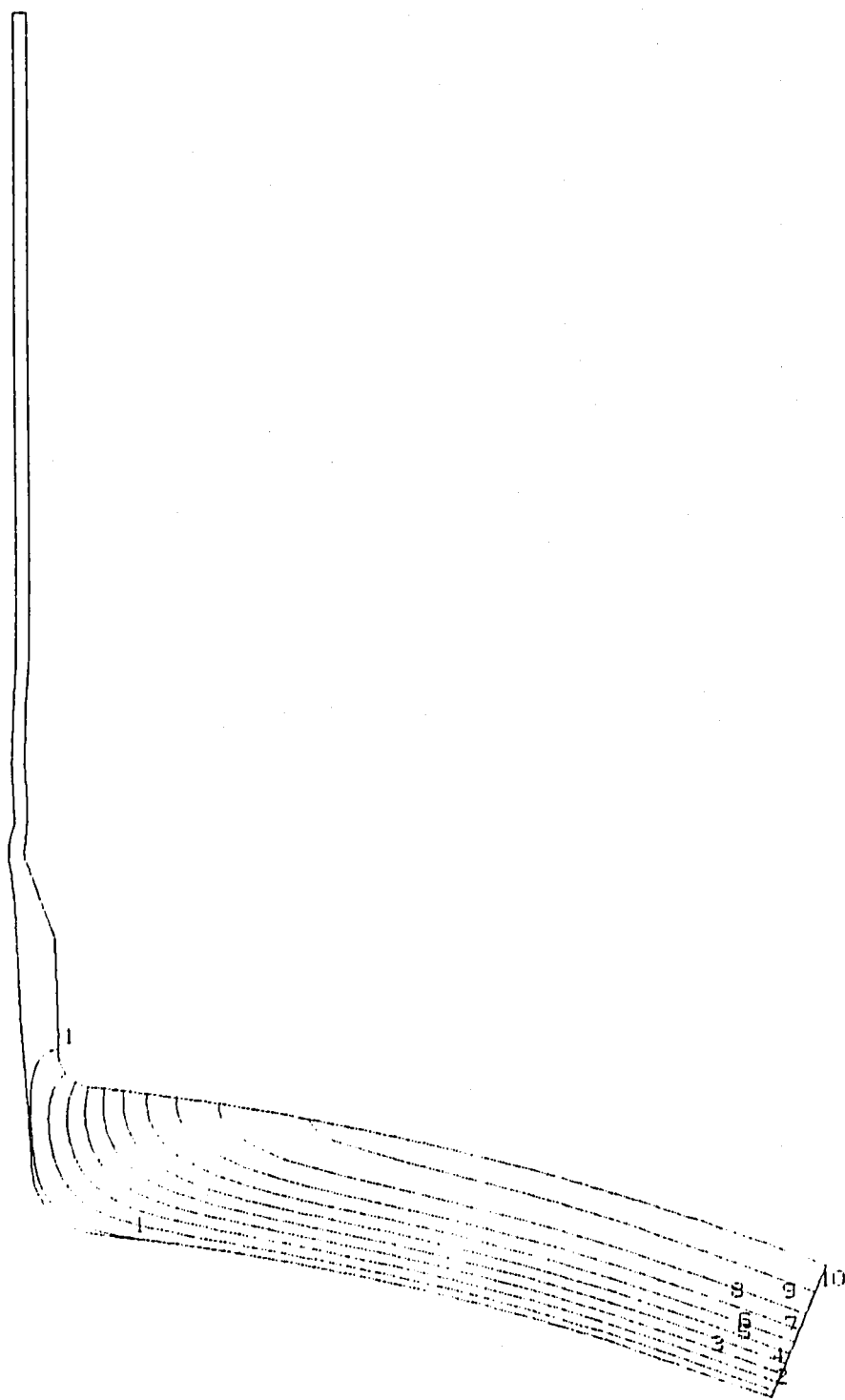
STEP 101. 135

図10.7 温度コンター t=100 sec

FINNS
TEMPERATURE

CONTOUR VALUES

| | |
|----|----------|
| 1 | 306.9999 |
| 2 | 321.0000 |
| 3 | 335.0000 |
| 4 | 348.9999 |
| 5 | 363.0000 |
| 6 | 377.0000 |
| 7 | 390.9999 |
| 8 | 405.0000 |
| 9 | 419.0000 |
| 10 | 433.9999 |



CONT. SCALE _____ 50.0000

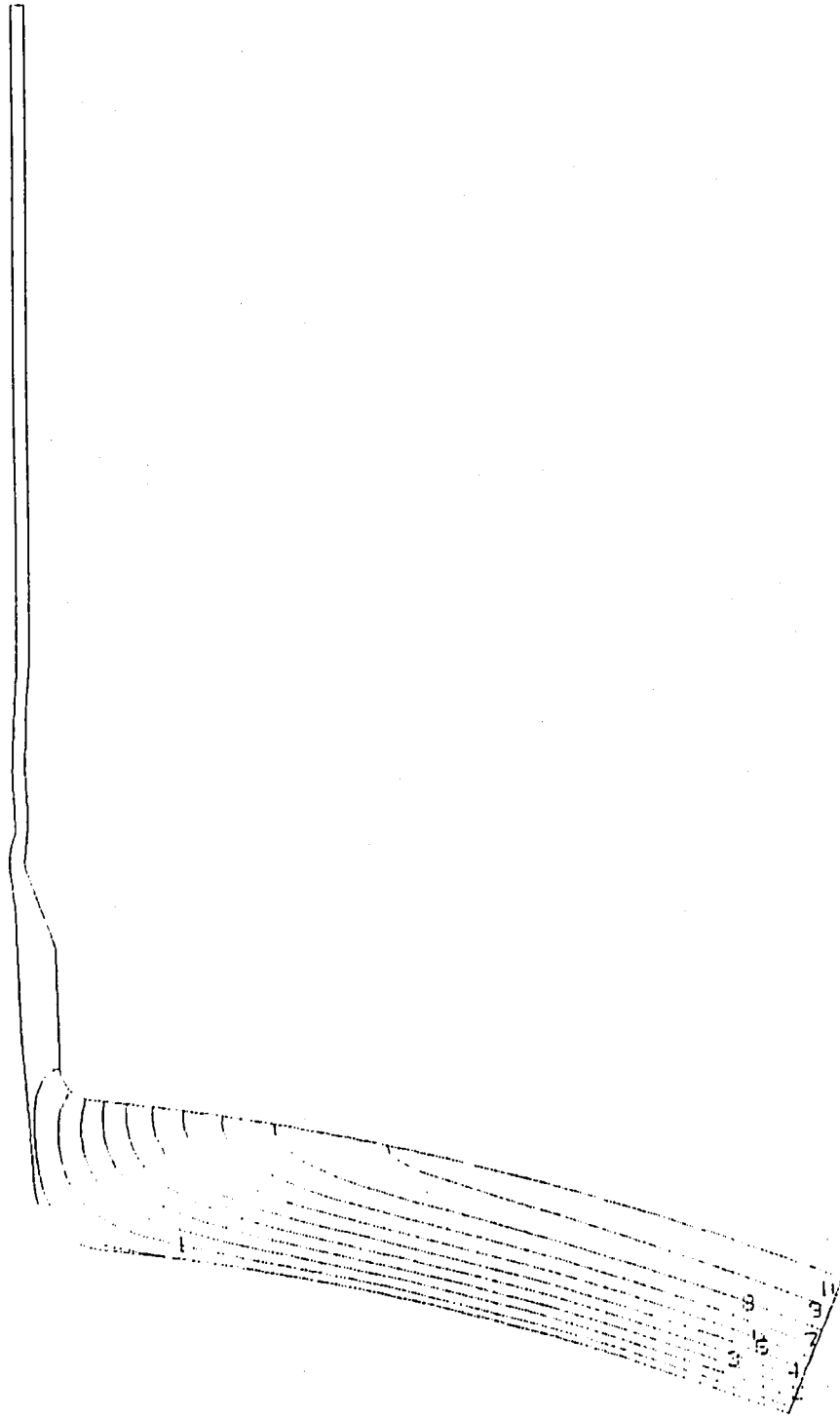
STEP NO. 85

図10.8 温度コンター t=200 sec

FIHRS
TEMPERATURE

CONTOUR VALUES

- 1 307.6996
- 2 310.7996
- 3 317.9996
- 4 325.1996
- 5 332.3994
- 6 339.5994
- 7 346.7990
- 8 353.9990
- 9 361.1991
- 10 368.3991



GEOM. SCALE 50.0000

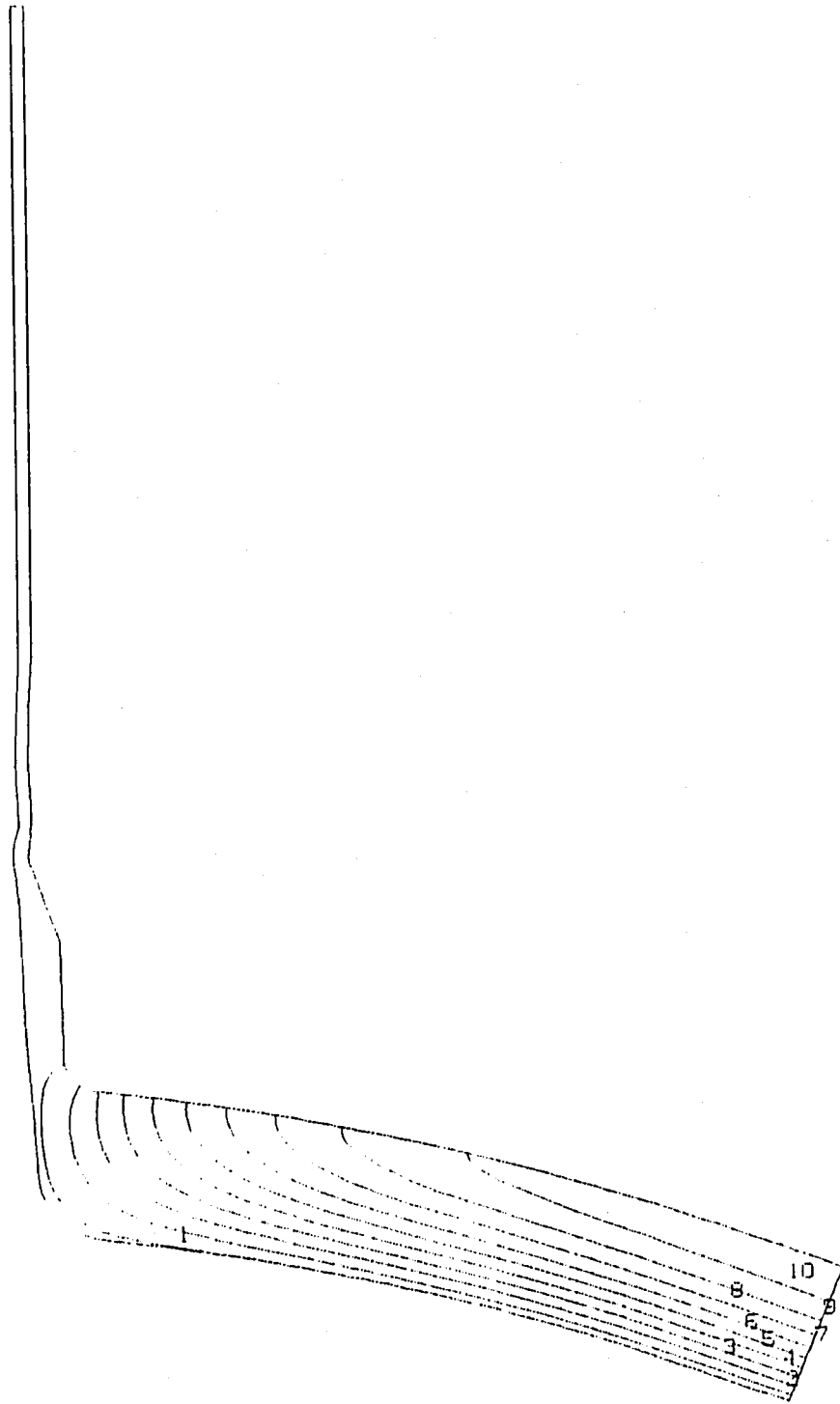
STEP NO. 95

図10.9 温度コンター t=300 sec

FILMS
TEMPERATURE

CONTOUR VALUES

- 1 300.9094
- 2 302.7993
- 3 304.6992
- 4 306.5991
- 5 308.4990
- 6 310.3989
- 7 312.2988
- 8 314.1987
- 9 316.0986
- 10 317.9985



GEOM. SCALE _____ 50.0000

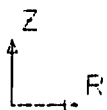
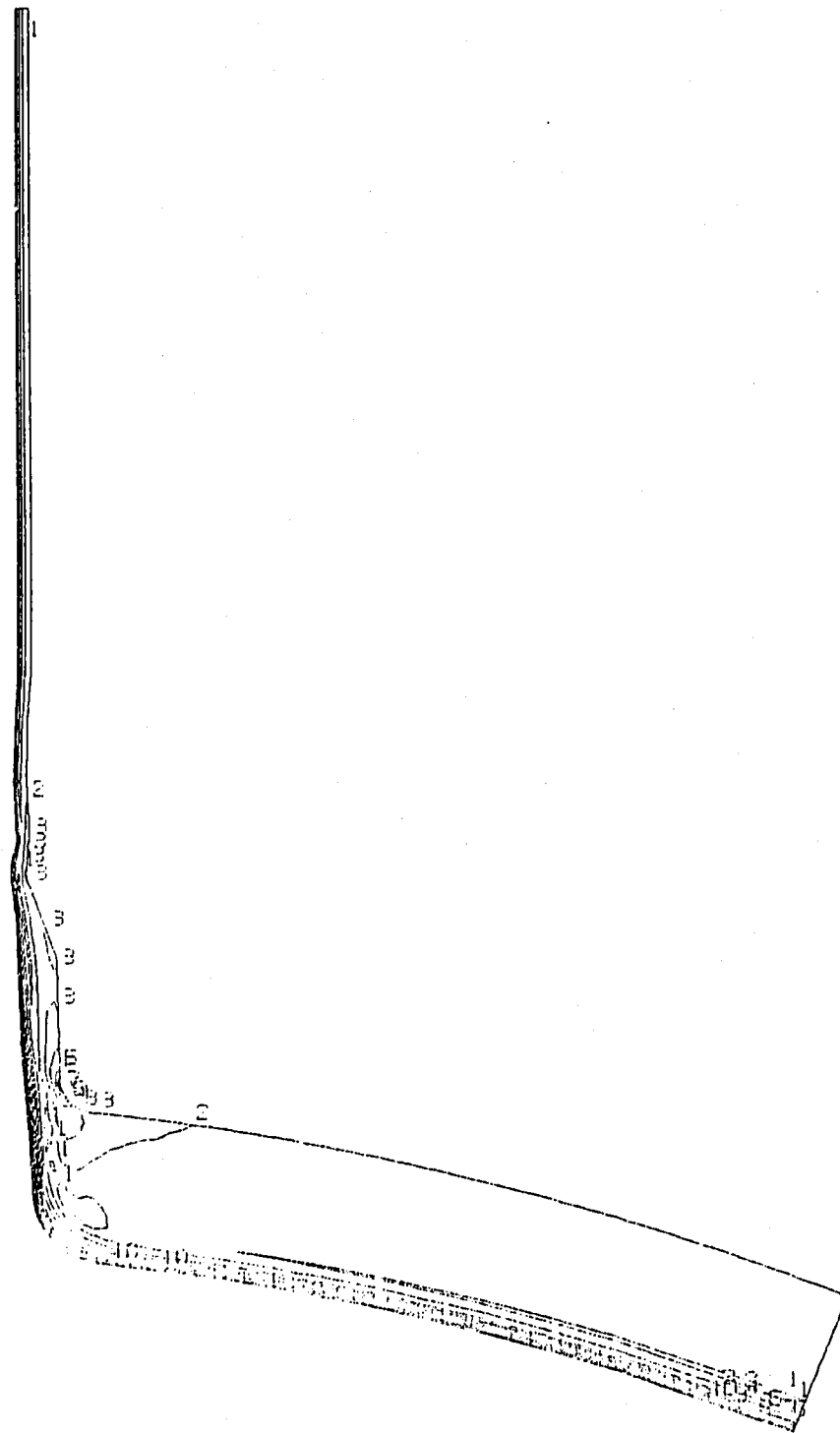
STEP 100. 105

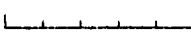
図10. 10 温度コンター t=500 sec

FINAG
VON MISES STRESS

CONTOUR VALUES

| | |
|----|----------|
| 1 | 0.700000 |
| 2 | 2.099997 |
| 3 | 3.499996 |
| 4 | 4.899994 |
| 5 | 6.299993 |
| 6 | 7.699992 |
| 7 | 9.099990 |
| 8 | 10.49998 |
| 9 | 11.89998 |
| 10 | 13.29998 |



GEOM. SCALE  50.0000

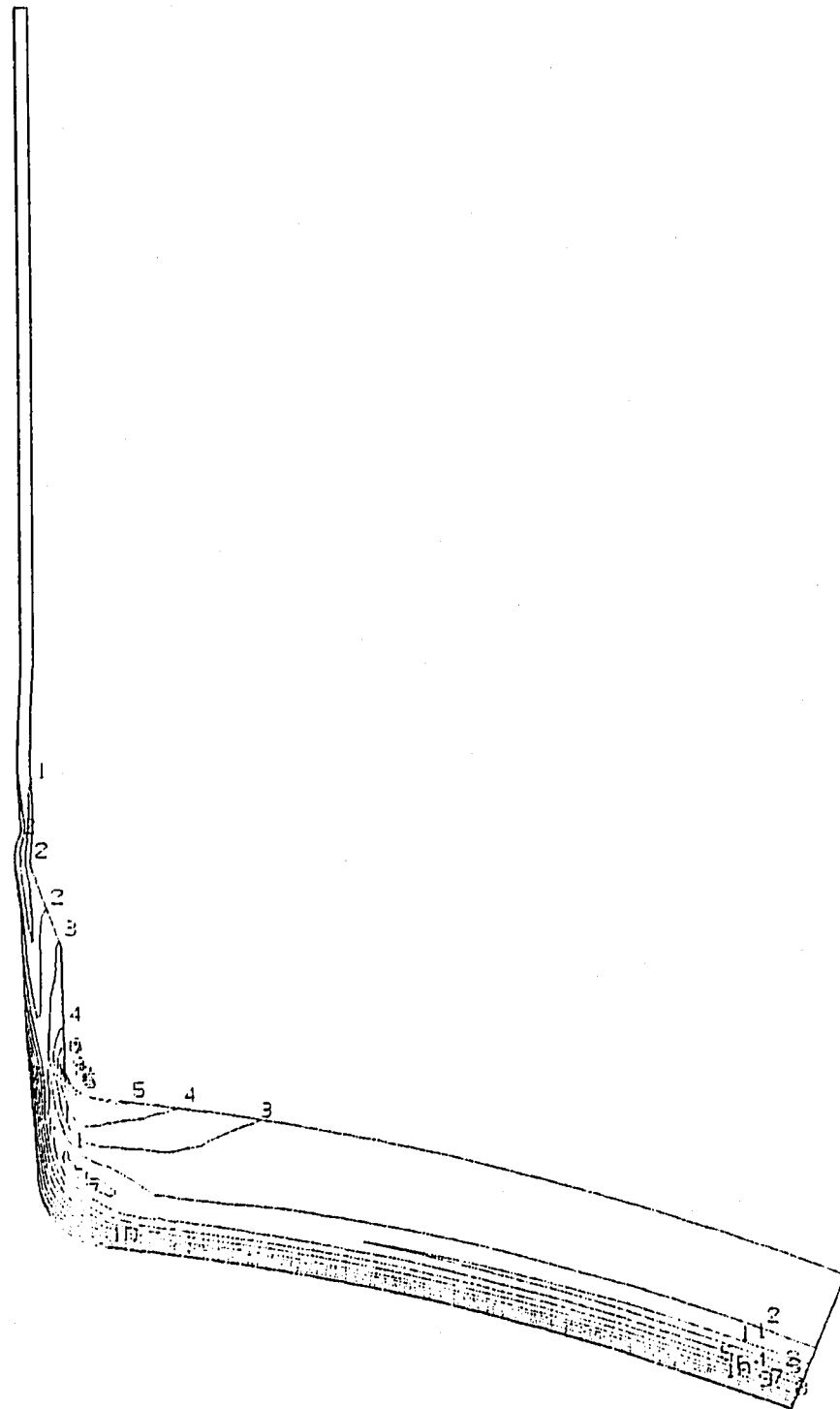
STEP NO. 11

図11.1 ミーゼスの等価応力コンター t=5 sec

FINAS
VON MISES STRESS

CONTOUR VALUES

- 1 1.499999
- 2 4.499997
- 3 7.499995
- 4 10.499993
- 5 13.499991
- 6 16.499989
- 7 19.499987
- 8 22.499985
- 9 25.499984
- 10 28.499982



GEOM. SCALE 50.0000

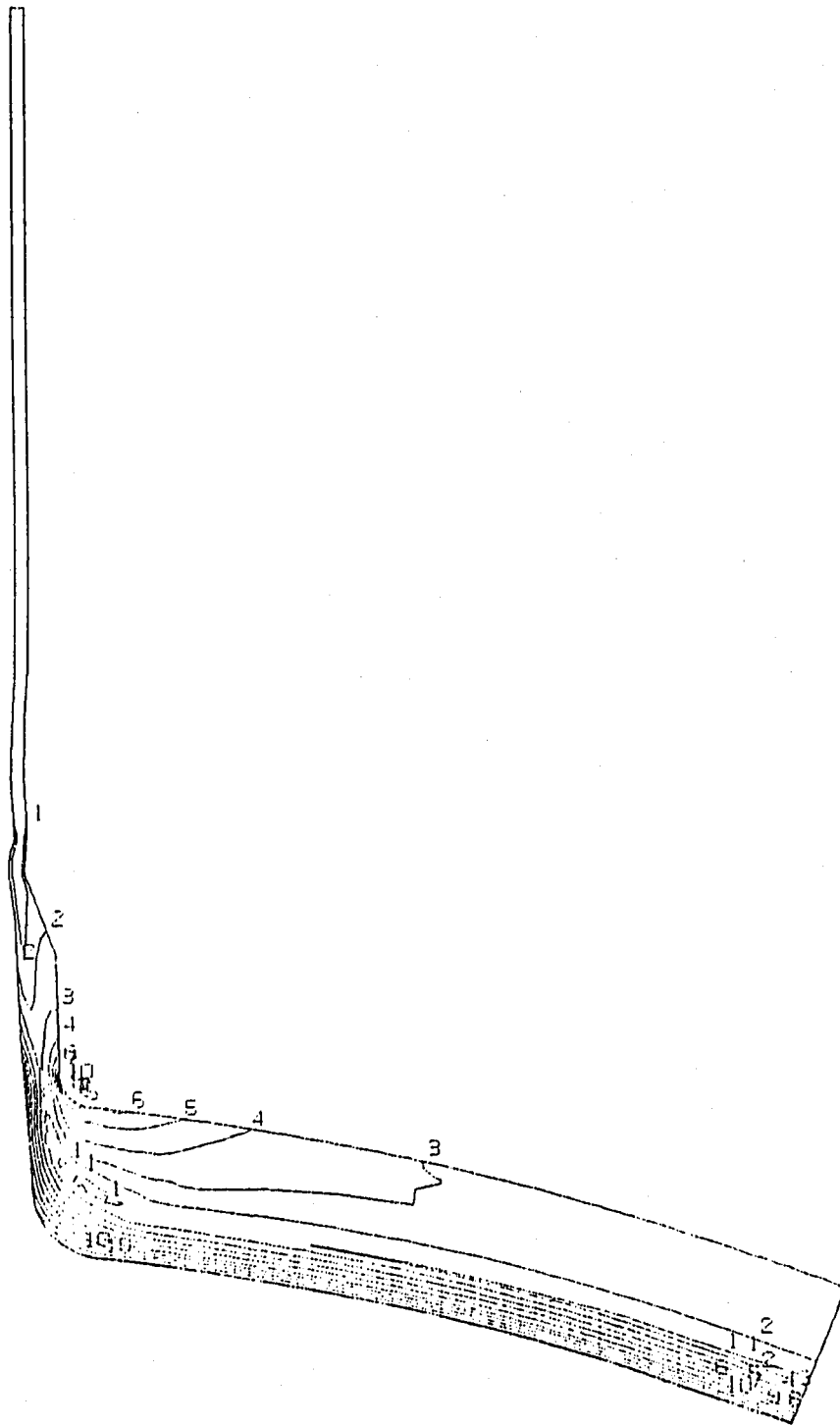
STEP NO. 21

図11.2 ミーゼスの等価応力コンター t = 15 sec

FINAS
VON MISES STRESS

CONTOUR VALUES

| | |
|----|-----------|
| 1 | 1.999999 |
| 2 | 5.999997 |
| 3 | 9.999995 |
| 4 | 13.999993 |
| 5 | 17.999991 |
| 6 | 21.999989 |
| 7 | 25.999987 |
| 8 | 29.999985 |
| 9 | 33.999983 |
| 10 | 37.999981 |



GEOM. SCALE 50.0000

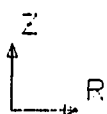
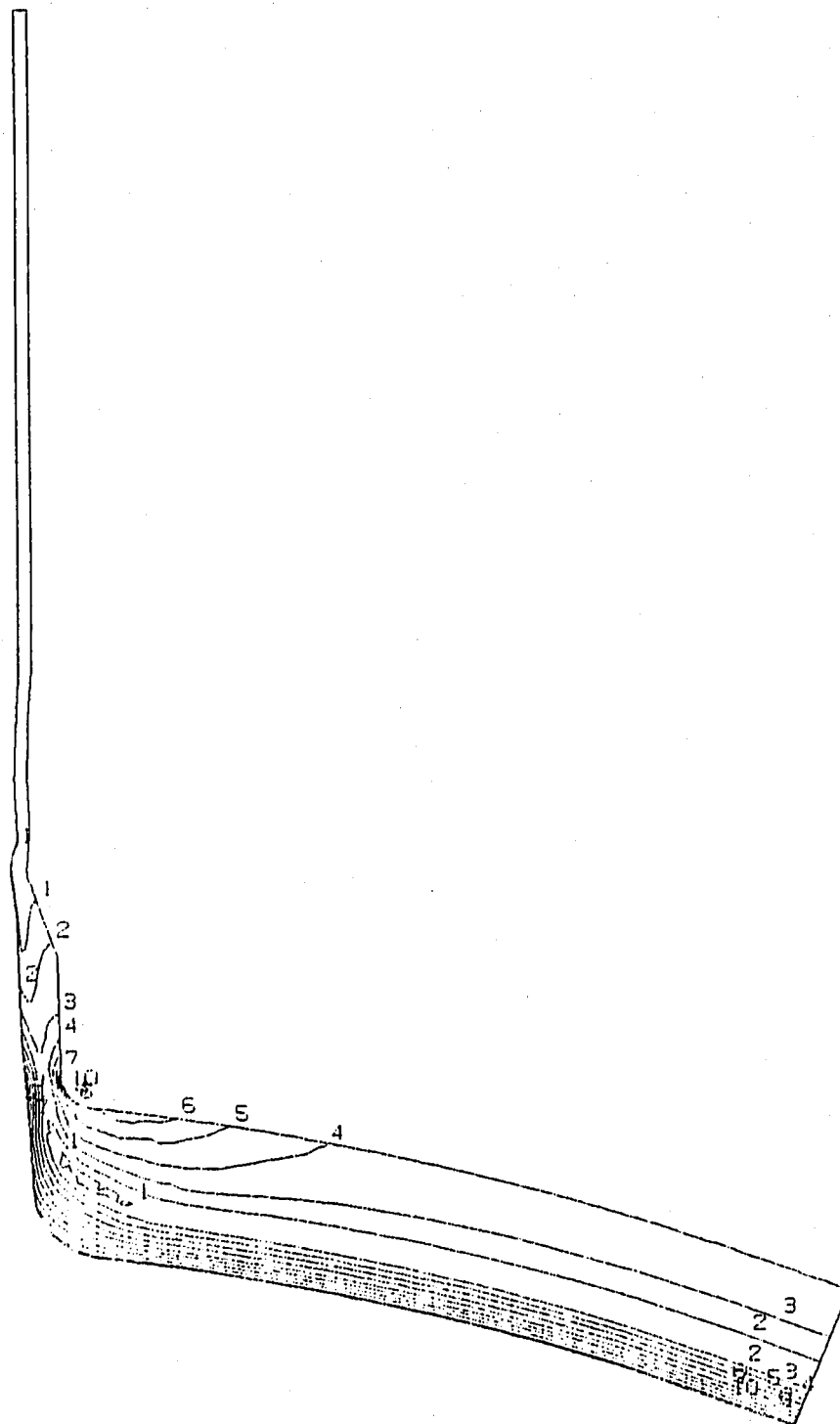
STEP NO. 31

図11.3 ミーゼスの等価応力コンター t = 25 sec

FINAS
VON MISES STRESS

CONTOUR VALUES

| | |
|----|----------|
| 1 | 2.399998 |
| 2 | 7.099996 |
| 3 | 11.79999 |
| 4 | 16.49998 |
| 5 | 21.19997 |
| 6 | 25.89998 |
| 7 | 30.59997 |
| 8 | 35.29997 |
| 9 | 39.99997 |
| 10 | 44.69997 |



GEOM. SCALE _____ 50.0000

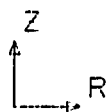
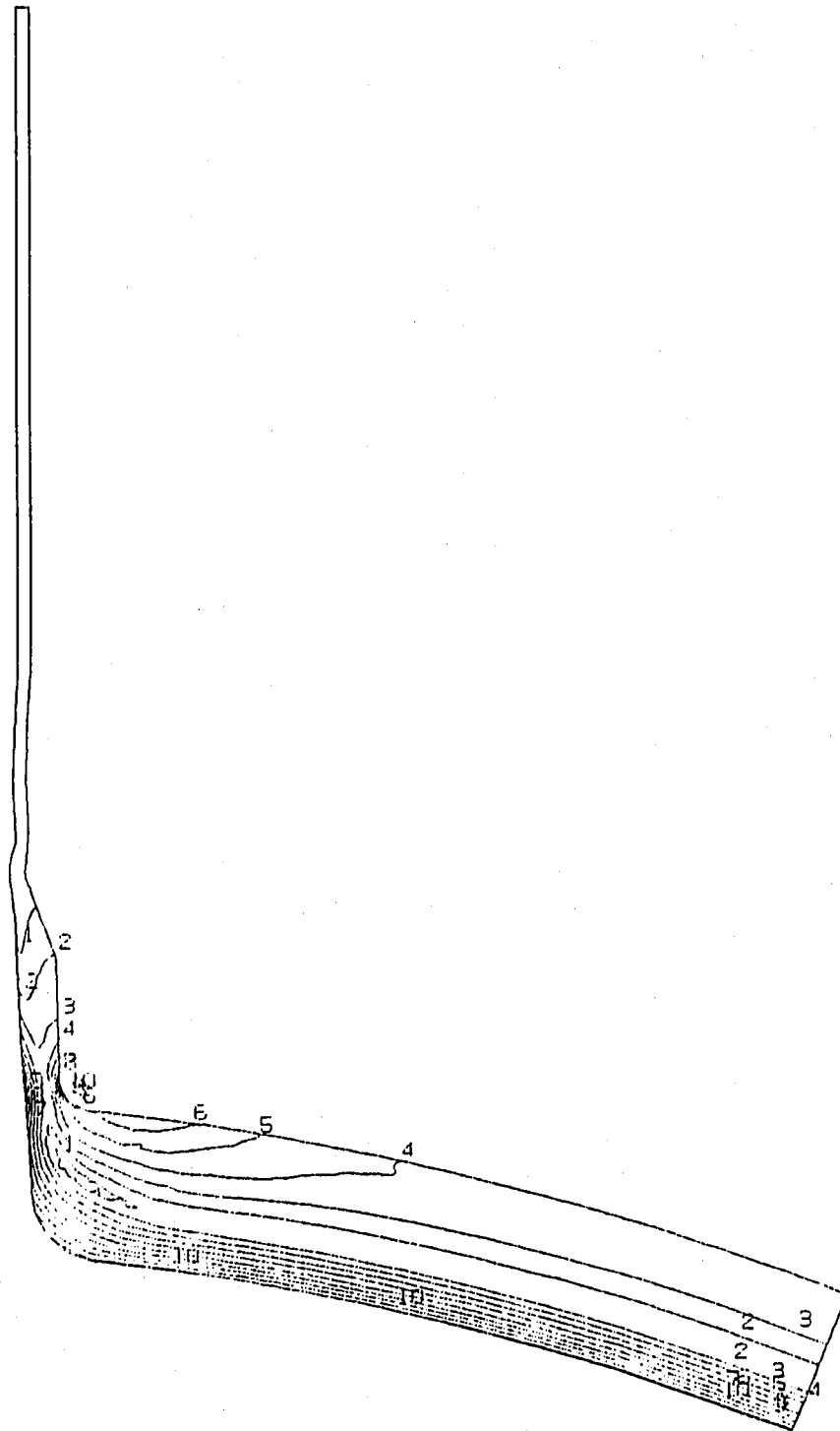
STEP NO. 41

図11.4 ミーゼスの等価応力コンター t=35 sec

FINAS
VON MISES STRESS

CONTOUR VALUES

| | |
|----|-----------|
| 1 | 2.699993 |
| 2 | 7.999996 |
| 3 | 13.299993 |
| 4 | 18.599993 |
| 5 | 23.899997 |
| 6 | 29.199997 |
| 7 | 34.499995 |
| 8 | 39.799994 |
| 9 | 45.099993 |
| 10 | 50.399992 |



STEP NO. 46


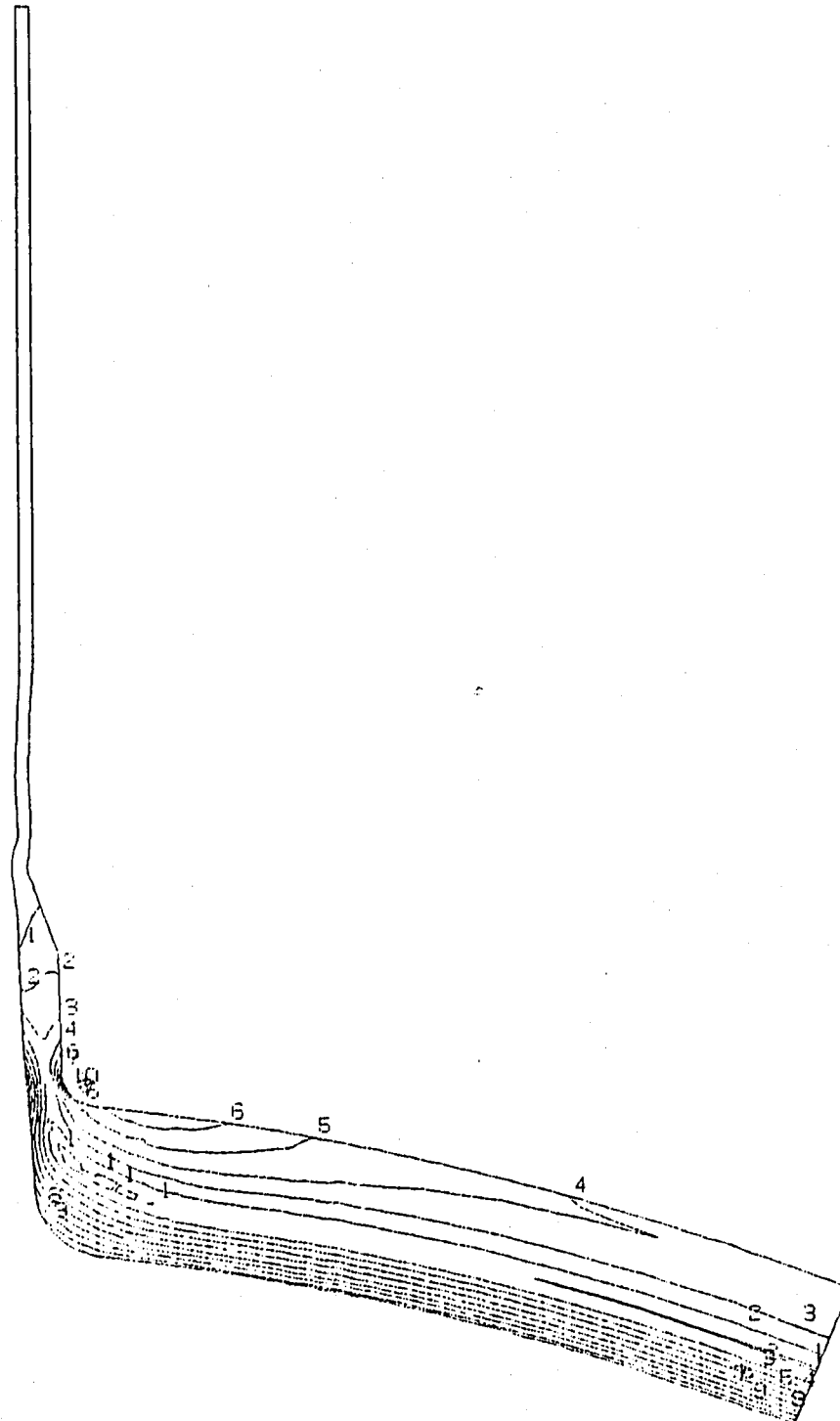
GEOM. SCALE  50.0000

図11.5 ミーゼスの等価応力コンター t=45 sec

FINAS
VON MISES STRESS

CONTOUR VALUES

| | |
|----|-----------|
| 1 | 3.199993 |
| 2 | 9.599996 |
| 3 | 15.999999 |
| 4 | 22.399997 |
| 5 | 28.799997 |
| 6 | 35.199996 |
| 7 | 41.599996 |
| 8 | 47.999996 |
| 9 | 54.399995 |
| 10 | 60.799995 |



GEOM. SCALE 50.0000

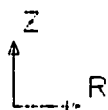
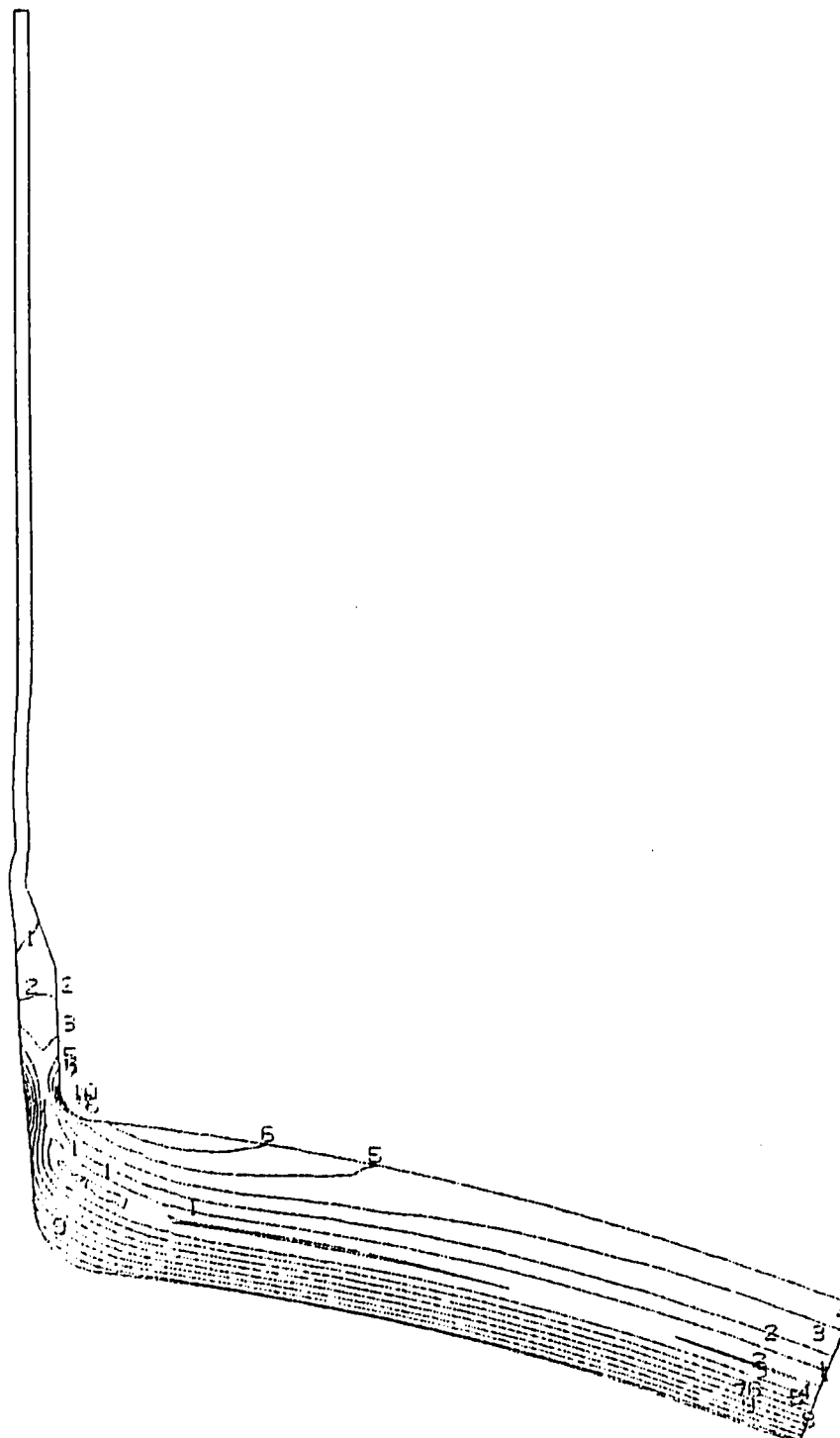
STEP NO. 56


図11.6 ミーゼスの等価応力コンター t=70 sec

FINAS
VON MISES STRESS

CONTOUR VALUES

| | |
|----|-----------|
| 1 | 3.199999 |
| 2 | 9.599996 |
| 3 | 15.999993 |
| 4 | 22.399987 |
| 5 | 28.799987 |
| 6 | 35.199986 |
| 7 | 41.599980 |
| 8 | 47.999976 |
| 9 | 54.399975 |
| 10 | 60.799975 |



GEOM. SCALE  50.0000

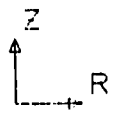
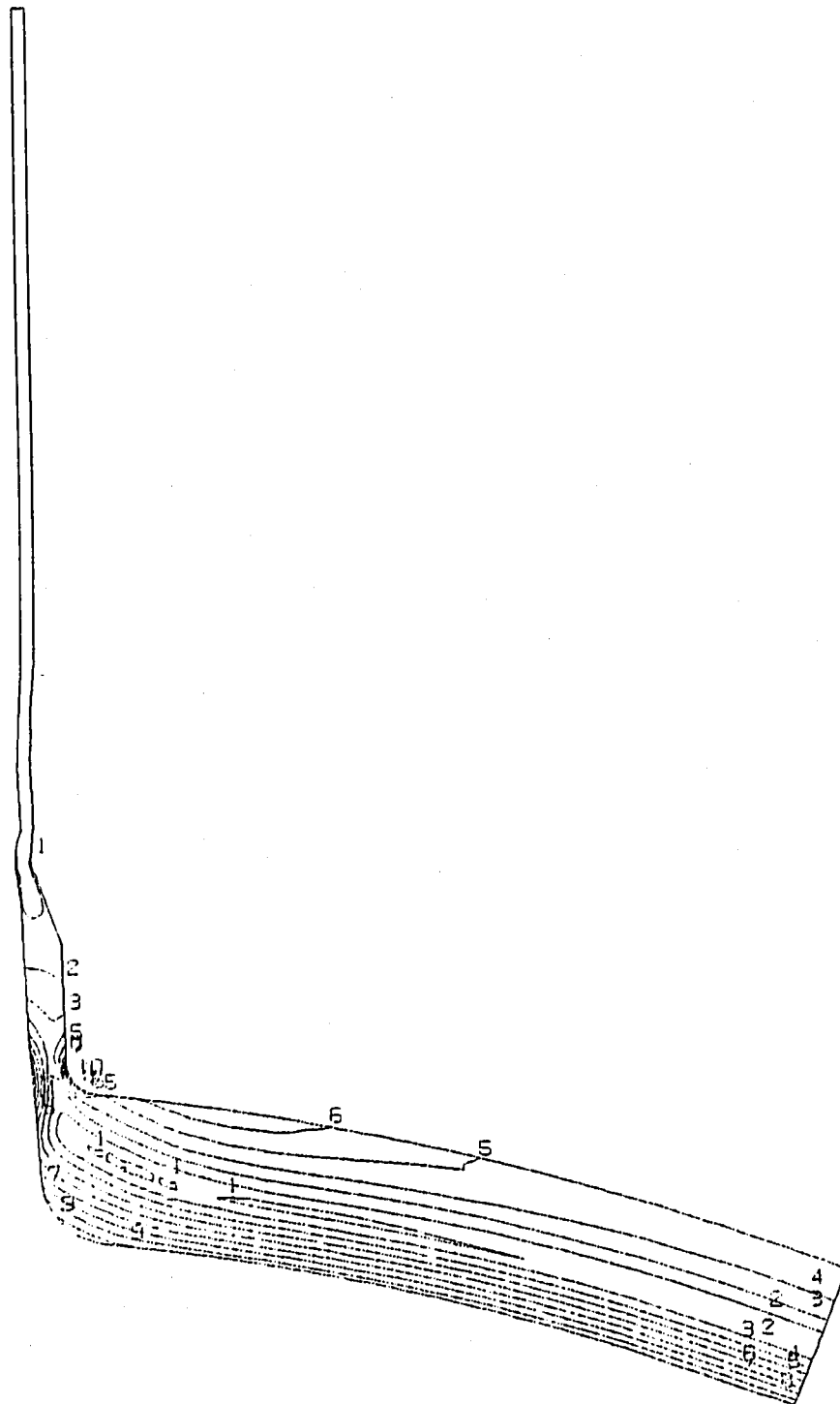
STEP NO. 66

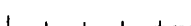
図11.7 ミーゼスの等価応力コンター t = 100 sec

FTHAS
VOH MISES STRESS

CONTOUR VALUES

| | |
|----|----------|
| 1 | 1.99999 |
| 2 | 6.19996 |
| 3 | 10.39999 |
| 4 | 14.59999 |
| 5 | 18.79999 |
| 6 | 22.99998 |
| 7 | 27.19998 |
| 8 | 31.39998 |
| 9 | 35.59997 |
| 10 | 39.79997 |



GEOM. SCALE  50.0000

STEP NO. 86

図11.8 ミーゼスの等価応力コンター t=200 sec

FINAS
VON MISES STRESS

CONTOUR VALUES

| | |
|----|-----------|
| 1 | 1.099999 |
| 2 | 3.299998 |
| 3 | 5.499997 |
| 4 | 7.699995 |
| 5 | 9.899994 |
| 6 | 12.099993 |
| 7 | 14.299992 |
| 8 | 16.499991 |
| 9 | 18.699990 |
| 10 | 20.899989 |

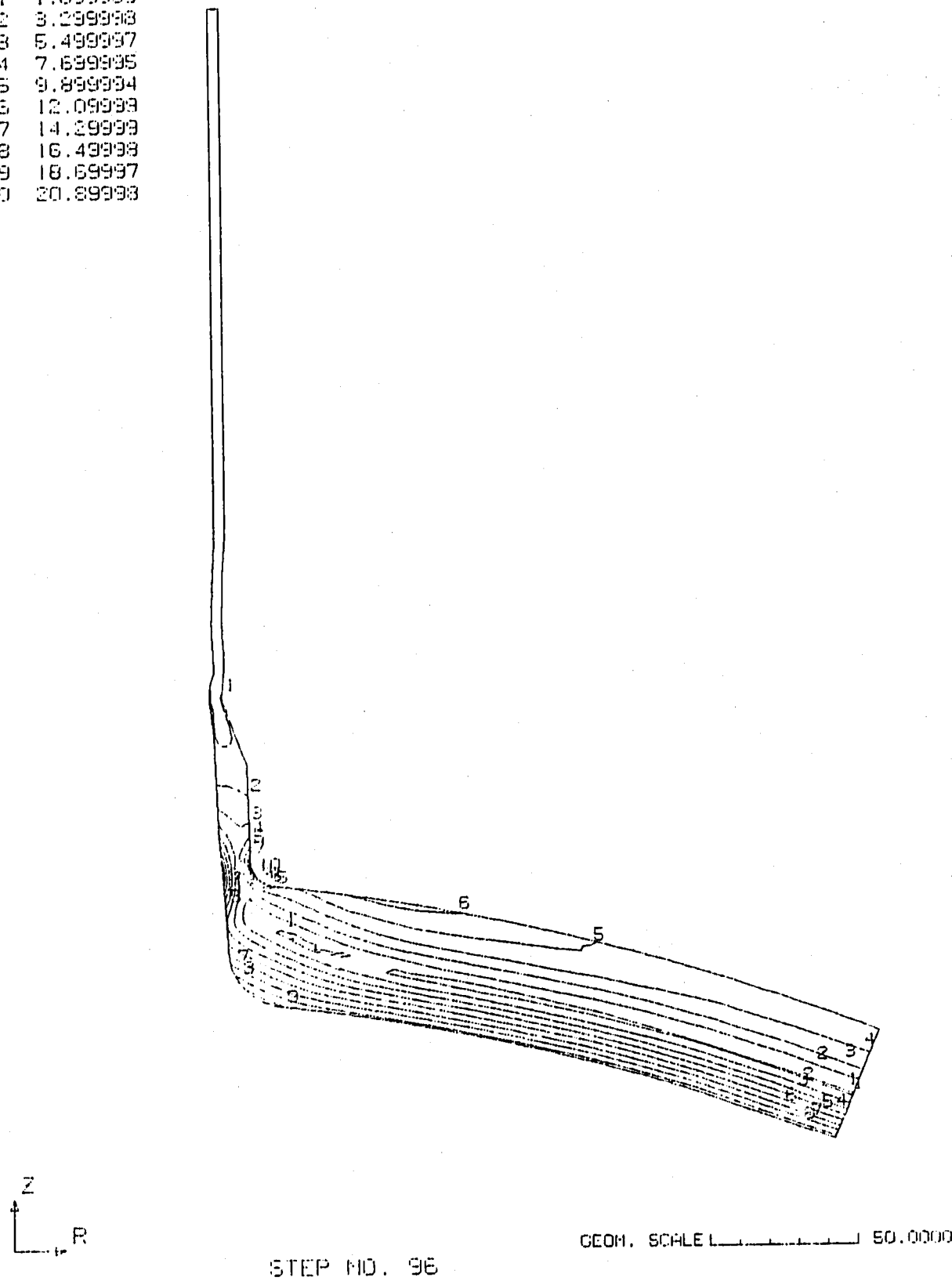


図11.9 ミーゼスの等価応力コンター t=300 sec

FINAS
VON MISES STRESS

CONTOUR VALUES

| | |
|----|----------|
| 1 | 0.300000 |
| 2 | 0.889999 |
| 3 | 1.479998 |
| 4 | 2.069997 |
| 5 | 2.659996 |
| 6 | 3.249995 |
| 7 | 3.839994 |
| 8 | 4.429993 |
| 9 | 5.019992 |
| 10 | 5.609991 |

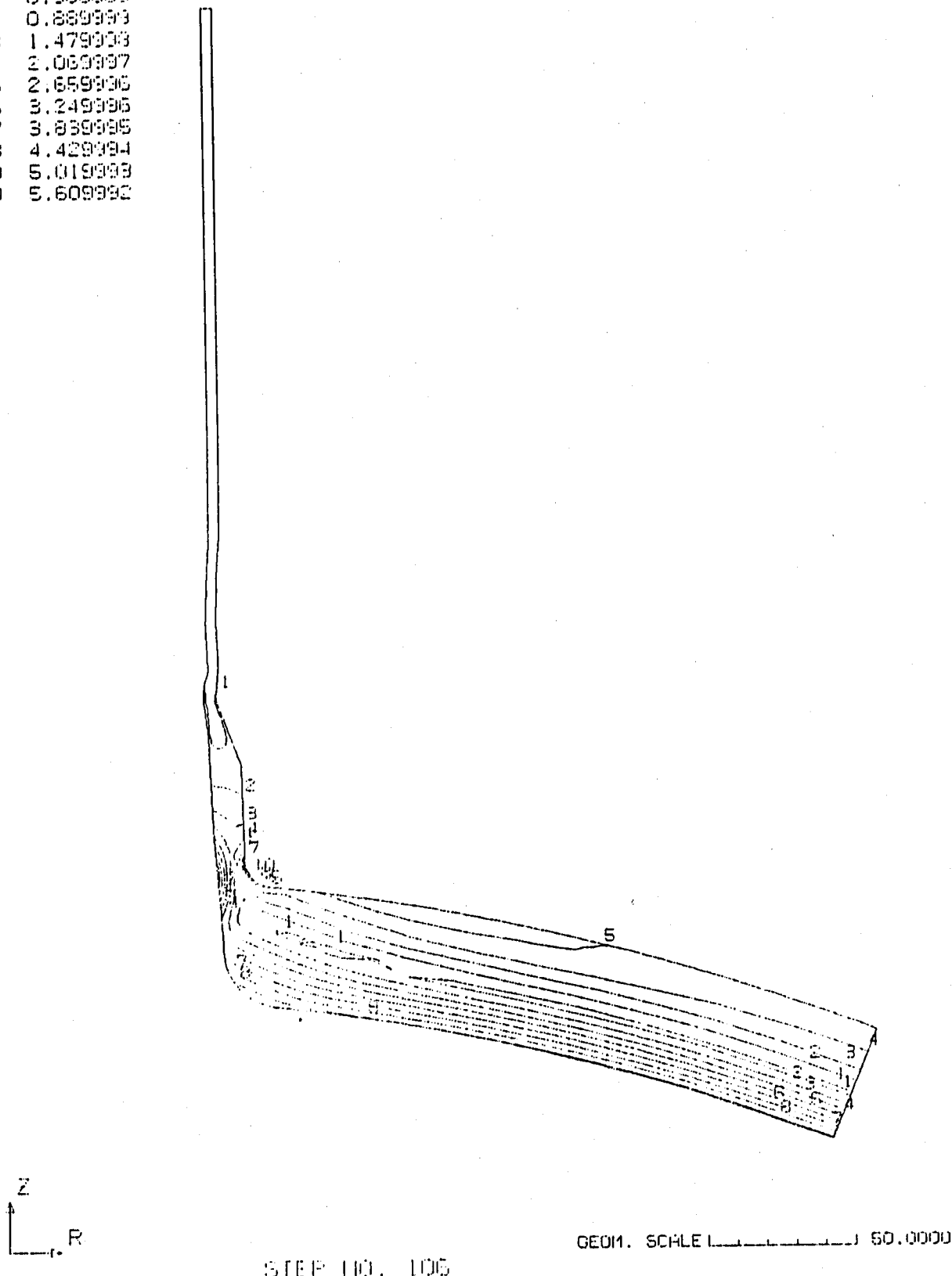
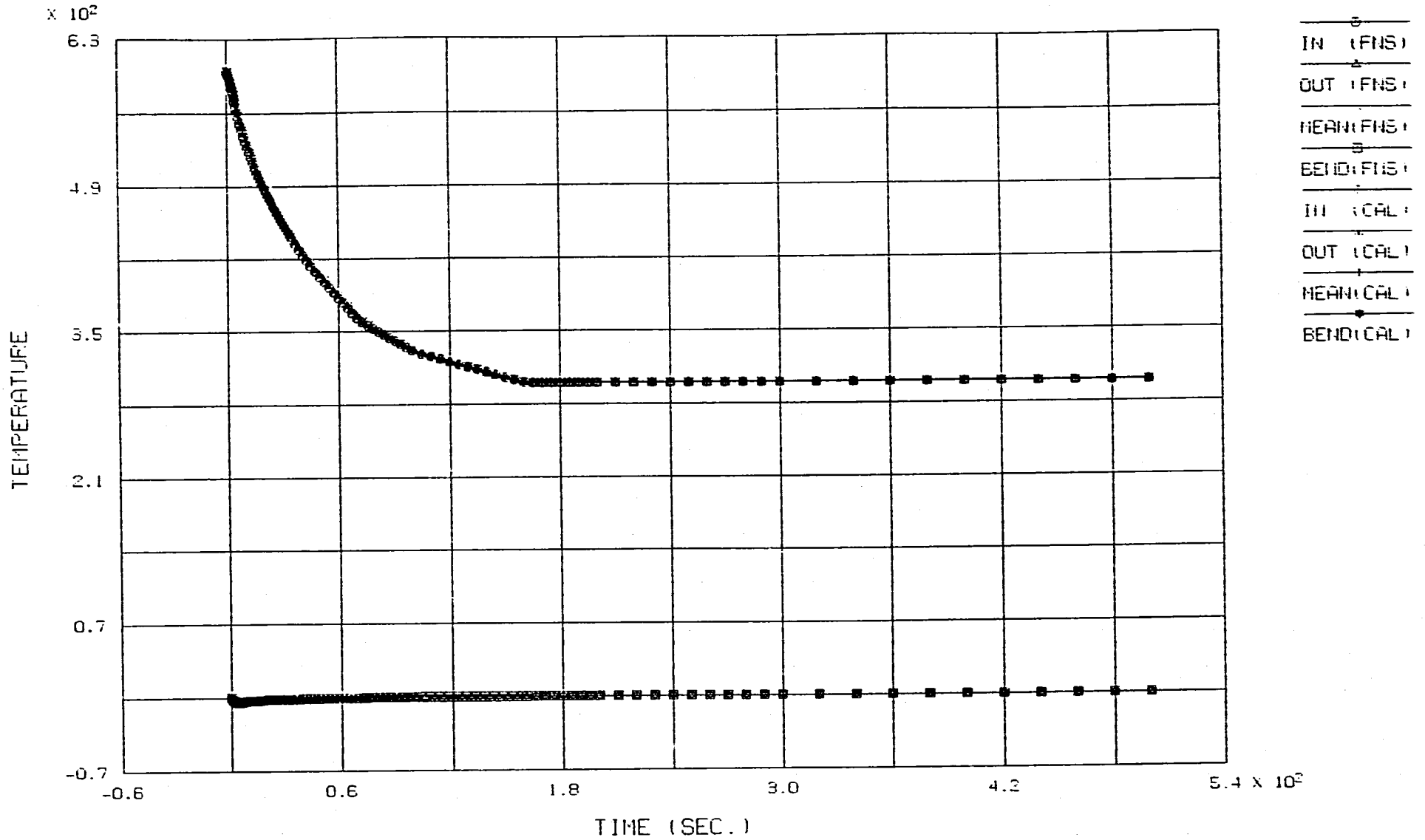
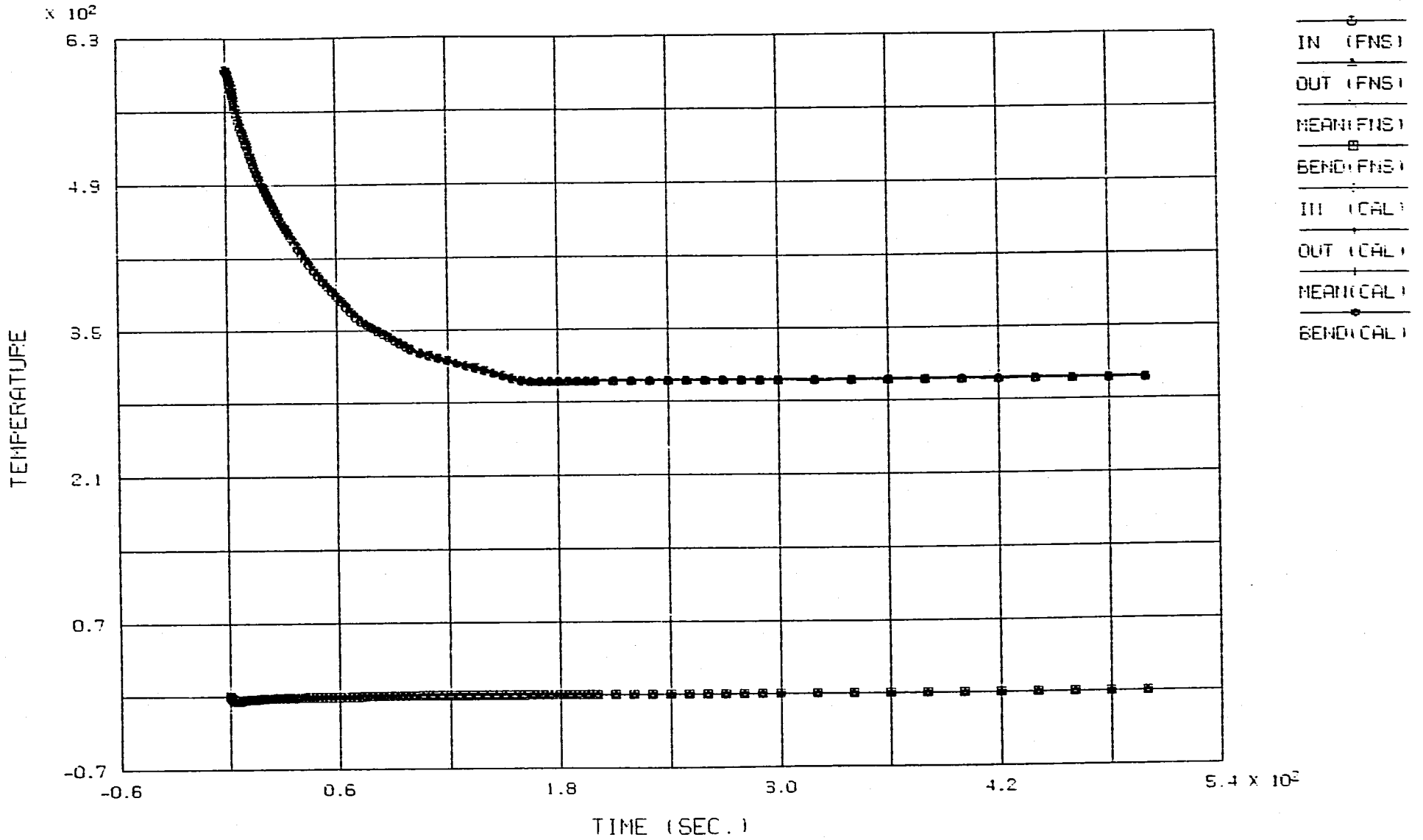


図11. 10 ミーゼスの等価応力コンター t=500 sec



TEMPERATURE OF SECTION(1)

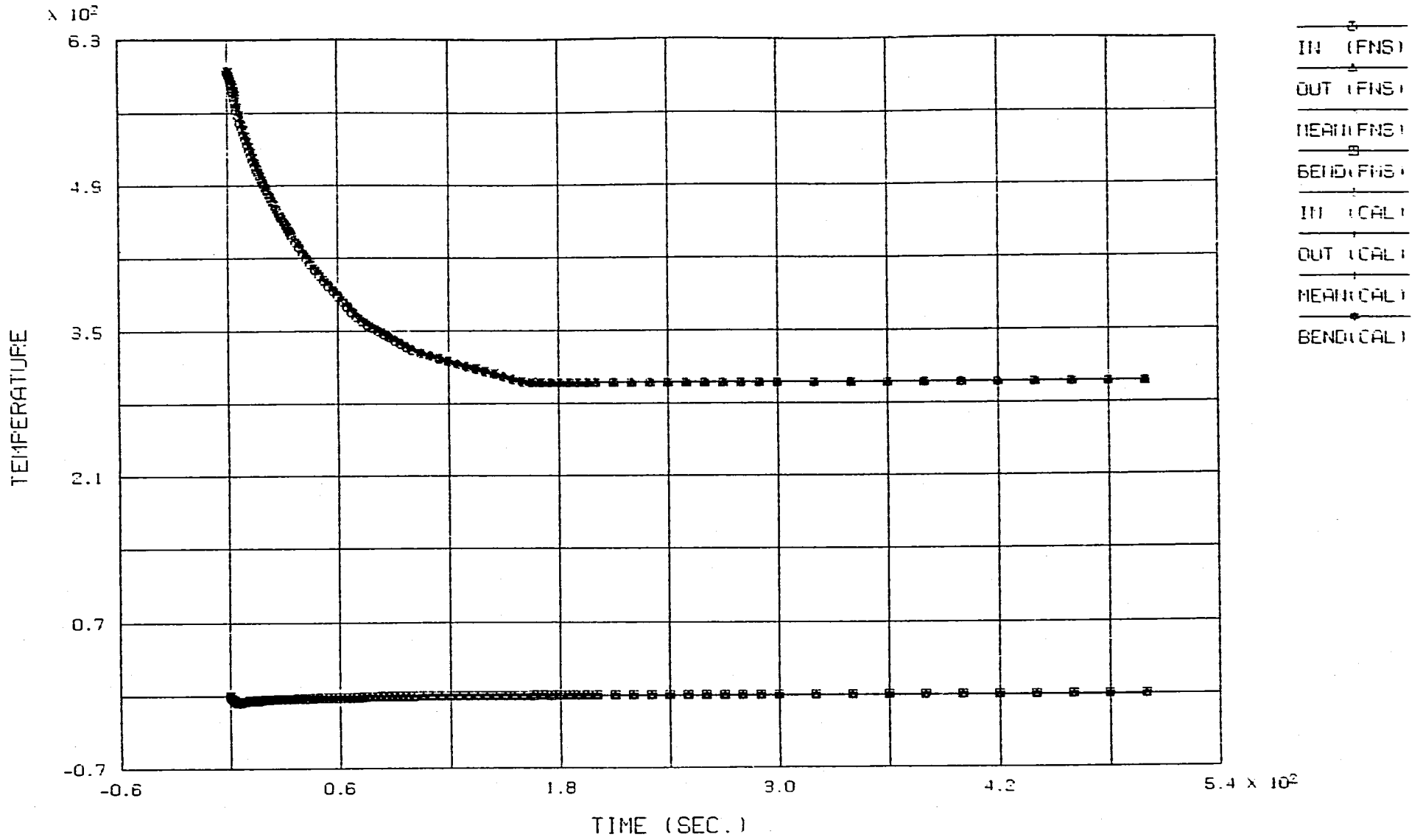
図12.1 評価断面1の温度



TEMPERATURE OF SECTION(2)

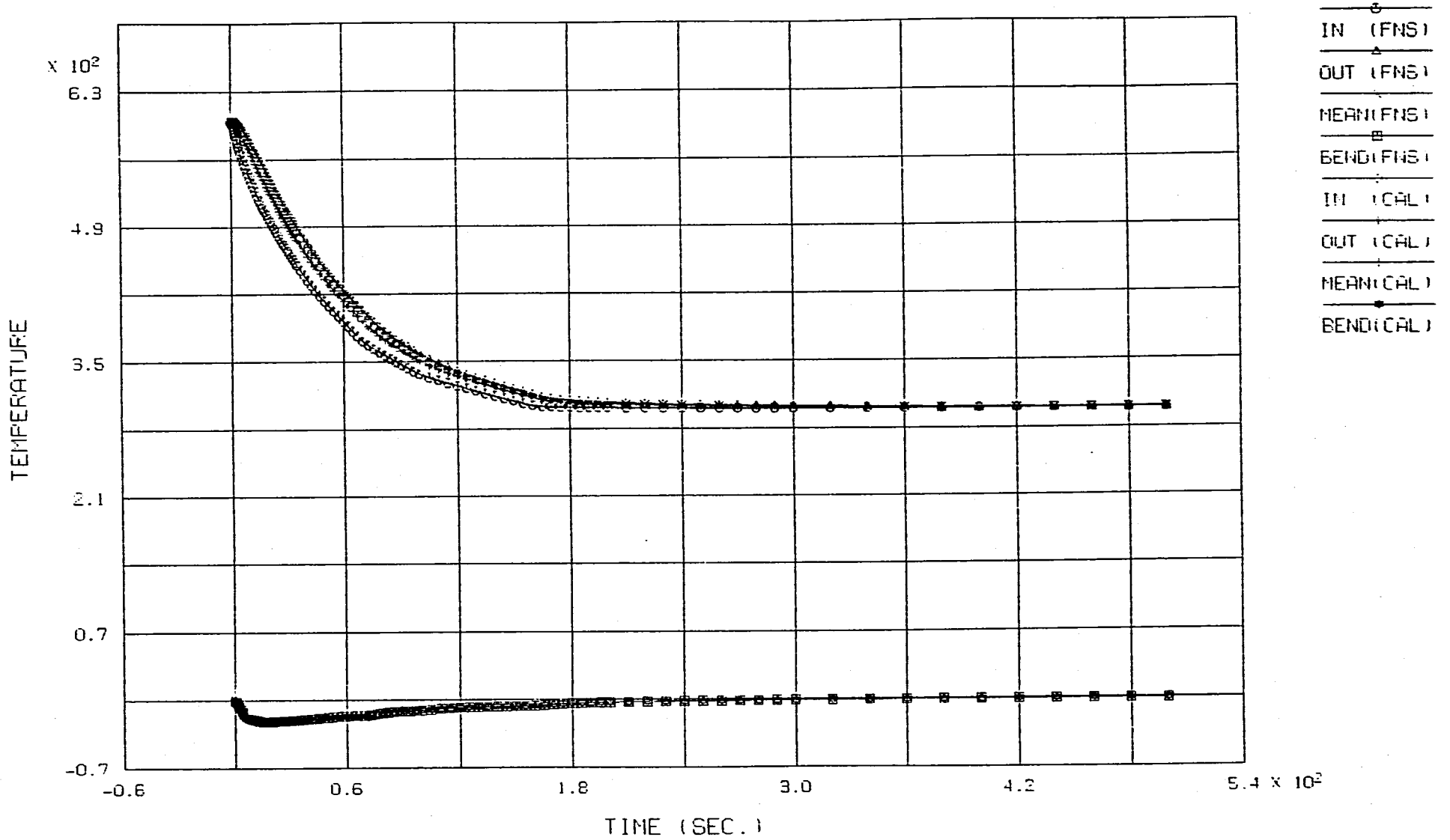
図12.2 評価断面2の温度

FINAS



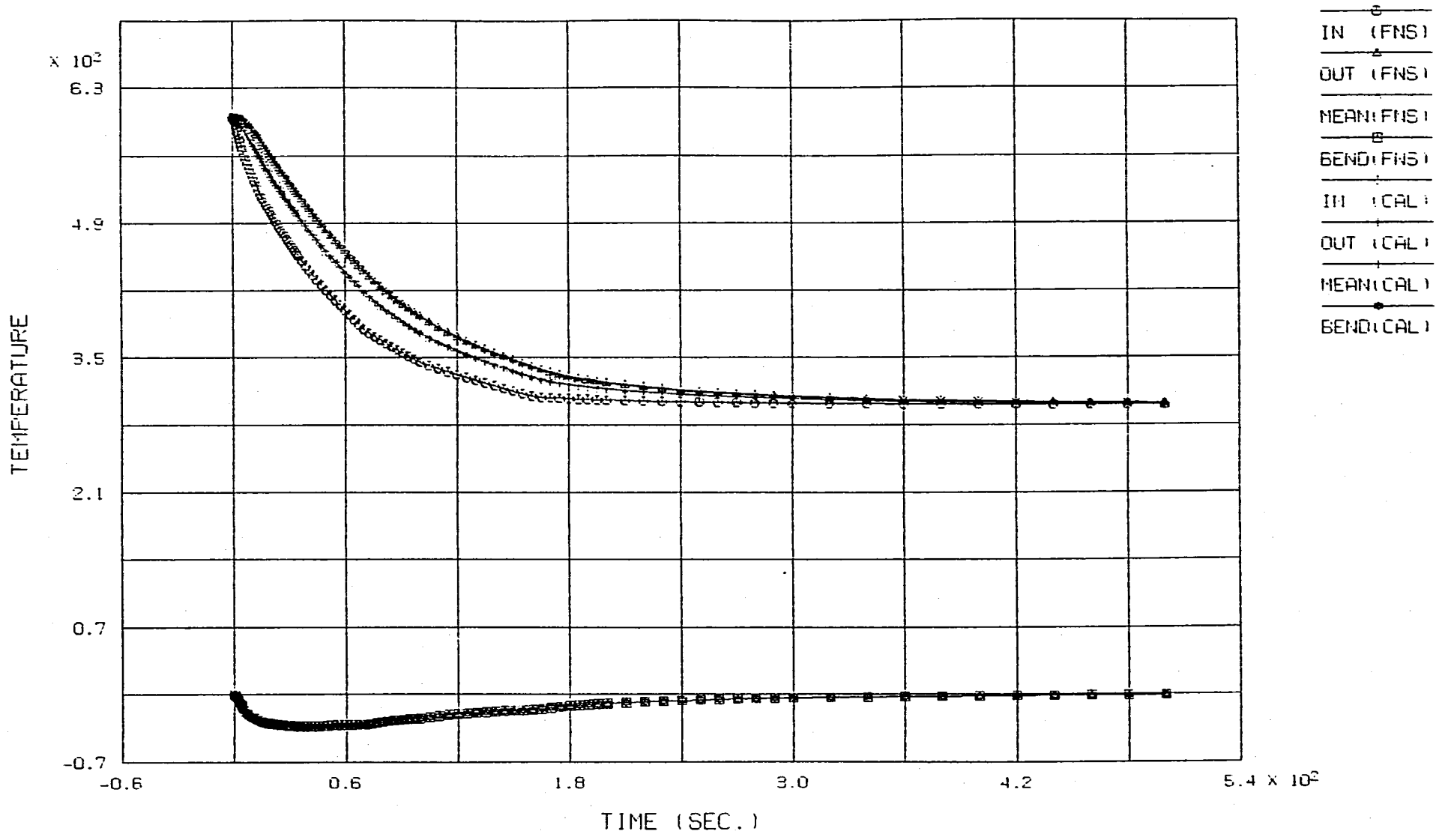
TEMPERATURE OF SECTION(3)

図12.3 評価断面3の温度



TEMPERATURE OF SECTION(4)

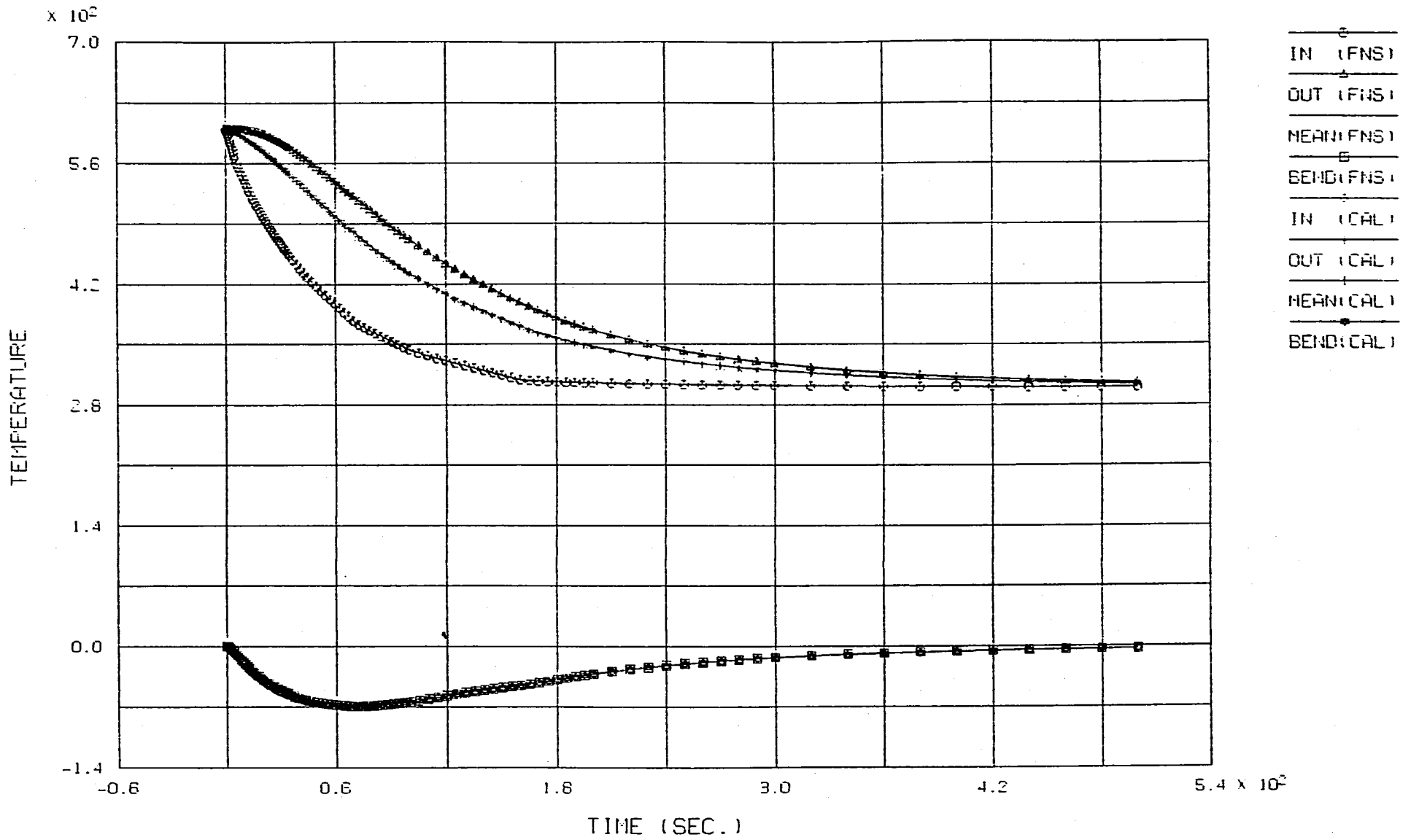
図12.4 評価断面4の温度



TEMPERATURE OF SECTION(5)

図12.5 評価断面5の温度

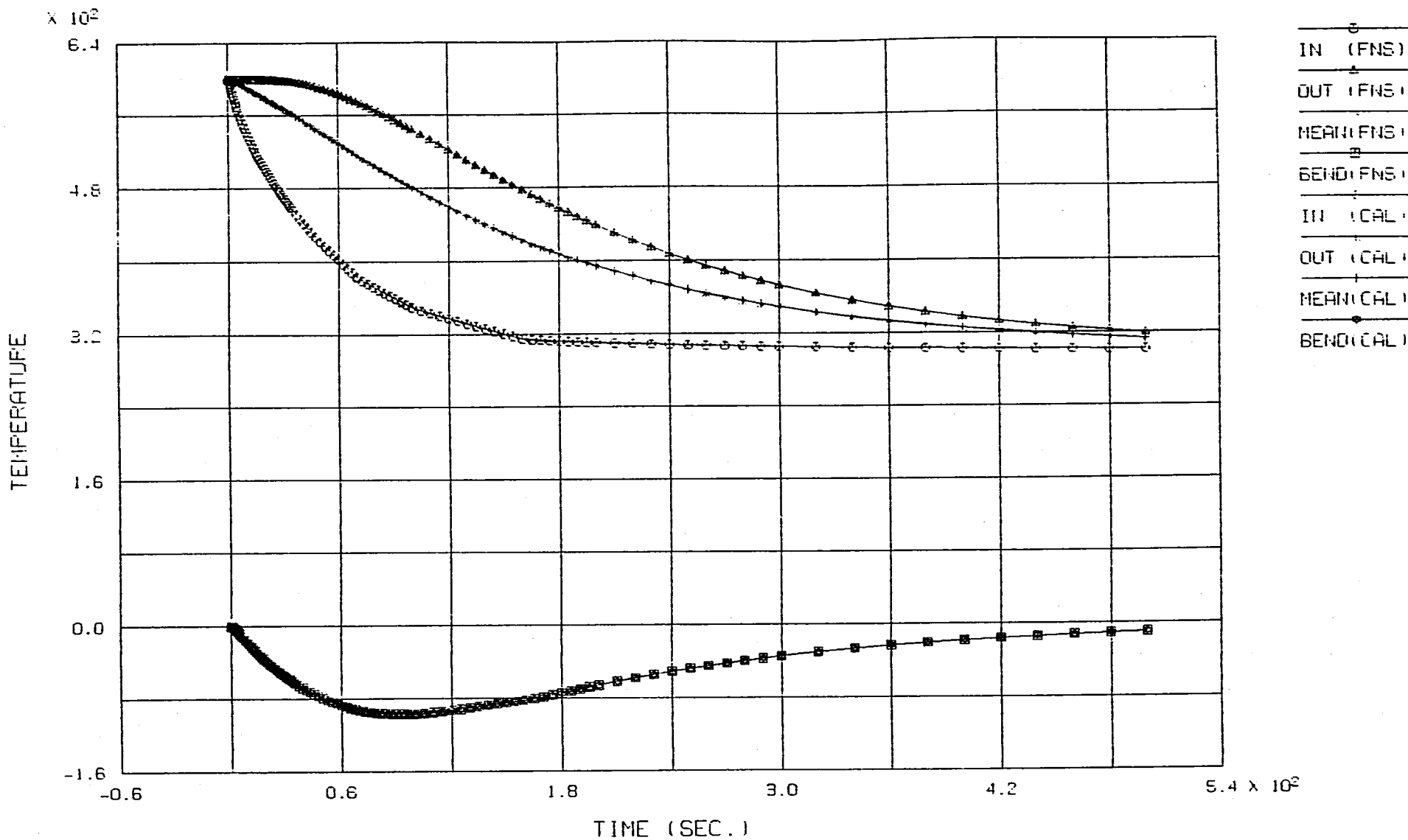
FINAS



TEMPERATURE OF SECTION(6)

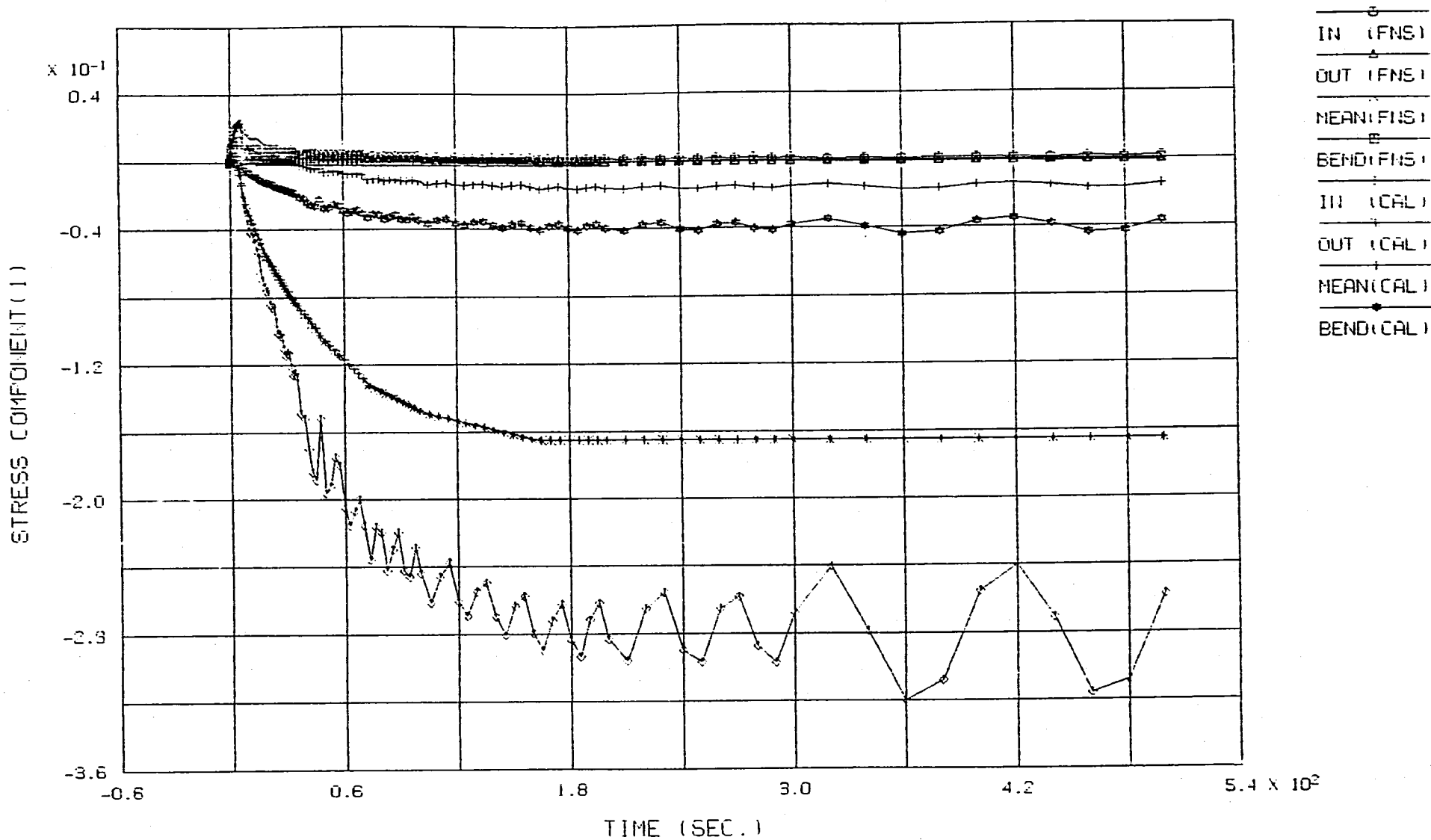
図12.6 評価断面6の温度

FINAS



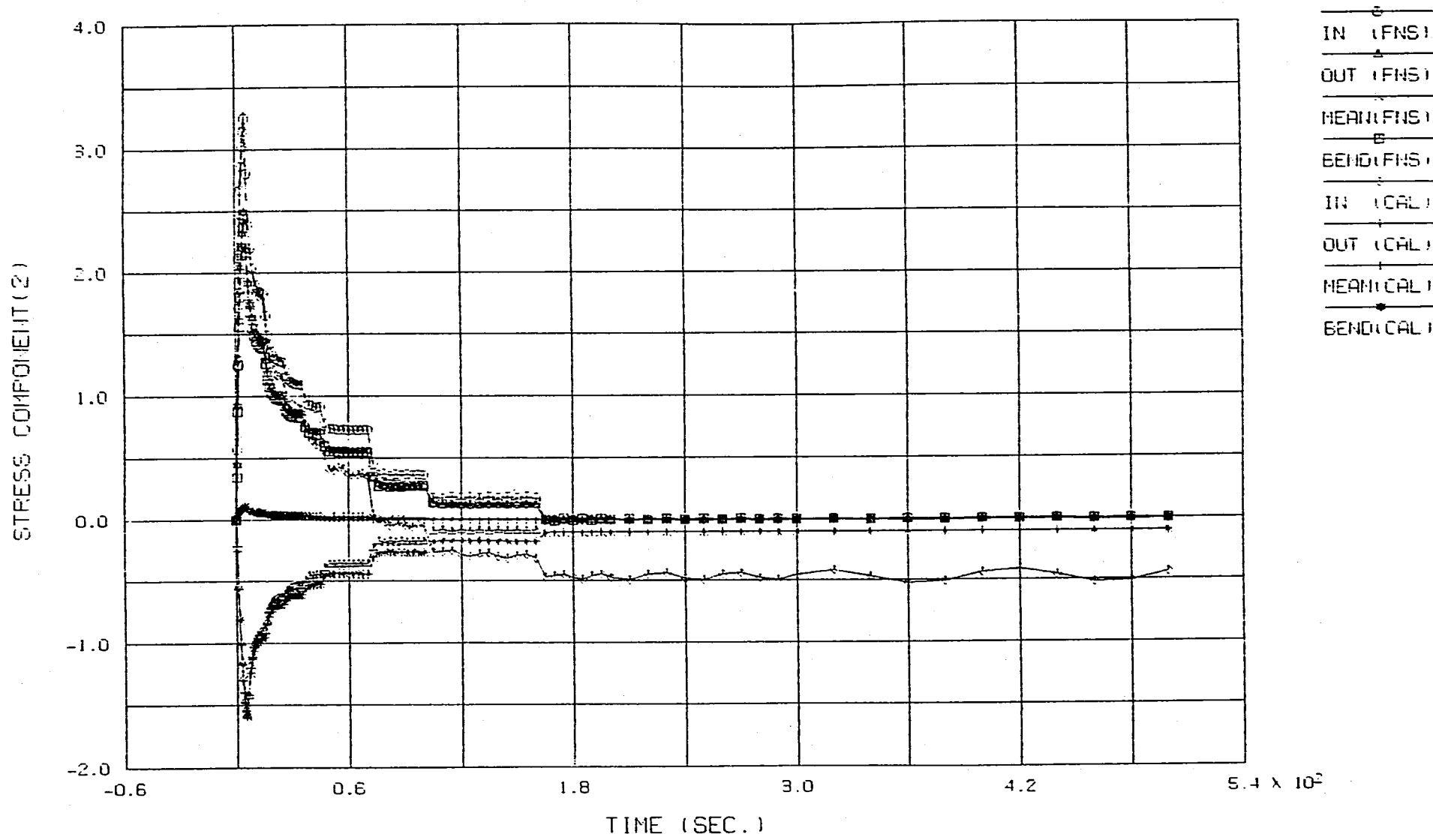
TEMPERATURE OF SECTION(7)

図12.7 評価断面7の温度



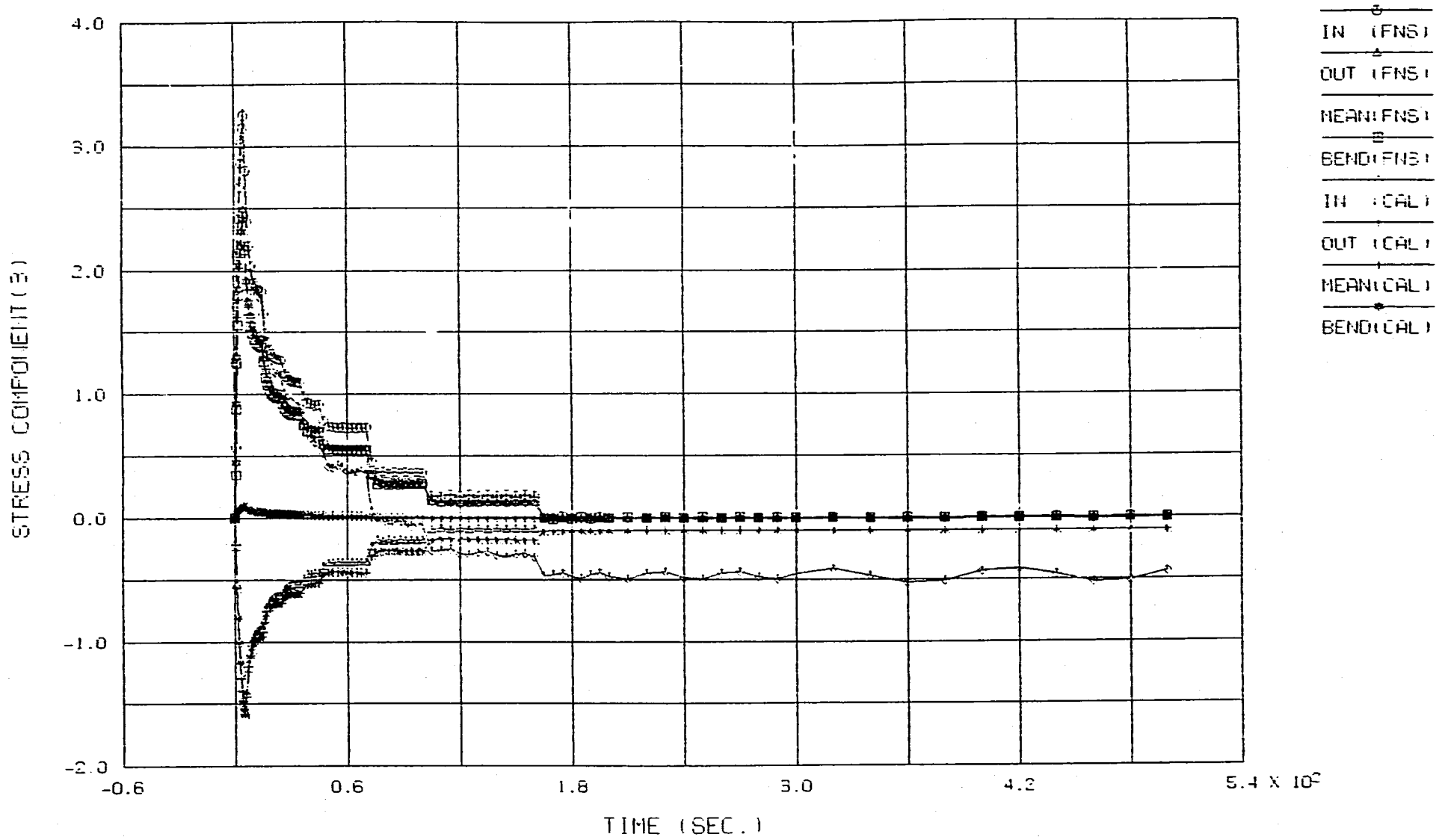
STRESS COMPONENT(1) OF SECTION(1)

図13. 1(1) 評価断面1の応力テンソル成分1



STRESS COMPONENT(2) OF SECTION(1)

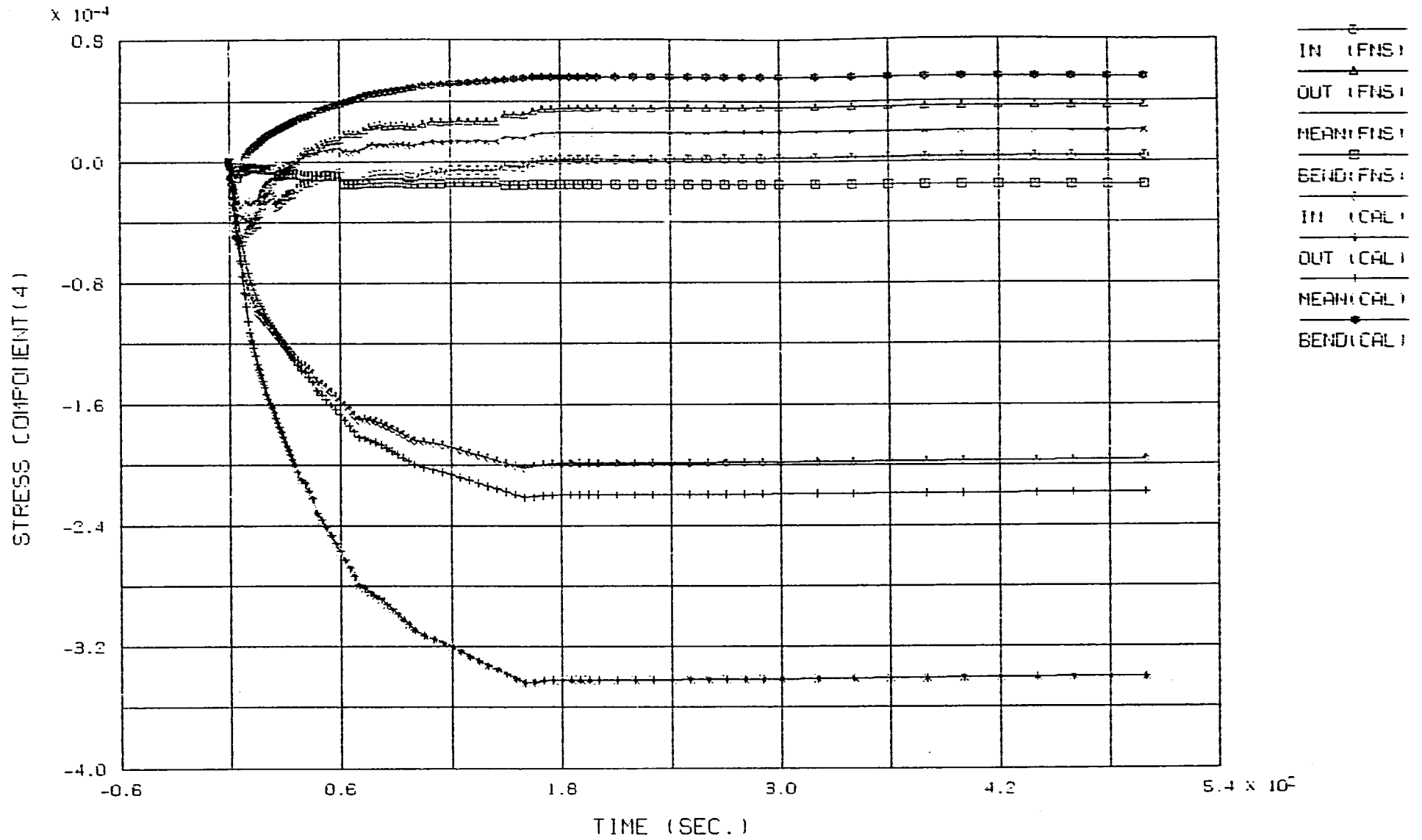
図13.1(2) 評価断面1の応力テンソル成分2



STRESS COMPONENT (3) OF SECTION (1)

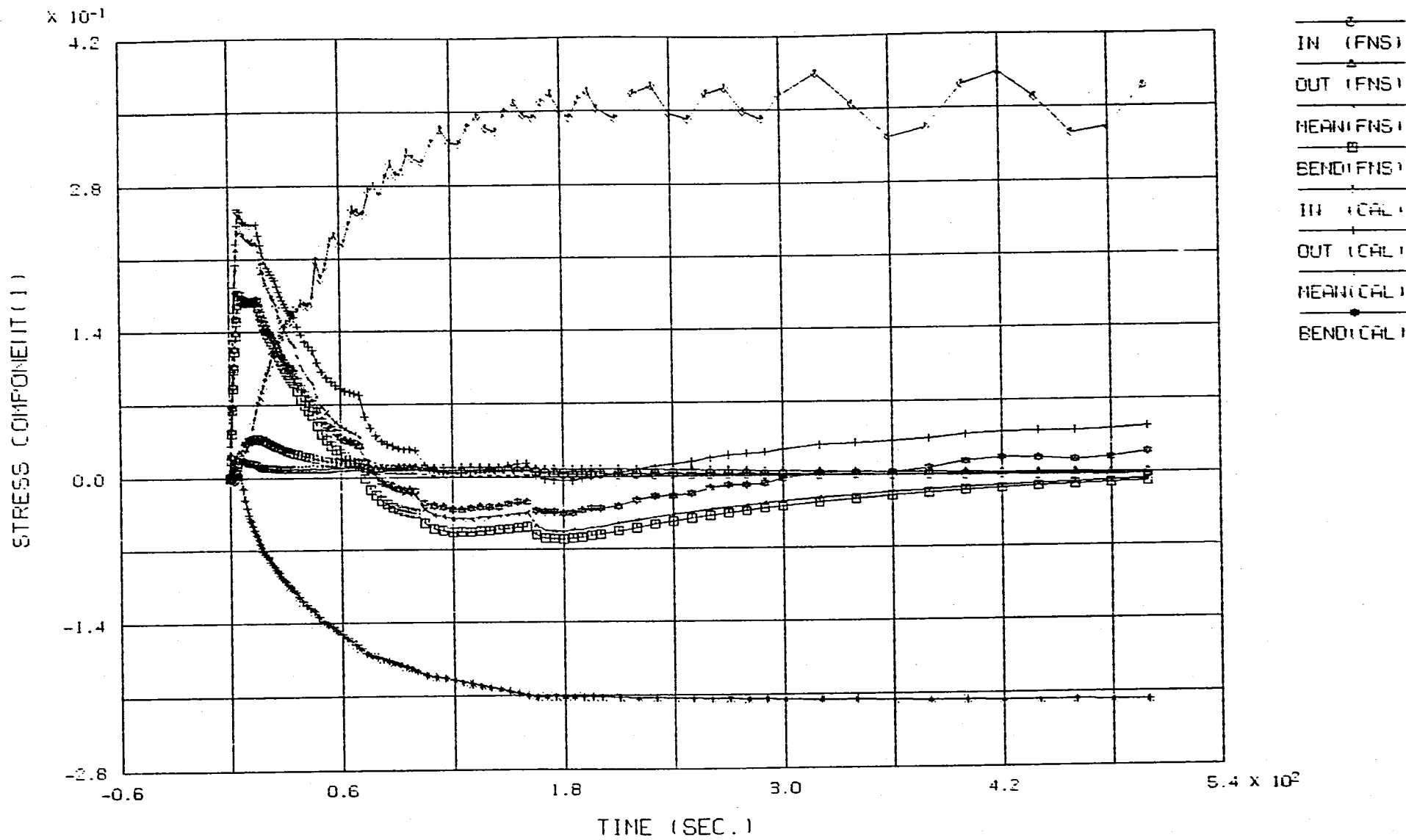
図13. 1 (3) 評価断面1の応力テンソル成分3

FINAS



STRESS COMPONENT (4) OF SECTION (1)

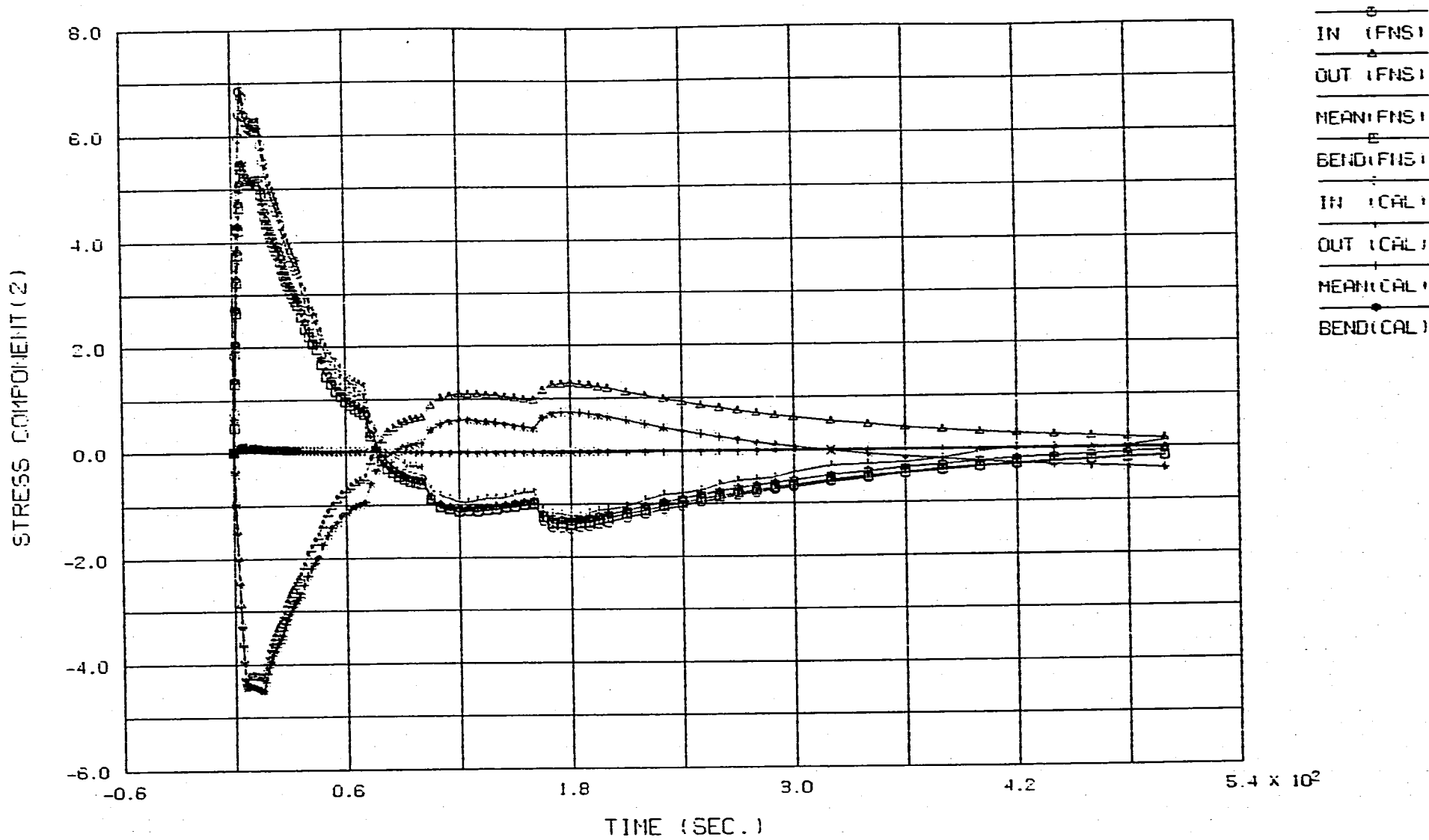
図13.1(4) 評価断面1の応力テンソル成分4



- 146 -

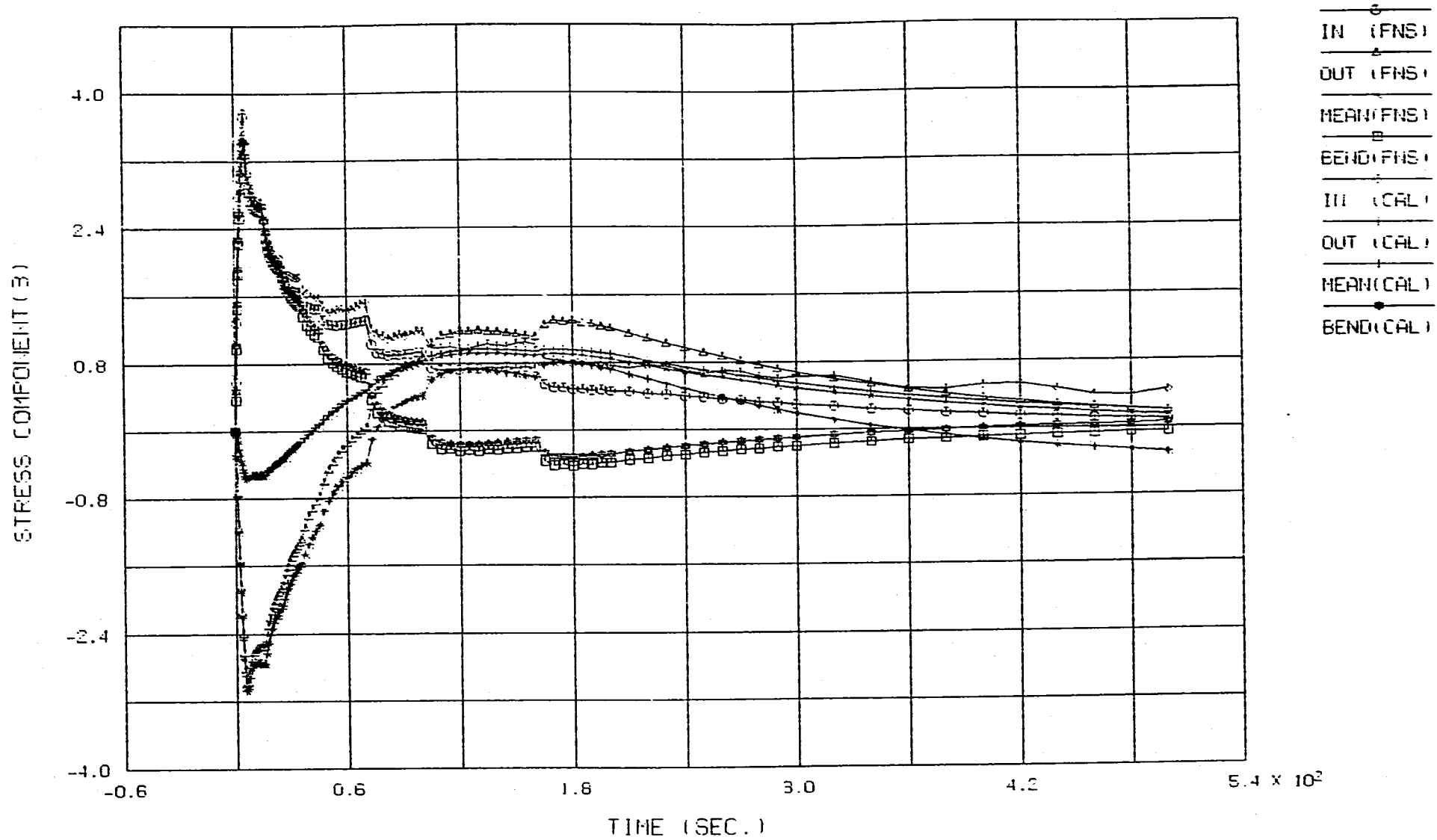
STRESS COMPONENT (1) OF SECTION (2)

図13. 2(1) 評価断面2の応力テンソル成分1



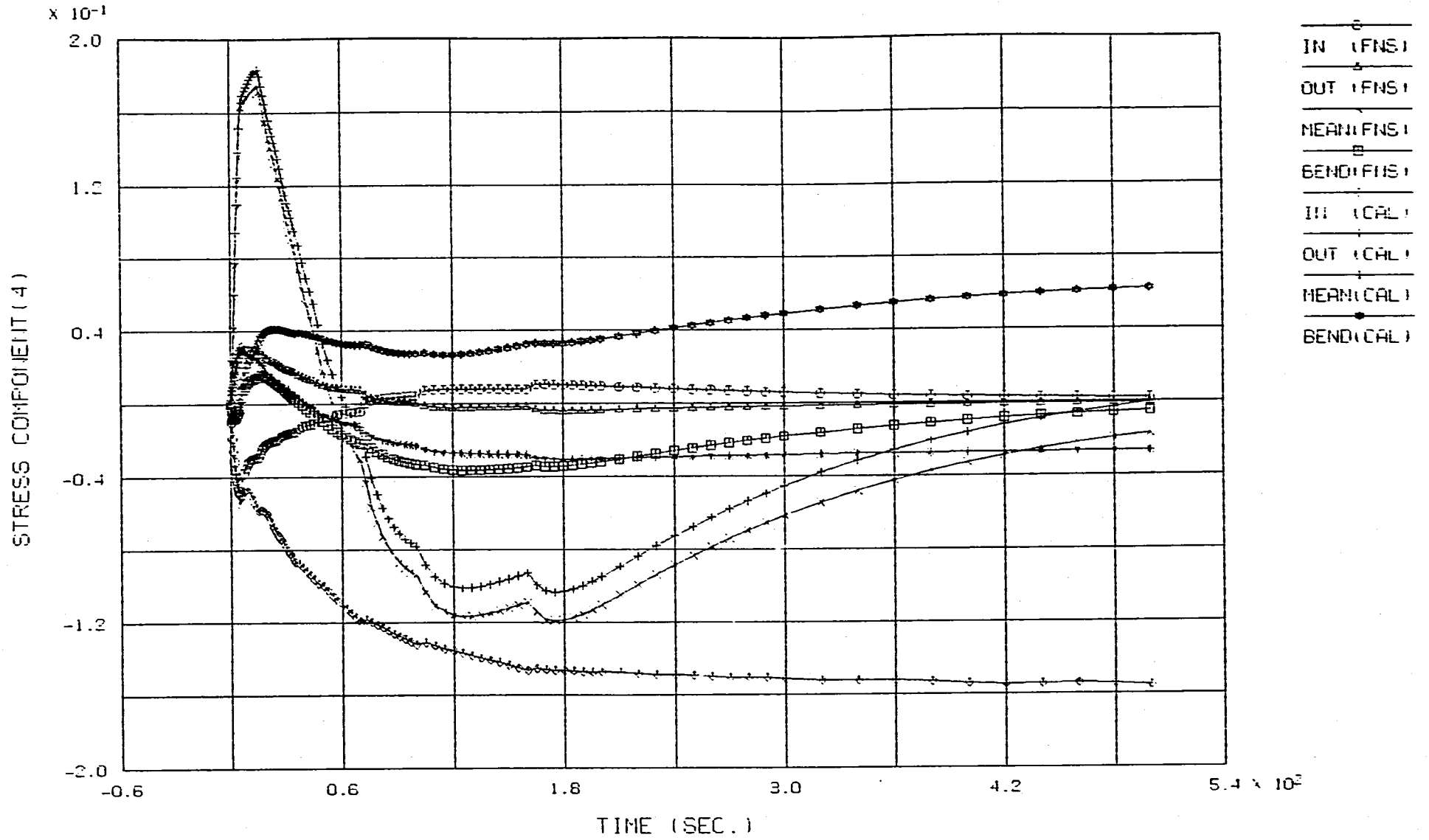
STRESS COMPONENT (2) OF SECTION (2)

図13. 2(2) 評価断面2の応力テンソル成分2



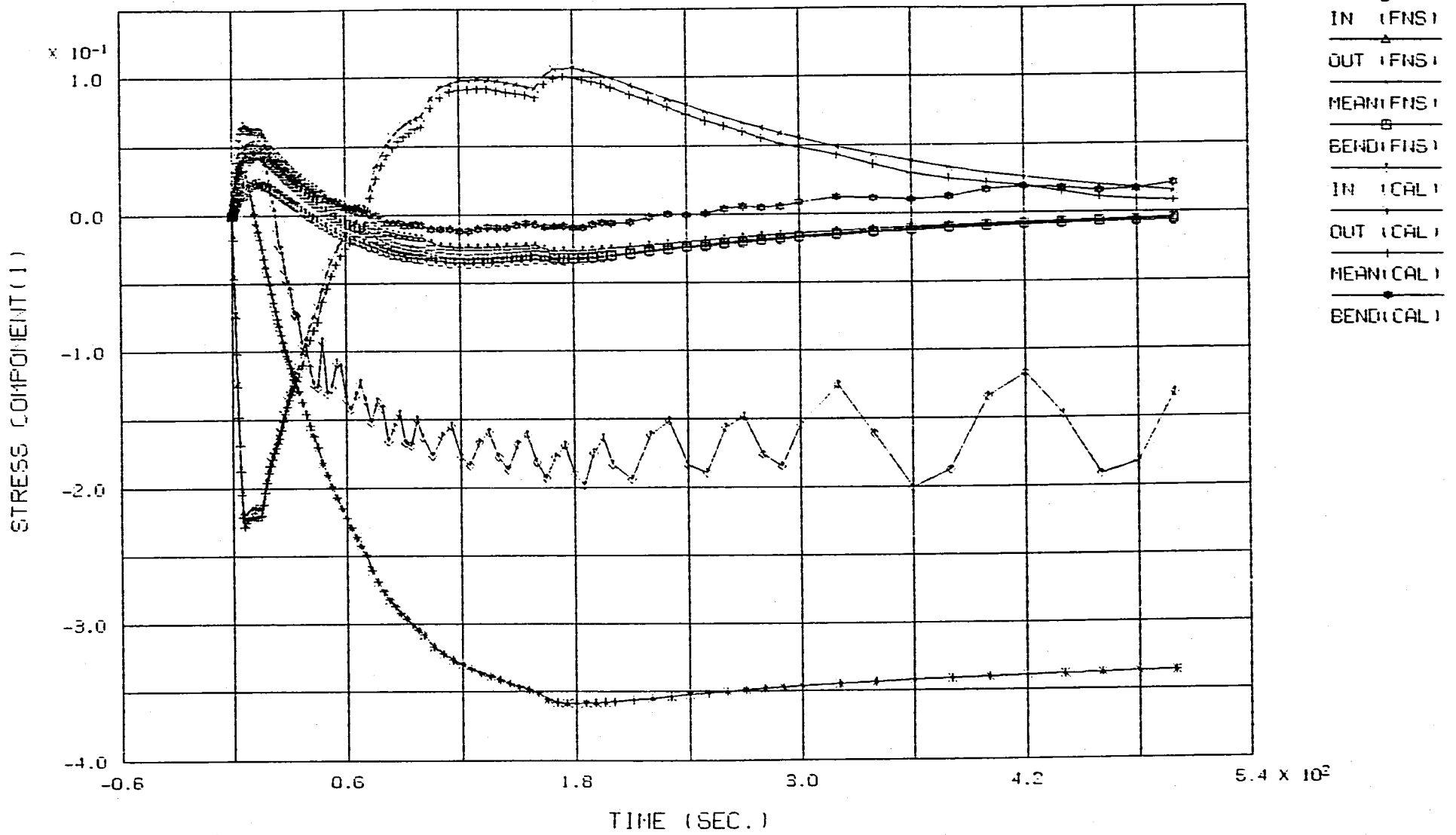
STRESS COMPONENT (3) OF SECTION (2)

図13. 2(3) 評価断面2の応力テンソル成分3



STRESS COMPONENT (4) OF SECTION (2)

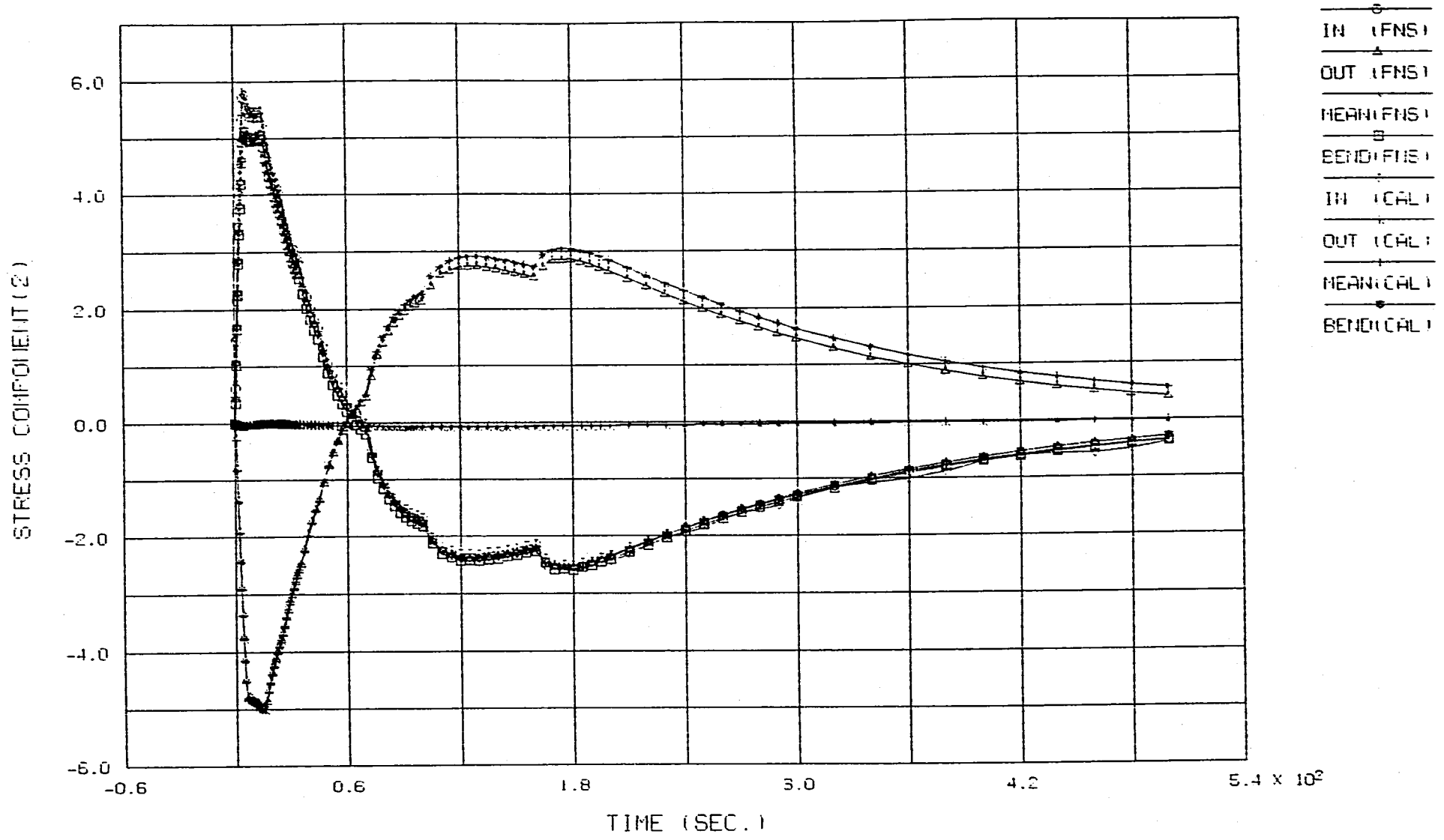
図13. 2(4) 評価断面2の応力テンソル成分4



- 150 -

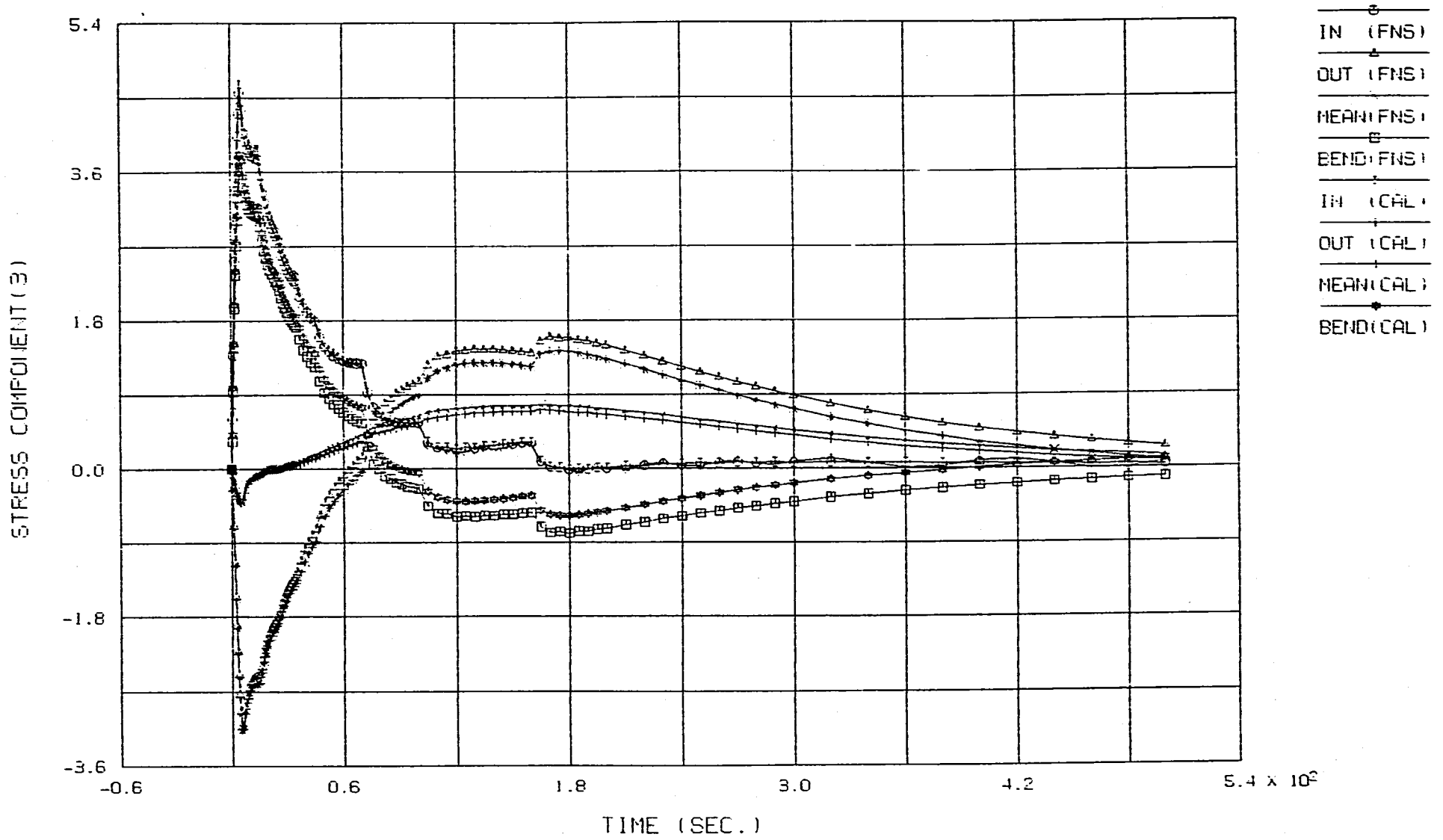
STRESS COMPONENT (1) OF SECTION (3)

図13.3(1) 評価断面3の応力テンソル成分1



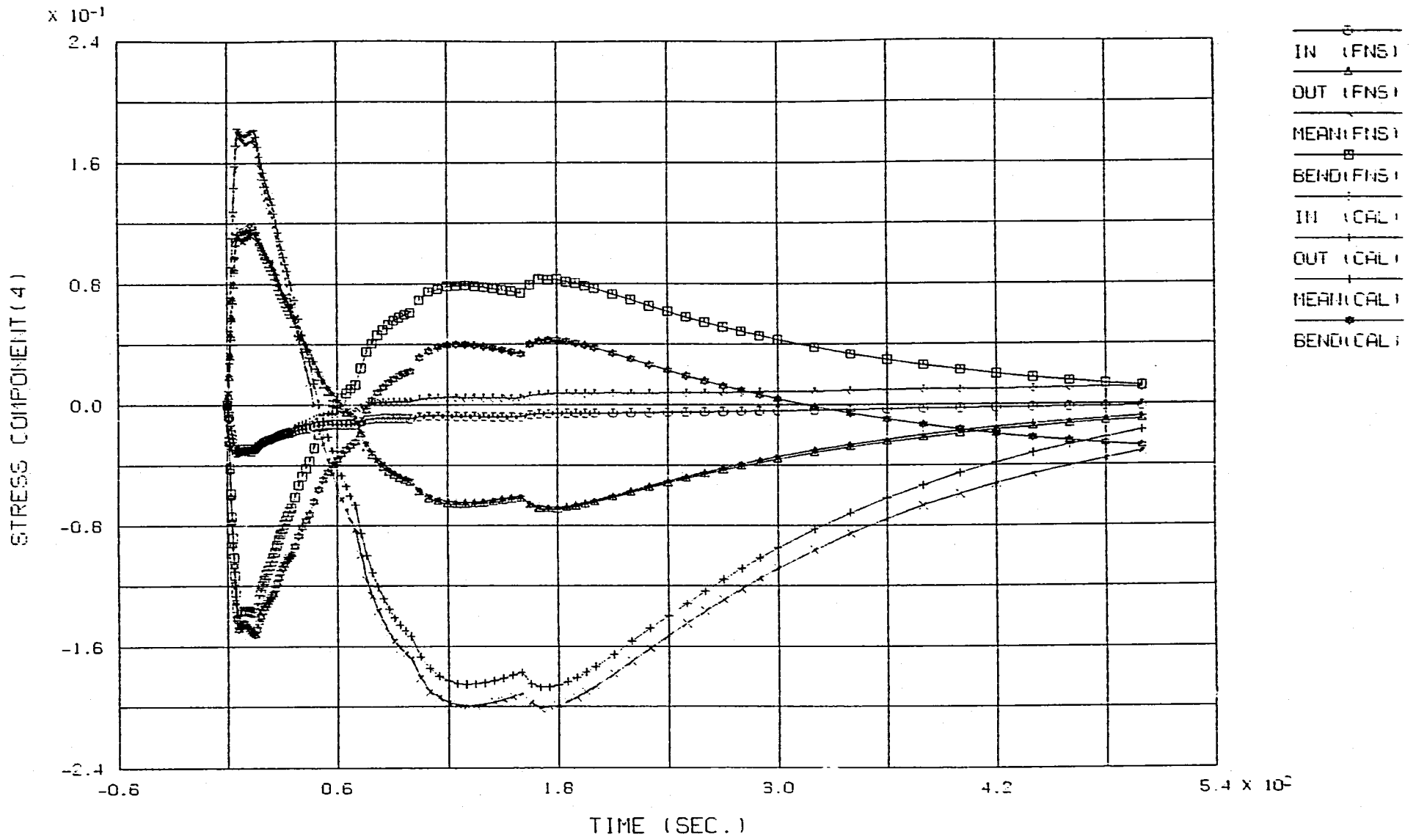
STRESS COMPONENT (2) OF SECTION (3)

図13.3(2) 評価断面3の応力テンソル成分2



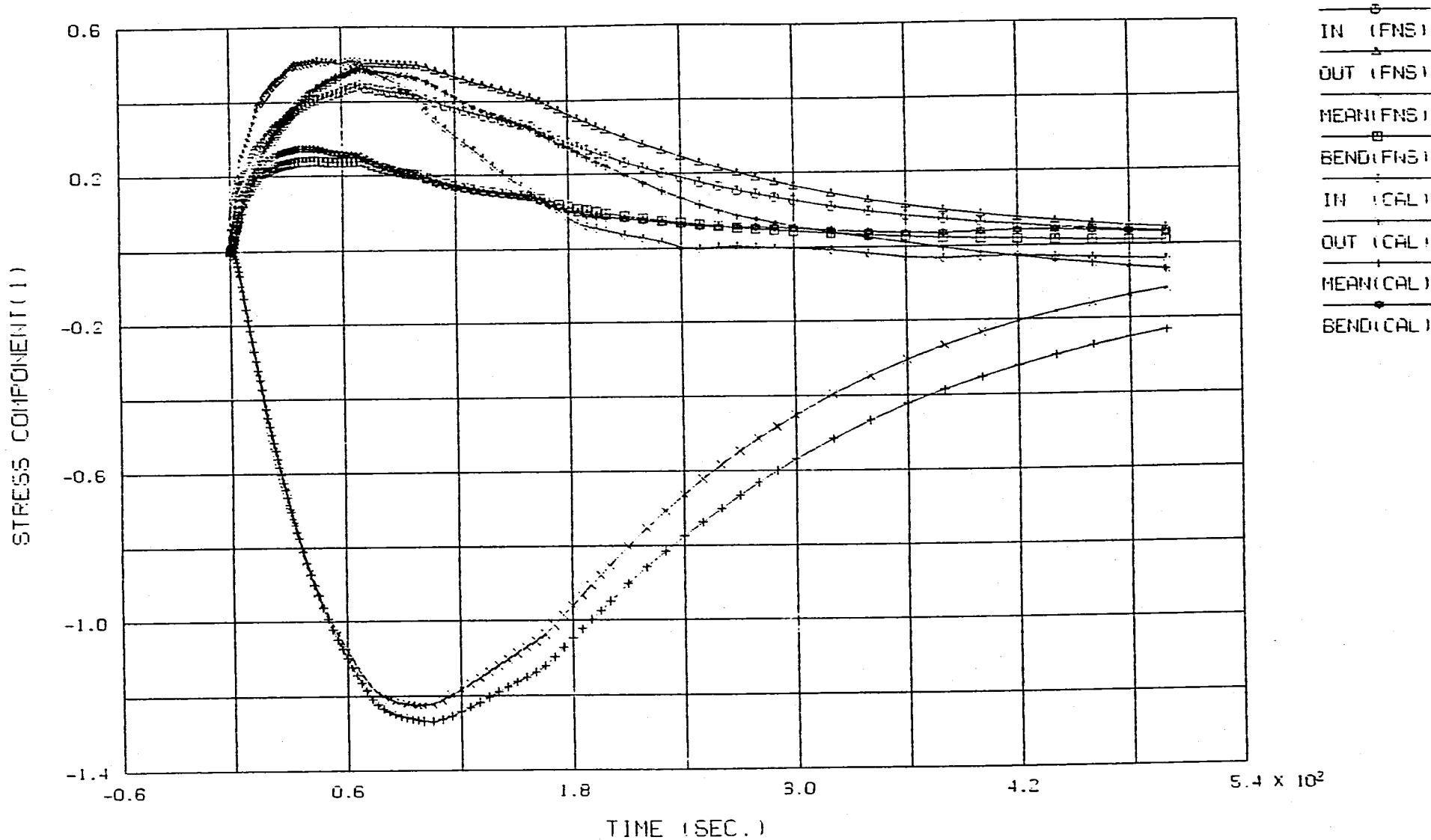
STRESS COMPONENT (3) OF SECTION (3)

図13. 3 (3) 評価断面3の応力テンソル成分3



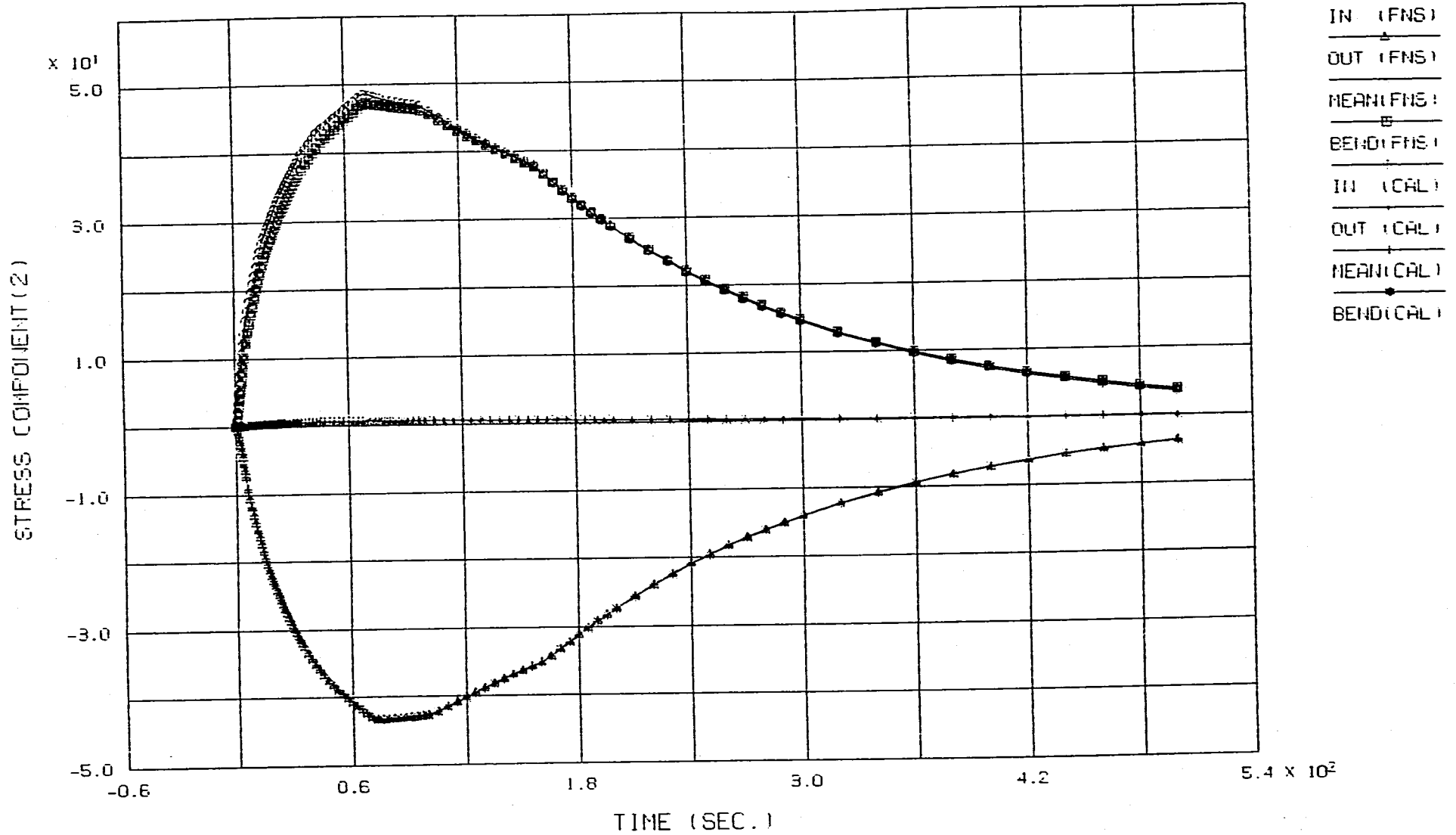
STRESS COMPONENT (4) OF SECTION (3)

図13. 3(4) 評価断面3の応力テンソル成分4



STRESS COMPONENT (1) OF SECTION (4)

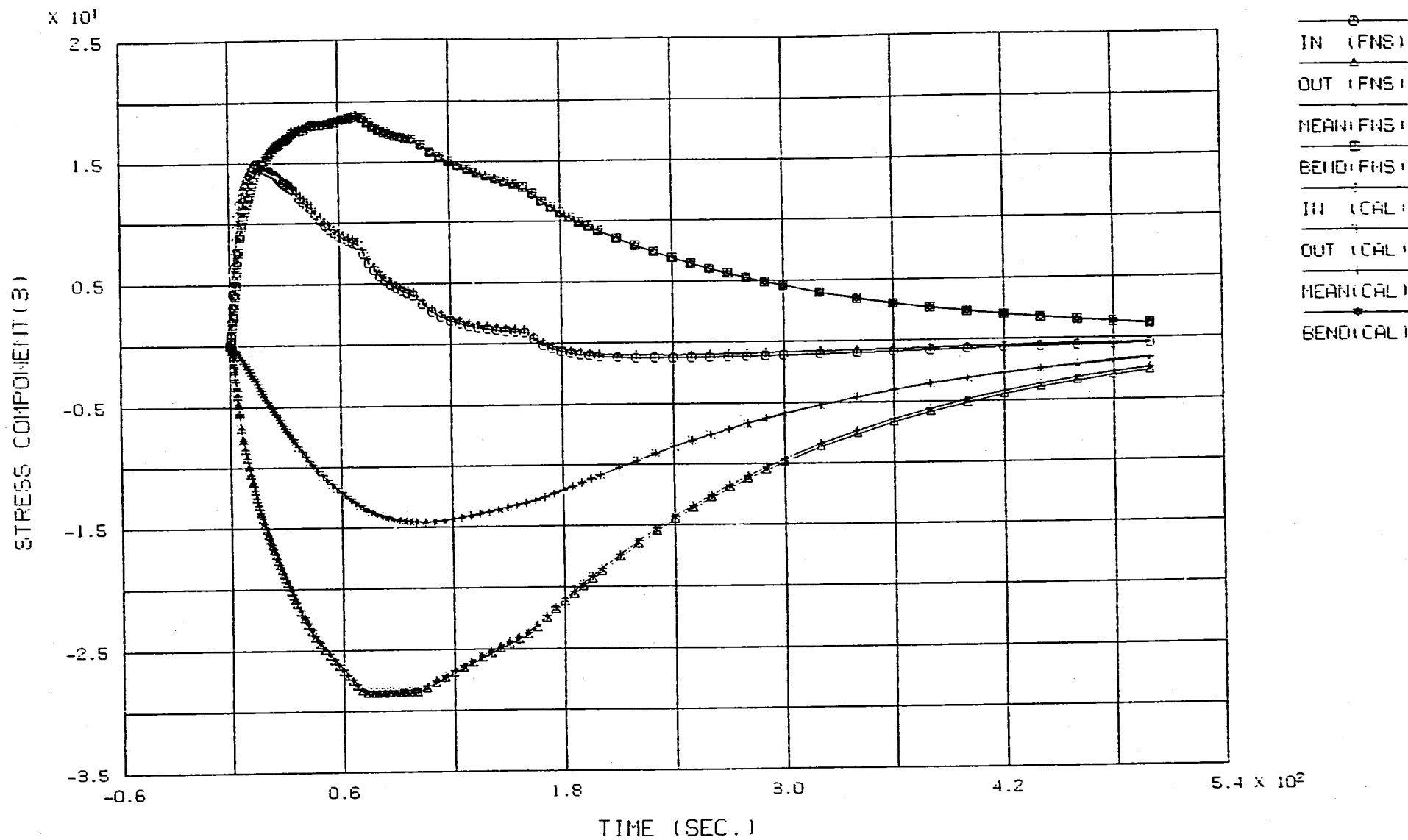
図13.4(1) 評価断面4の応力テンソル成分1



STRESS COMPONENT(2) OF SECTION(4)

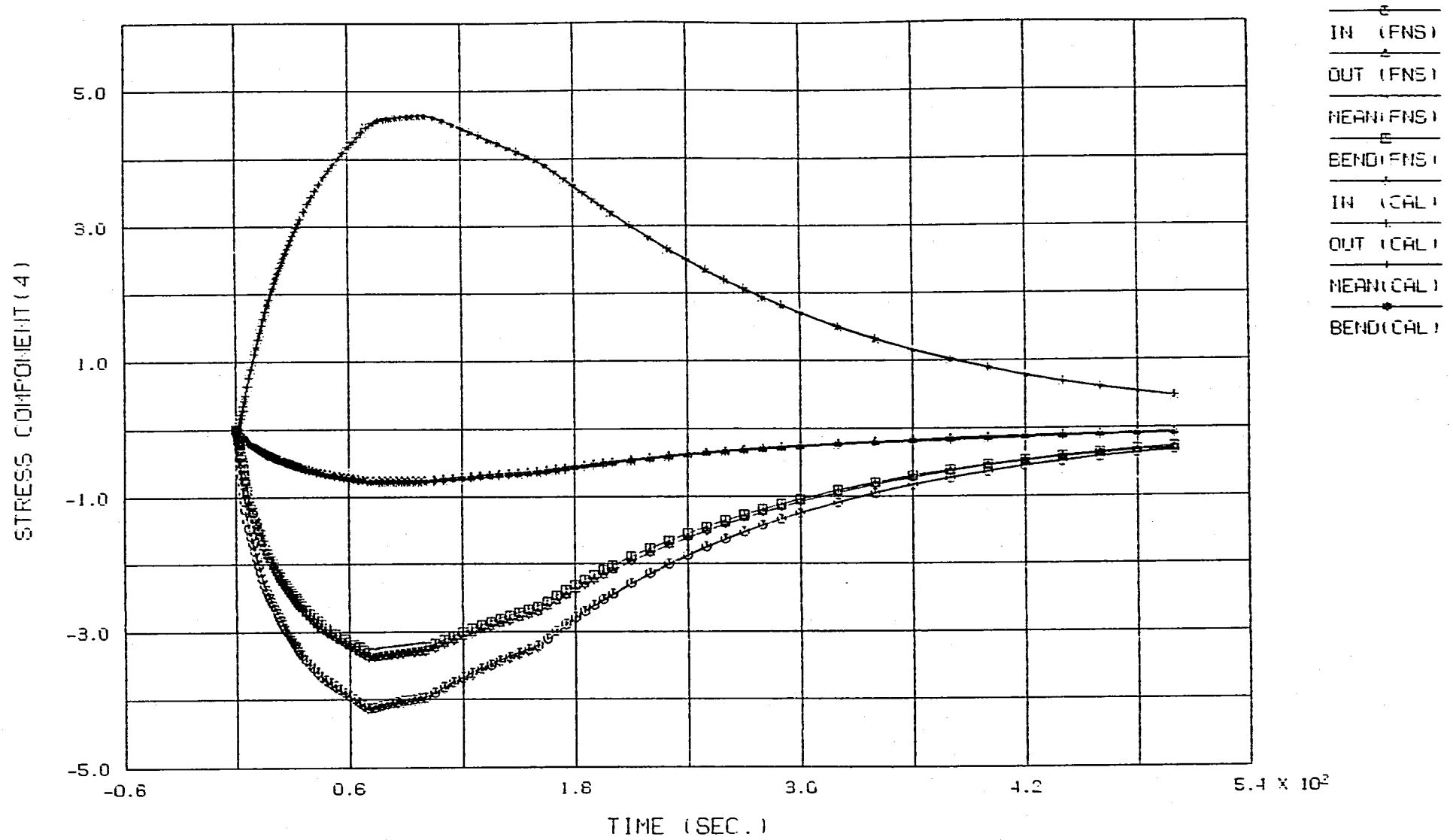
図13.4(2) 評価断面4の応力テンソル成分2

FINAS



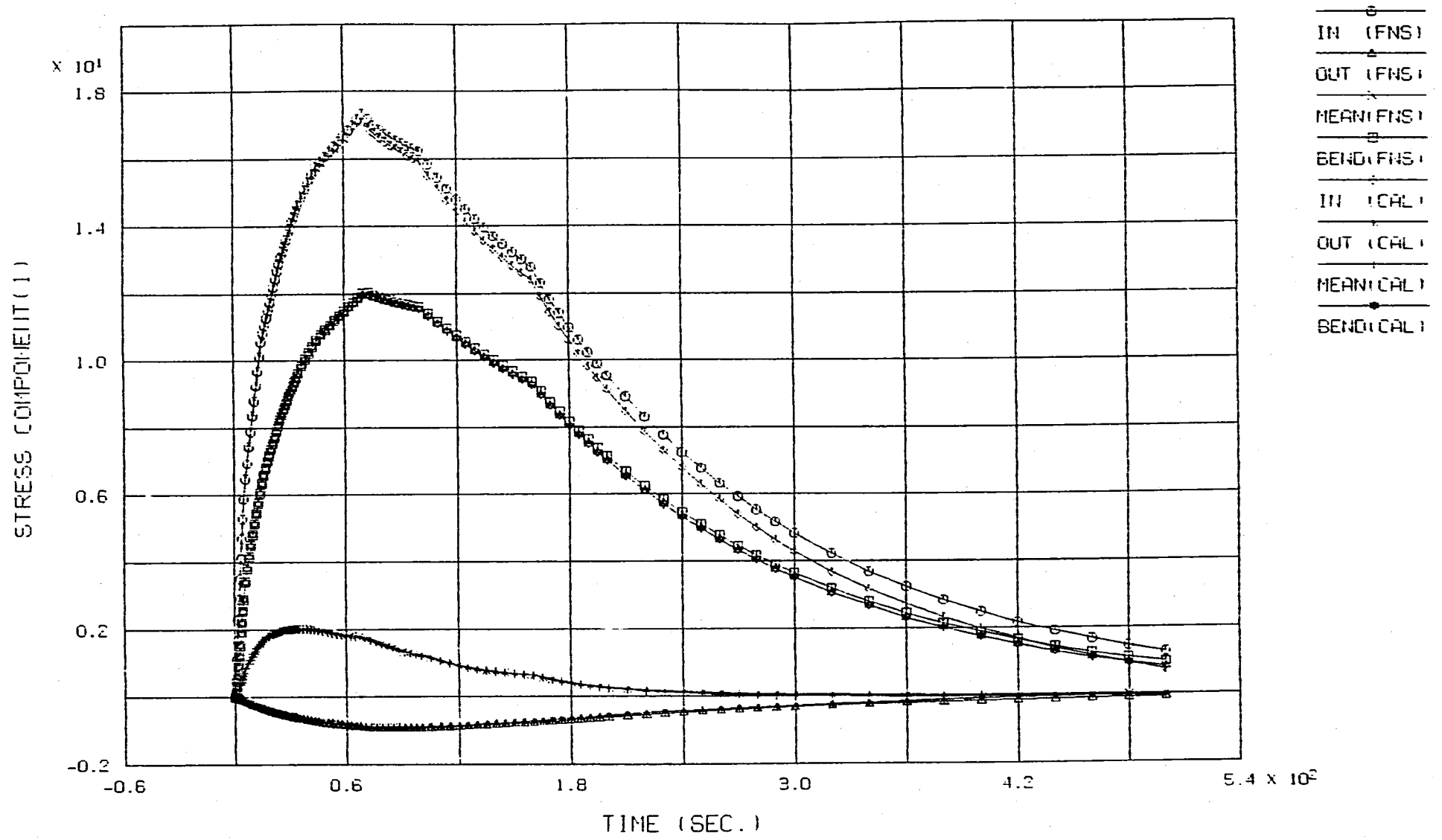
STRESS COMPONENT (3) OF SECTION (4)

図13.4(3) 評価断面4の応力テンソル成分3



STRESS COMPONENT (4) OF SECTION (4)

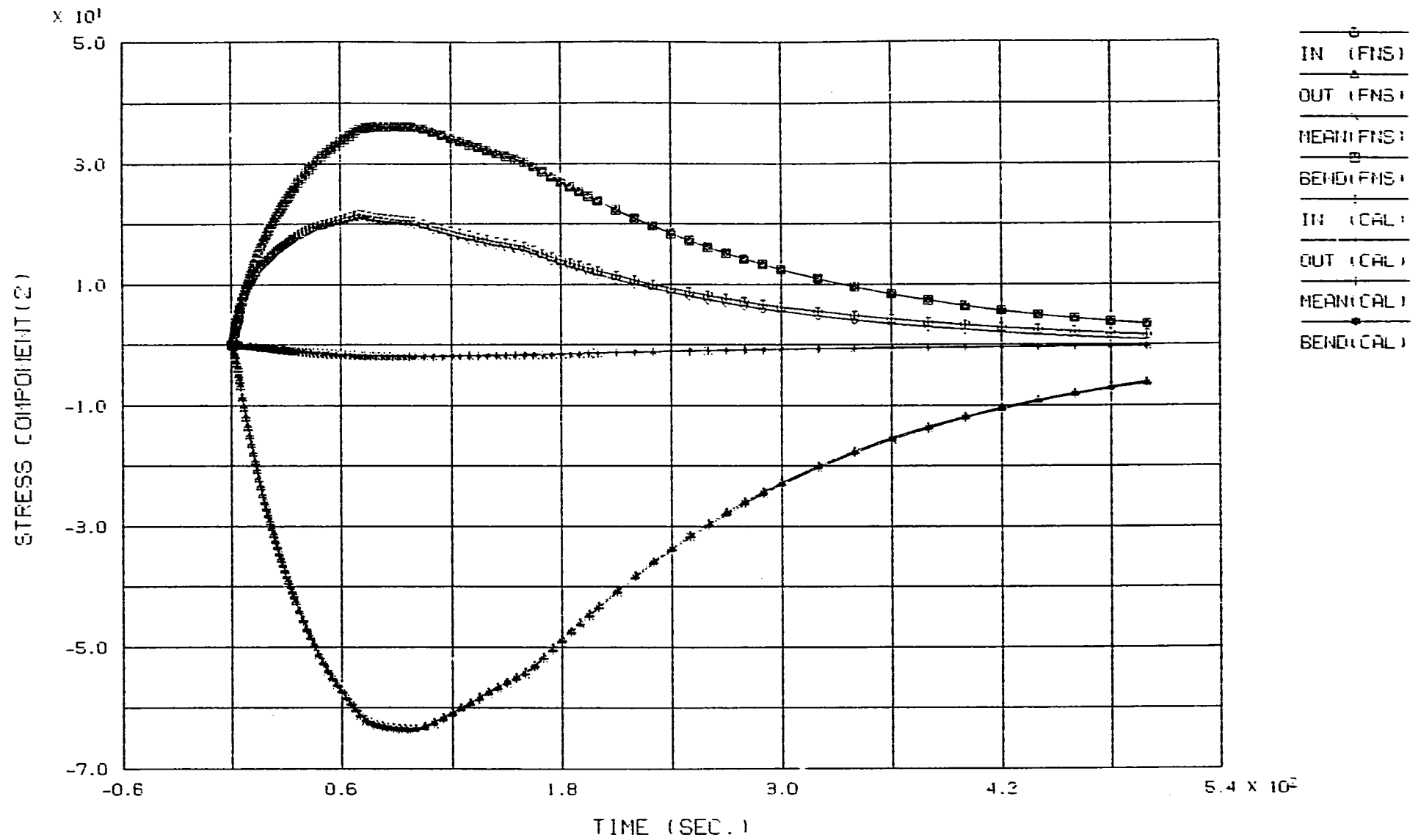
図13. 4 (4) 評価断面4の応力テンソル成分4



STRESS COMPONENT(1) OF SECTION(5)

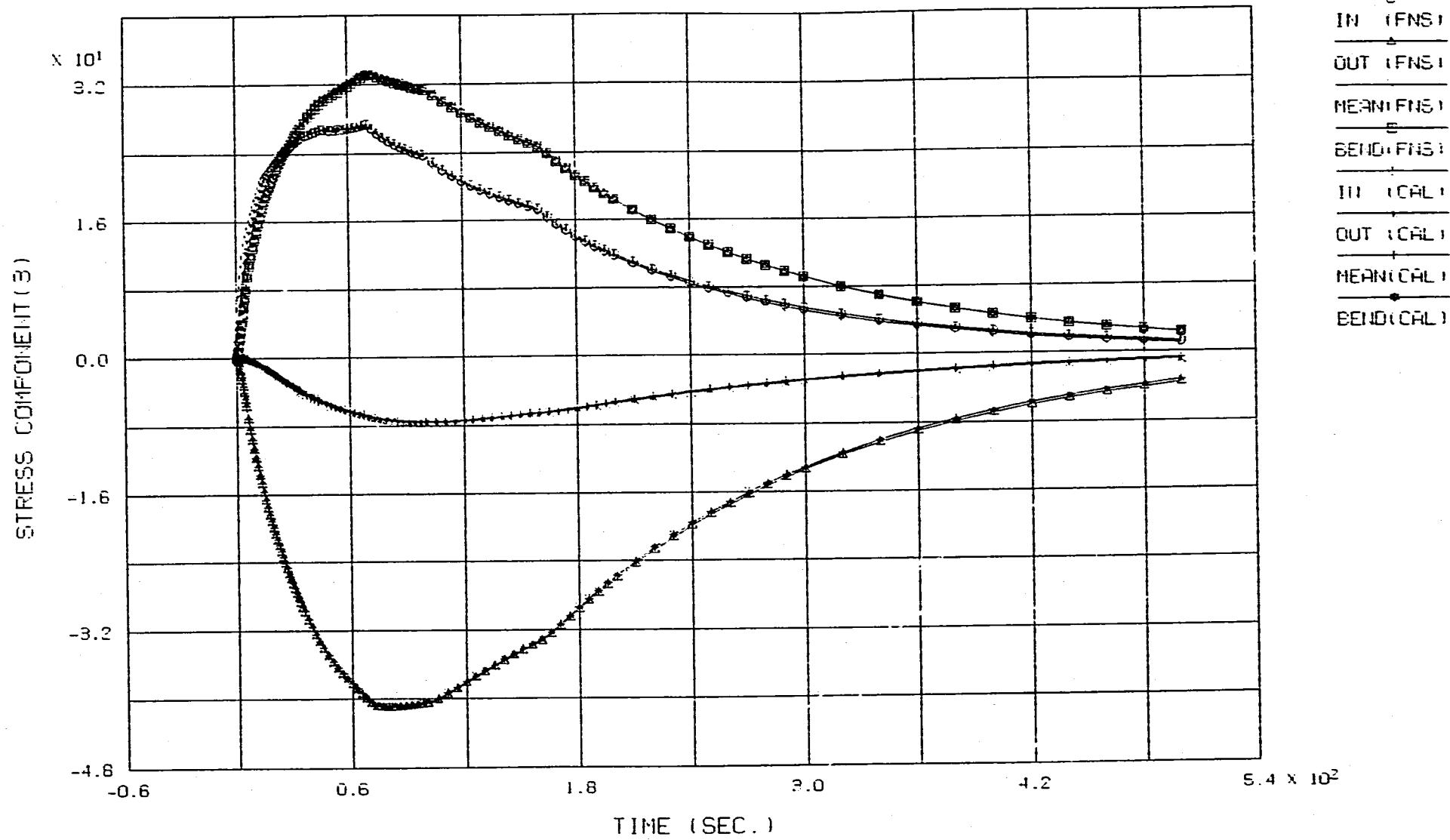
図13. 5(1) 評価断面5の応力テンソル成分1

FINAS



STRESS COMPONENT (2) OF SECTION (5)

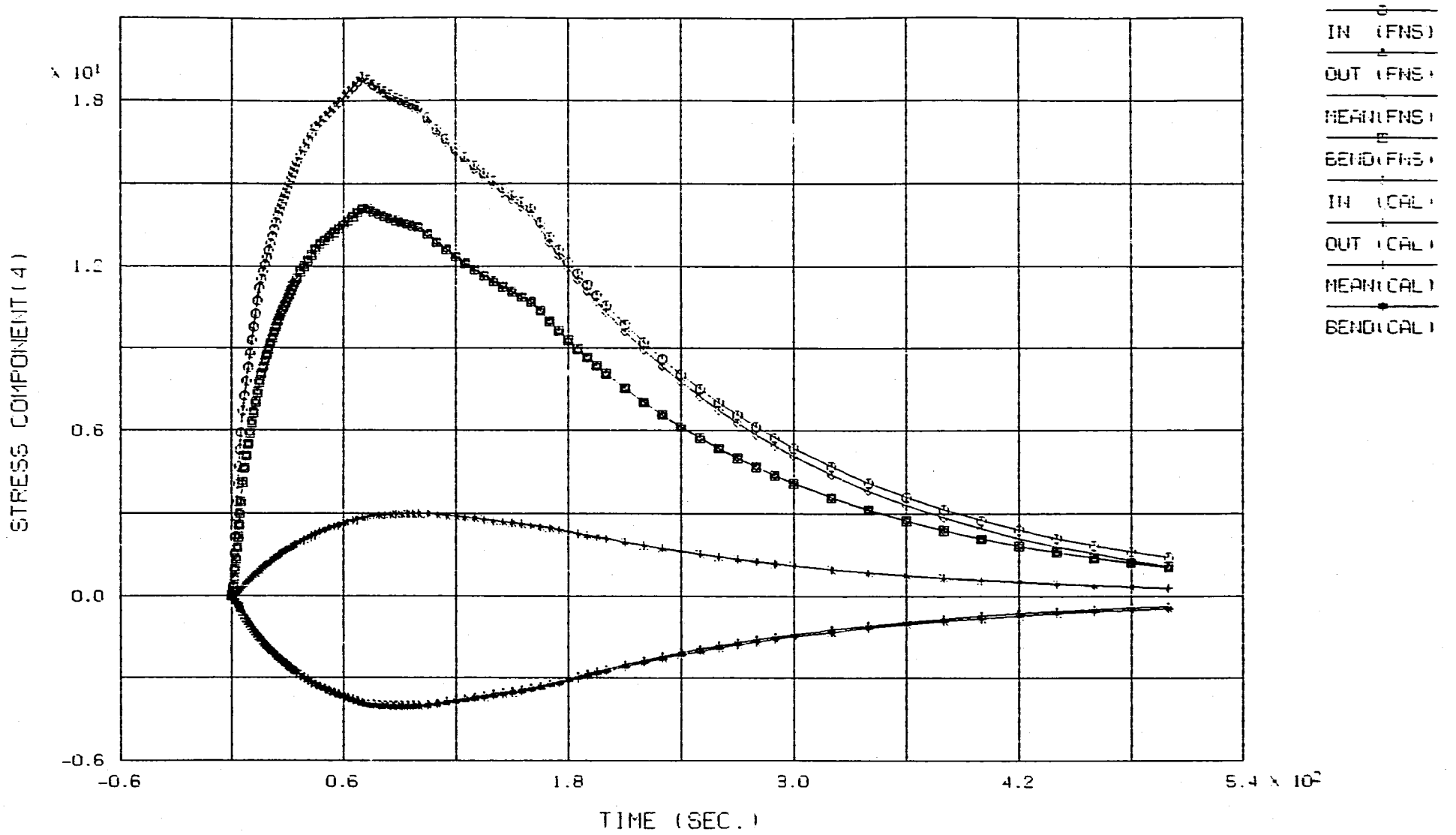
図13.5(2) 評価断面5の応力テンソル成分2



STRESS COMPONENT (3) OF SECTION (5)

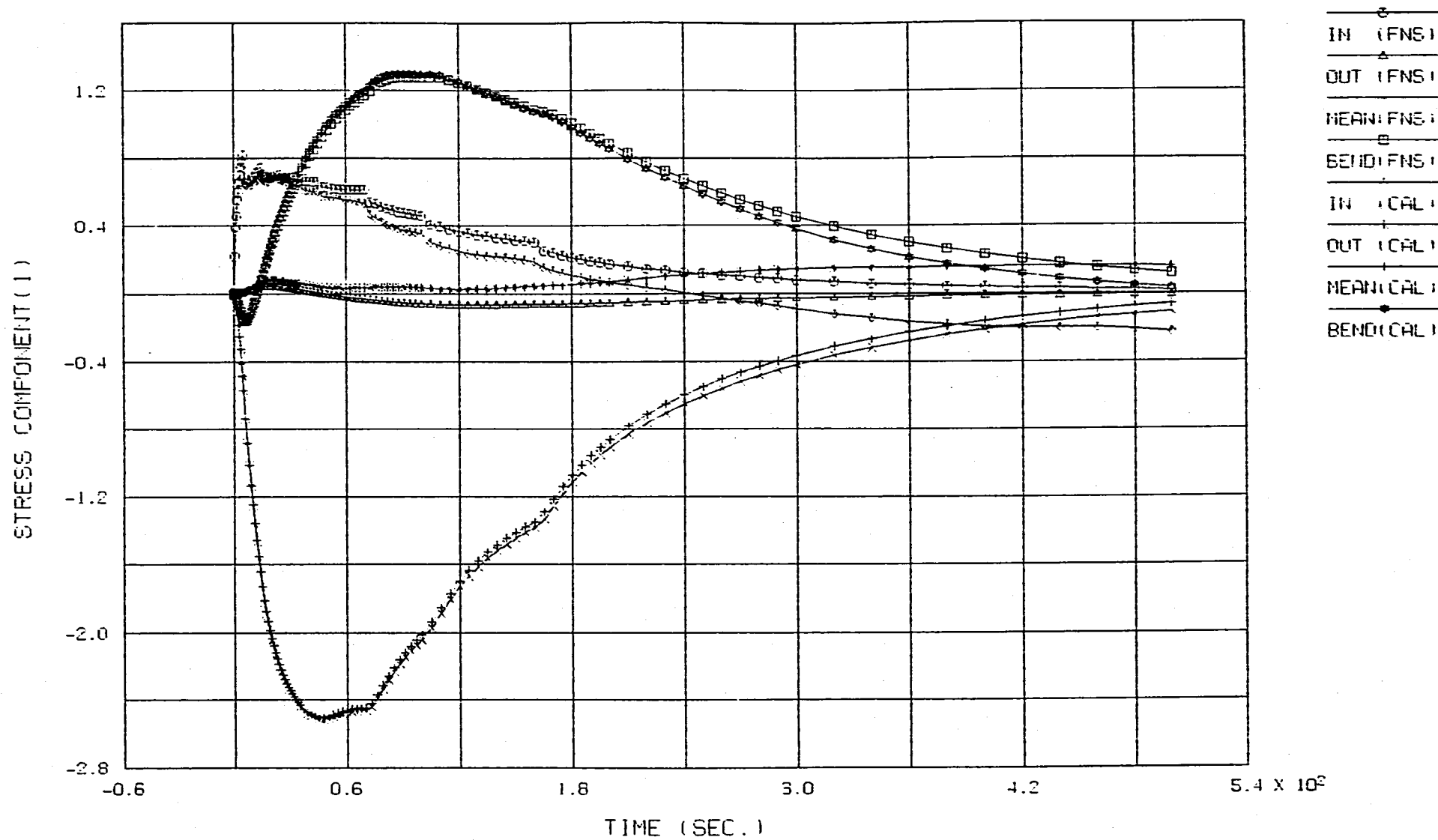
図13.5(3) 評価断面5の応力テンソル成分3

-160-



STRESS COMPONENT (4) OF SECTION (5)

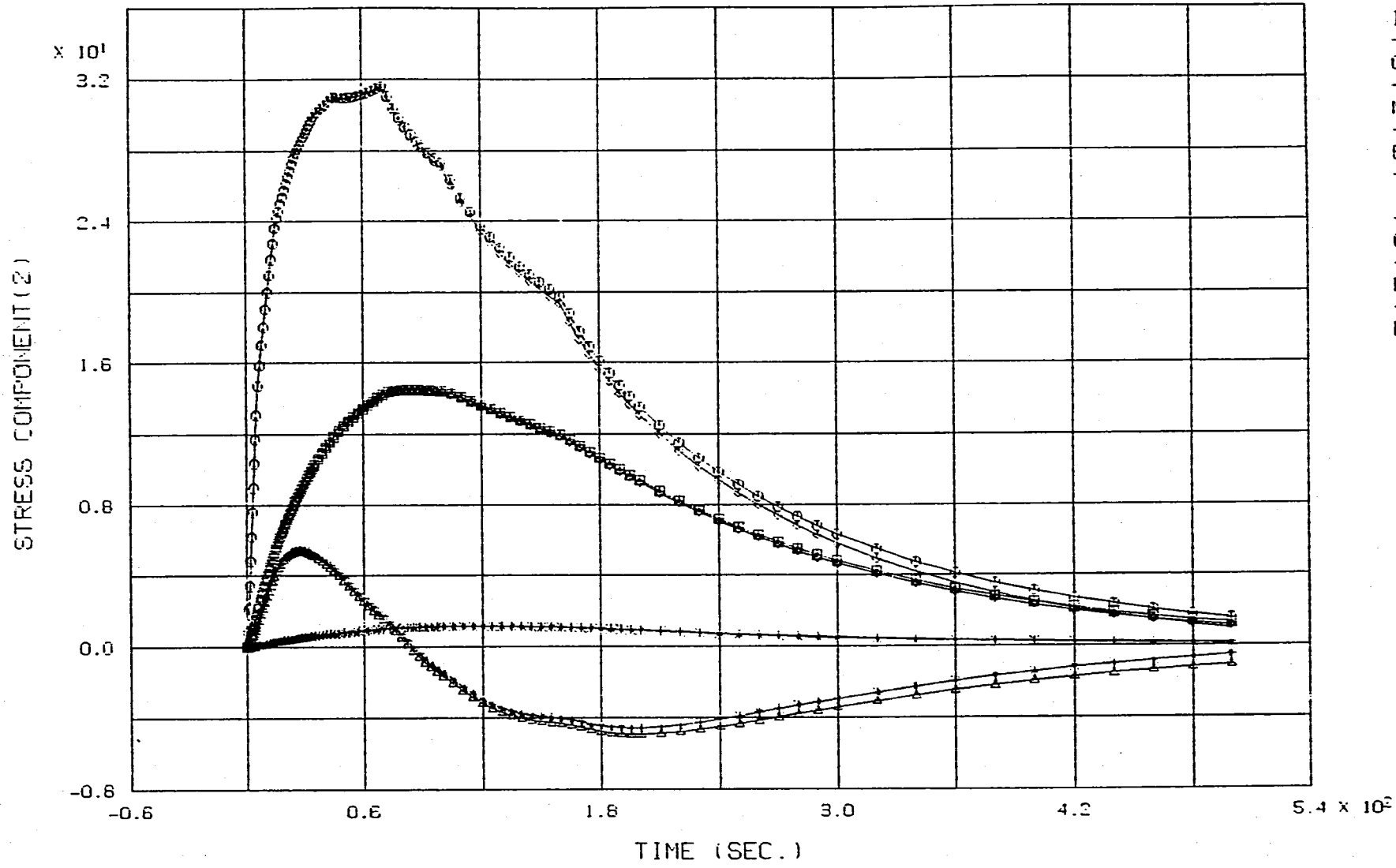
図13. 5(4) 評価断面5の応力テンソル成分4



STRESS COMPONENT (1) OF SECTION (6)

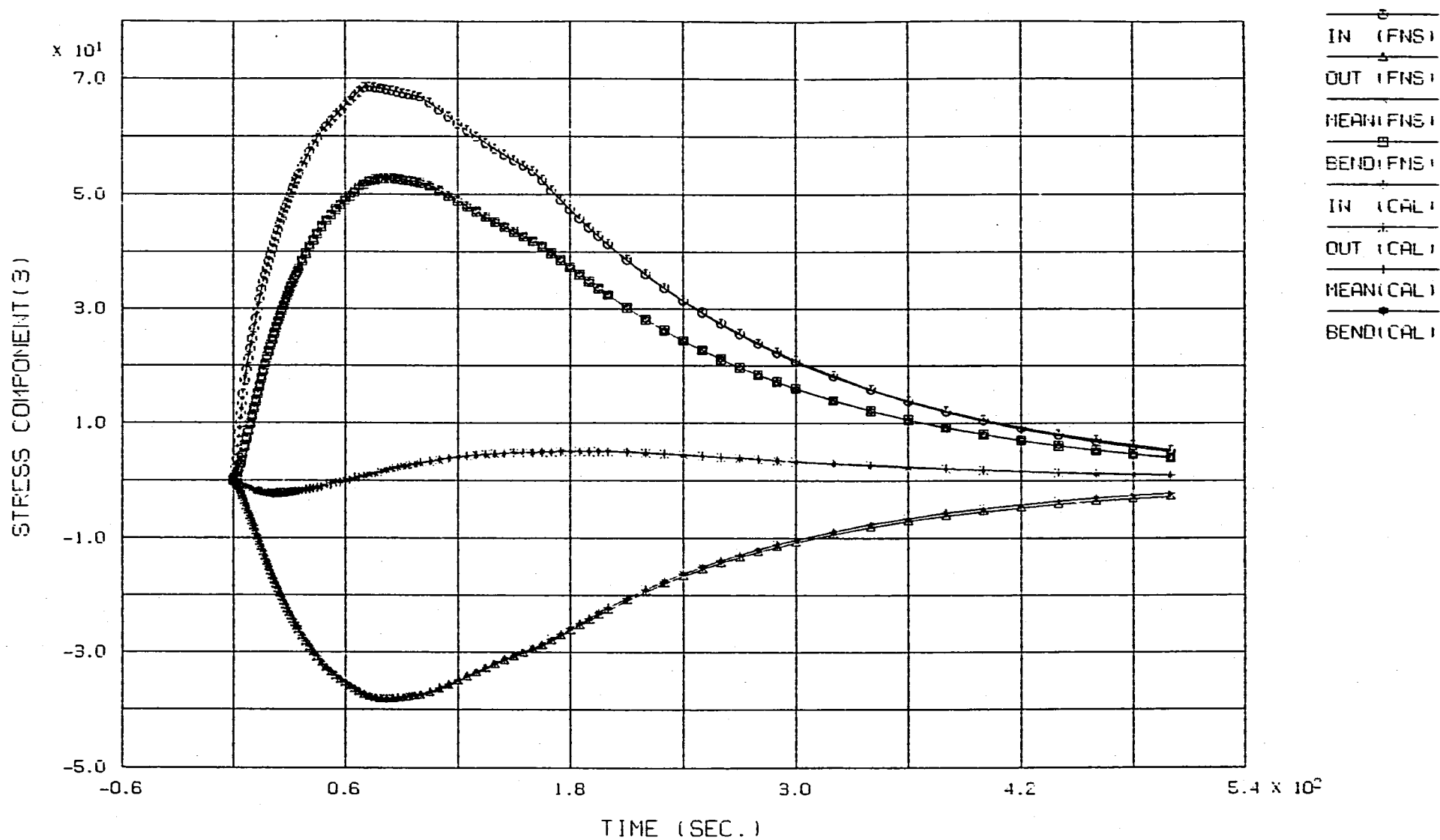
図13. 6 (1) 評価断面6の応力テンソル成分1

- IN (FNS)
- △ OUT (FNS)
- MEAN (FNS)
- ◇ BEND (FNS)
- IN (CAL)
- △ OUT (CAL)
- MEAN (CAL)
- ◇ BEND (CAL)



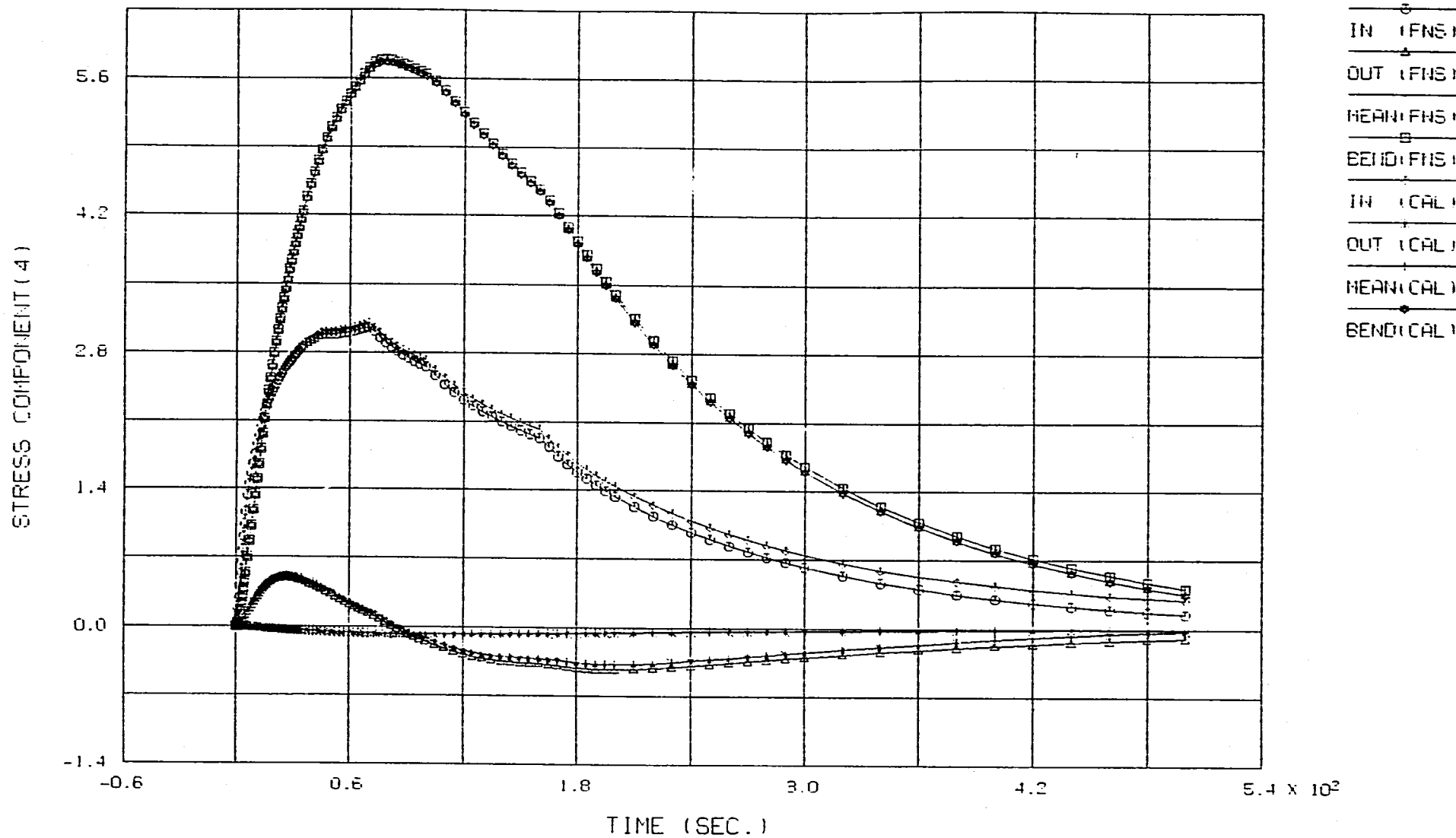
STRESS COMPONENT (2) OF SECTION (6)

図13.6(2) 評価断面6の応力テンソル成分2



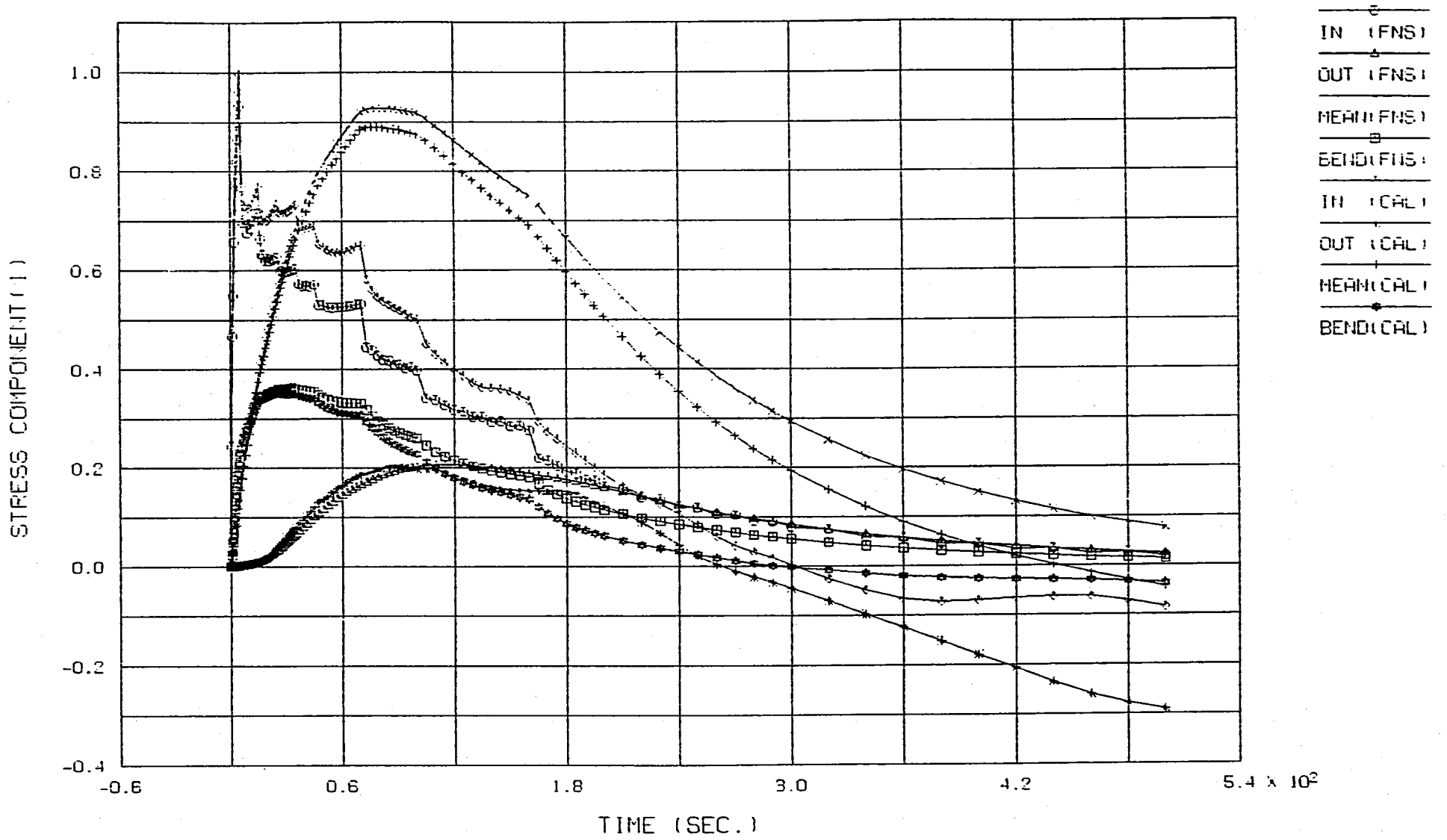
STRESS COMPONENT (3) OF SECTION (6)

図13.6(3) 評価断面6の応力テンソル成分3



STRESS COMPONENT (4) OF SECTION (6)

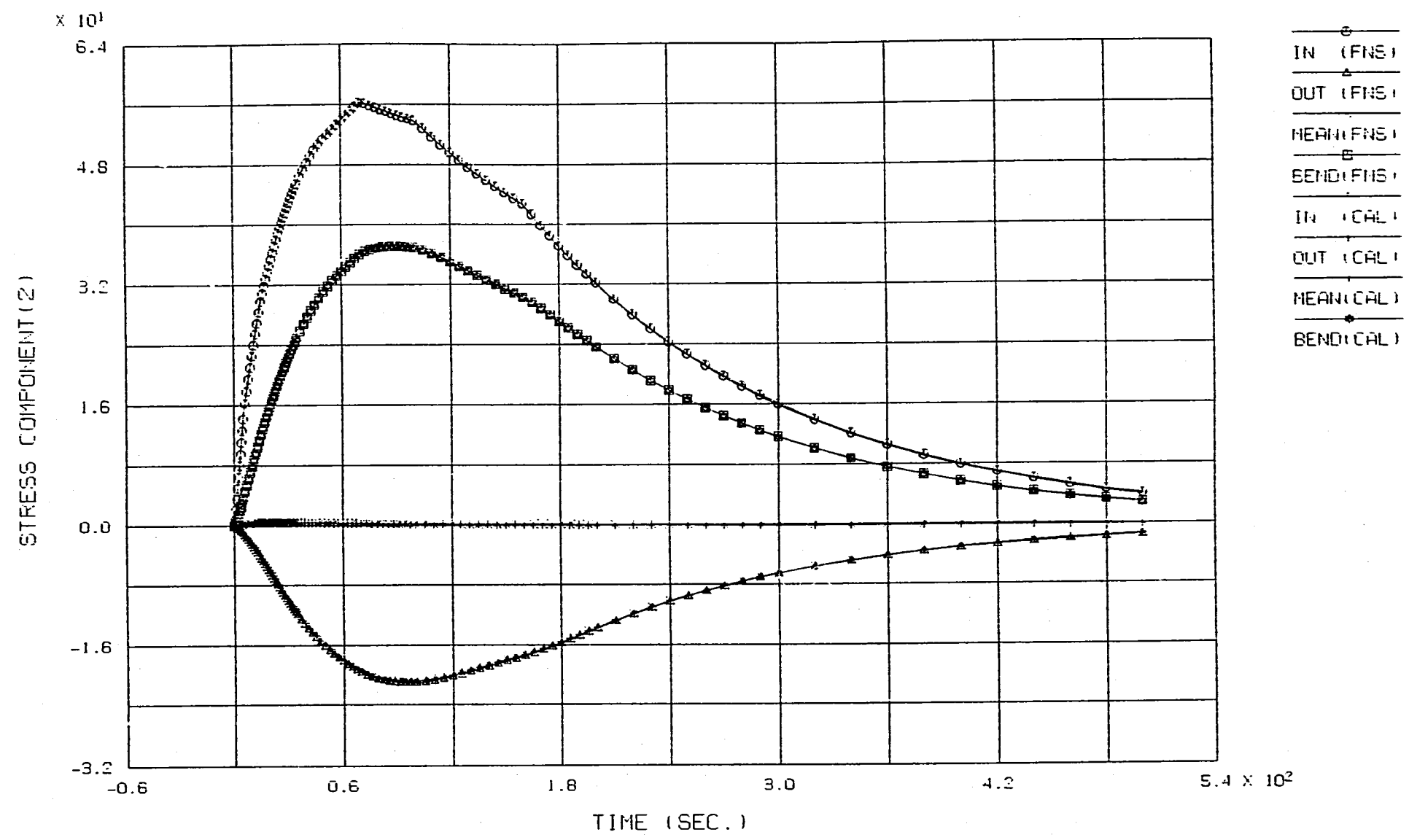
図13. 6(4) 評価断面6の応力テンソル成分4



STRESS COMPONENT (1) OF SECTION (7)

図13. 7 (1) 評価断面7の応力テンソル成分1

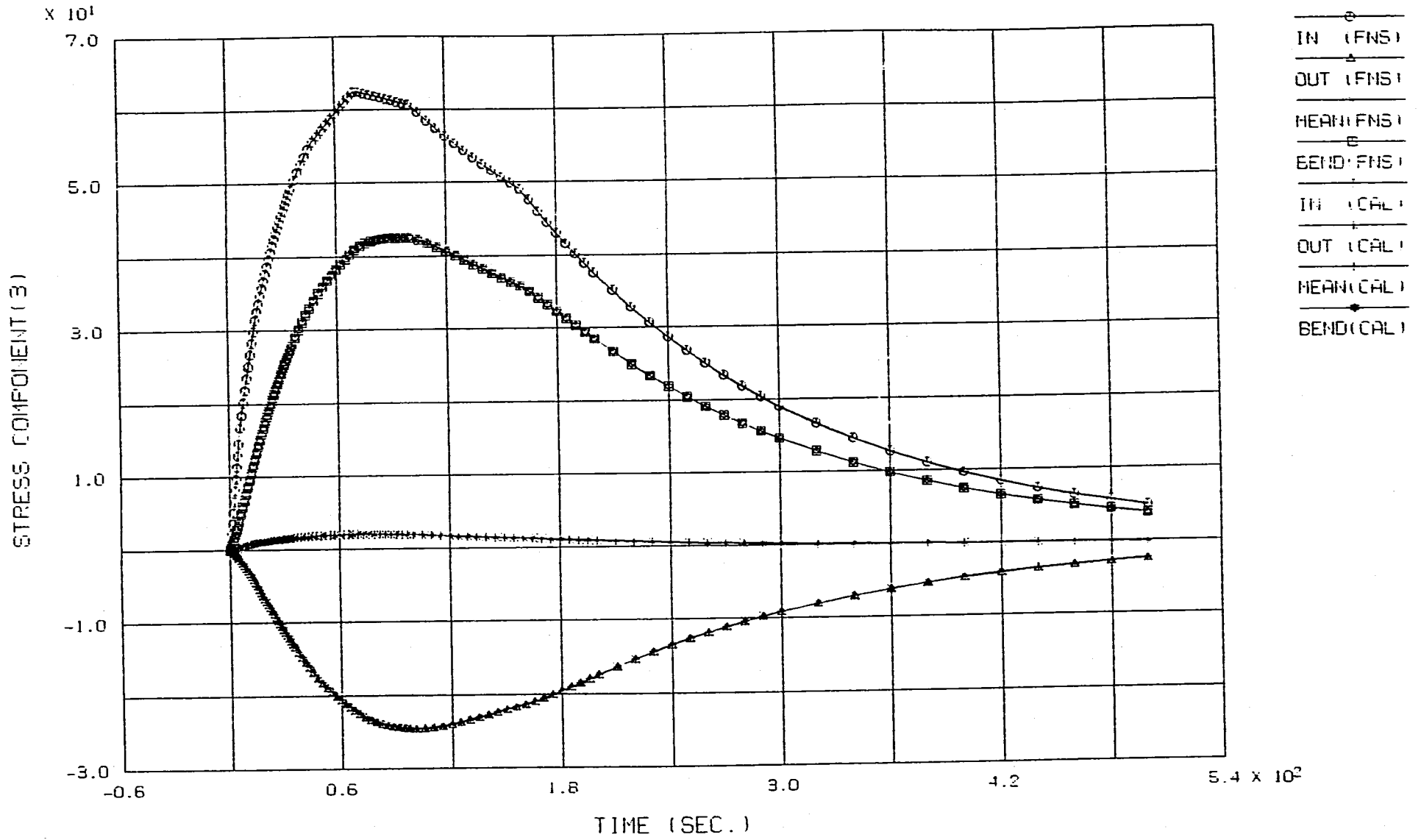
FINAS



STRESS COMPONENT (2) OF SECTION (7)

図13. 7 (2) 評価断面7の応力テンソル成分2

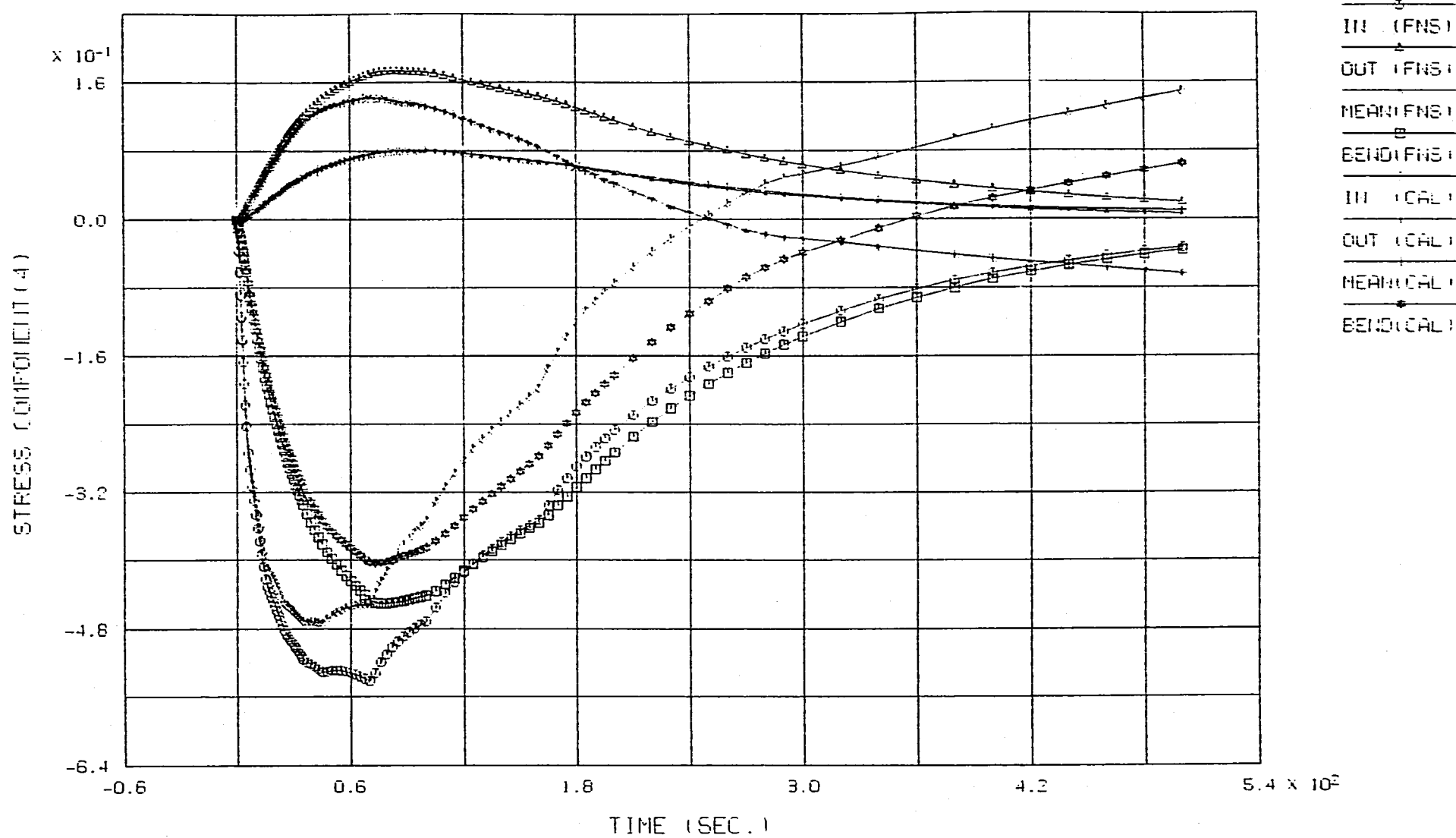
FINAS



STRESS COMPONENT (3) OF SECTION (7)

図13.7(3) 評価断面7の応力テンソル成分3

-188-



STRESS COMPONENT (4) OF SECTION (7)

図13.7(4) 評価断面7の応力テンソル成分4

表3. 1 評価断面1の温度

FINAS解と簡易計算値との比較 (コールドショック)

断面1の温度

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|--------|--------|-------|--------|--------|--------|-------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 600.00 | 600.00 | 600.00 | 0.00 | 600.00 | 600.00 | 600.00 | 0.00 |
| 2 | 0.5 | 598.17 | 599.83 | 599.37 | -0.75 | 597.91 | 599.93 | 599.32 | -0.97 |
| 3 | 1.0 | 595.15 | 599.03 | 597.77 | -1.91 | 595.03 | 599.05 | 597.73 | -2.00 |
| 4 | 1.5 | 591.89 | 597.34 | 595.49 | -2.72 | 591.71 | 597.35 | 595.45 | -2.84 |
| 5 | 2.0 | 588.19 | 594.96 | 592.64 | -3.39 | 588.06 | 594.97 | 592.61 | -3.50 |
| 6 | 2.5 | 584.28 | 592.05 | 589.36 | -3.92 | 584.14 | 592.06 | 589.32 | -4.03 |
| 7 | 3.0 | 580.11 | 588.71 | 585.72 | -4.34 | 579.99 | 588.71 | 585.69 | -4.45 |
| 8 | 3.5 | 575.80 | 585.03 | 581.81 | -4.67 | 575.67 | 585.03 | 581.78 | -4.78 |
| 9 | 4.0 | 571.32 | 581.08 | 577.67 | -4.94 | 571.22 | 581.08 | 577.65 | -5.05 |
| 10 | 4.5 | 566.75 | 576.91 | 573.35 | -5.15 | 566.66 | 576.91 | 573.33 | -5.26 |
| 11 | 5.0 | 562.08 | 572.58 | 568.90 | -5.32 | 562.00 | 572.56 | 568.88 | -5.43 |
| 12 | 6.0 | 554.85 | 564.05 | 560.74 | -4.72 | 554.88 | 564.04 | 560.76 | -4.77 |
| 13 | 7.0 | 548.80 | 556.56 | 553.81 | -3.95 | 548.69 | 556.66 | 553.80 | -4.17 |
| 14 | 8.0 | 542.95 | 550.11 | 547.58 | -3.65 | 542.94 | 550.16 | 547.56 | -3.80 |
| 15 | 9.0 | 537.52 | 544.16 | 541.81 | -3.37 | 537.47 | 544.21 | 541.78 | -3.57 |
| 16 | 10.0 | 532.19 | 538.57 | 536.32 | -3.24 | 532.17 | 538.61 | 536.28 | -3.41 |
| 17 | 11.0 | 527.03 | 533.20 | 531.02 | -3.14 | 526.98 | 533.23 | 530.96 | -3.31 |
| 18 | 12.0 | 521.89 | 527.97 | 525.83 | -3.09 | 521.86 | 527.98 | 525.76 | -3.25 |
| 19 | 13.0 | 516.83 | 522.82 | 520.71 | -3.05 | 516.79 | 522.83 | 520.63 | -3.21 |
| 20 | 14.0 | 511.77 | 517.73 | 515.63 | -3.03 | 511.74 | 517.73 | 515.55 | -3.18 |
| 21 | 15.0 | 506.75 | 512.67 | 510.59 | -3.01 | 506.72 | 512.66 | 510.49 | -3.17 |
| 22 | 16.0 | 502.41 | 507.79 | 505.87 | -2.75 | 502.49 | 507.75 | 505.81 | -2.82 |
| 23 | 17.0 | 498.50 | 503.34 | 501.63 | -2.46 | 498.54 | 503.34 | 501.56 | -2.59 |
| 24 | 18.0 | 494.67 | 499.28 | 497.65 | -2.34 | 494.76 | 499.27 | 497.59 | -2.45 |
| 25 | 19.0 | 491.01 | 495.41 | 493.86 | -2.24 | 491.09 | 495.42 | 493.80 | -2.36 |
| 26 | 20.0 | 487.38 | 491.69 | 490.17 | -2.19 | 487.48 | 491.70 | 490.12 | -2.30 |
| 27 | 21.0 | 483.81 | 488.04 | 486.55 | -2.15 | 483.93 | 488.06 | 486.50 | -2.26 |
| 28 | 22.0 | 480.26 | 484.45 | 482.98 | -2.13 | 480.39 | 484.47 | 482.93 | -2.24 |
| 29 | 23.0 | 476.74 | 480.90 | 479.43 | -2.11 | 476.87 | 480.92 | 479.39 | -2.23 |
| 30 | 24.0 | 473.21 | 477.36 | 475.90 | -2.11 | 473.37 | 477.39 | 475.86 | -2.22 |
| 31 | 25.0 | 469.71 | 473.84 | 472.38 | -2.10 | 469.88 | 473.87 | 472.34 | -2.21 |
| 32 | 26.0 | 466.42 | 470.38 | 468.98 | -2.01 | 466.64 | 470.40 | 468.95 | -2.10 |
| 33 | 27.0 | 463.29 | 467.06 | 465.73 | -1.92 | 463.49 | 467.10 | 465.70 | -2.02 |
| 34 | 28.0 | 460.18 | 463.87 | 462.57 | -1.88 | 460.41 | 463.91 | 462.55 | -1.97 |
| 35 | 29.0 | 457.12 | 460.75 | 459.47 | -1.84 | 457.36 | 460.79 | 459.45 | -1.94 |
| 36 | 30.0 | 454.08 | 457.67 | 456.41 | -1.82 | 454.32 | 457.72 | 456.39 | -1.92 |
| 37 | 31.0 | 451.06 | 454.62 | 453.37 | -1.81 | 451.31 | 454.68 | 453.35 | -1.91 |
| 38 | 32.0 | 448.04 | 451.59 | 450.34 | -1.80 | 448.31 | 451.65 | 450.33 | -1.90 |
| 39 | 33.0 | 445.03 | 448.57 | 447.33 | -1.80 | 445.31 | 448.63 | 447.32 | -1.90 |
| 40 | 34.0 | 442.02 | 445.56 | 444.32 | -1.80 | 442.31 | 445.62 | 444.31 | -1.90 |
| 41 | 35.0 | 439.02 | 442.56 | 441.31 | -1.79 | 439.31 | 442.62 | 441.31 | -1.90 |
| 42 | 37.0 | 433.57 | 436.78 | 435.64 | -1.63 | 433.90 | 436.80 | 435.59 | -1.72 |
| 43 | 39.0 | 428.45 | 431.46 | 430.40 | -1.53 | 428.73 | 431.46 | 430.31 | -1.63 |
| 44 | 41.0 | 423.37 | 426.36 | 425.30 | -1.52 | 423.70 | 426.33 | 425.20 | -1.60 |
| 45 | 43.0 | 418.36 | 421.31 | 420.27 | -1.49 | 418.71 | 421.28 | 420.16 | -1.58 |
| 46 | 45.0 | 413.34 | 416.30 | 415.26 | -1.50 | 413.71 | 416.26 | 415.15 | -1.58 |
| 47 | 47.5 | 407.84 | 410.39 | 409.48 | -1.30 | 408.17 | 410.35 | 409.40 | -1.35 |
| 48 | 50.0 | 402.73 | 405.11 | 404.28 | -1.21 | 403.12 | 405.06 | 404.16 | -1.27 |
| 49 | 52.5 | 397.68 | 400.06 | 399.22 | -1.21 | 398.07 | 399.98 | 399.09 | -1.25 |
| 50 | 55.0 | 392.68 | 395.03 | 394.20 | -1.19 | 393.02 | 394.95 | 394.07 | -1.25 |
| 51 | 57.5 | 387.67 | 390.03 | 389.20 | -1.20 | 388.04 | 389.95 | 389.07 | -1.25 |
| 52 | 60.0 | 382.67 | 385.02 | 384.20 | -1.19 | 383.10 | 384.95 | 384.07 | -1.24 |
| 53 | 62.5 | 377.67 | 380.03 | 379.20 | -1.20 | 378.12 | 379.96 | 379.07 | -1.24 |
| 54 | 65.0 | 372.67 | 375.02 | 374.20 | -1.19 | 373.11 | 374.96 | 374.07 | -1.25 |

| | | | | | | | | | |
|-----|-------|--------|--------|--------|-------|--------|--------|--------|-------|
| 55 | 67.5 | 367.67 | 370.03 | 369.20 | -1.20 | 368.10 | 369.96 | 369.07 | -1.25 |
| 56 | 70.0 | 362.67 | 365.03 | 364.20 | -1.19 | 363.14 | 364.97 | 364.08 | -1.25 |
| 57 | 73.0 | 358.54 | 360.02 | 359.48 | -0.76 | 359.24 | 360.12 | 359.56 | -0.78 |
| 58 | 76.0 | 355.40 | 356.58 | 356.17 | -0.59 | 355.97 | 356.66 | 356.17 | -0.66 |
| 59 | 79.0 | 352.32 | 353.54 | 353.10 | -0.63 | 352.92 | 353.54 | 353.08 | -0.63 |
| 60 | 82.0 | 349.35 | 350.50 | 350.10 | -0.58 | 349.96 | 350.52 | 350.06 | -0.62 |
| 61 | 85.0 | 346.32 | 347.52 | 347.09 | -0.61 | 346.93 | 347.52 | 347.05 | -0.62 |
| 62 | 88.0 | 343.34 | 344.50 | 344.10 | -0.59 | 343.92 | 344.52 | 344.05 | -0.63 |
| 63 | 91.0 | 340.32 | 341.52 | 341.09 | -0.61 | 340.97 | 341.52 | 341.06 | -0.62 |
| 64 | 94.0 | 337.34 | 338.51 | 338.10 | -0.59 | 337.98 | 338.52 | 338.06 | -0.62 |
| 65 | 97.0 | 334.32 | 335.51 | 335.09 | -0.60 | 334.94 | 335.52 | 335.06 | -0.63 |
| 66 | 100.0 | 331.34 | 332.51 | 332.09 | -0.59 | 331.98 | 332.53 | 332.06 | -0.63 |
| 67 | 105.0 | 328.09 | 328.69 | 328.47 | -0.30 | 328.91 | 328.84 | 328.58 | -0.32 |
| 68 | 110.0 | 325.68 | 326.24 | 326.05 | -0.28 | 326.32 | 326.22 | 325.99 | -0.29 |
| 69 | 115.0 | 323.14 | 323.76 | 323.54 | -0.32 | 323.80 | 323.71 | 323.48 | -0.29 |
| 70 | 120.0 | 320.68 | 321.24 | 321.04 | -0.28 | 321.35 | 321.22 | 320.98 | -0.29 |
| 71 | 125.0 | 318.14 | 318.76 | 318.54 | -0.31 | 318.87 | 318.72 | 318.48 | -0.29 |
| 72 | 130.0 | 315.67 | 316.24 | 316.04 | -0.29 | 316.35 | 316.22 | 315.98 | -0.29 |
| 73 | 135.0 | 313.15 | 313.76 | 313.54 | -0.31 | 313.84 | 313.72 | 313.48 | -0.29 |
| 74 | 140.0 | 310.67 | 311.25 | 311.04 | -0.29 | 311.38 | 311.22 | 310.99 | -0.29 |
| 75 | 145.0 | 308.15 | 308.76 | 308.54 | -0.31 | 308.91 | 308.72 | 308.49 | -0.29 |
| 76 | 150.0 | 305.67 | 306.25 | 306.04 | -0.29 | 306.38 | 306.23 | 305.99 | -0.29 |
| 77 | 155.0 | 303.15 | 303.75 | 303.54 | -0.30 | 303.87 | 303.73 | 303.49 | -0.29 |
| 78 | 160.0 | 300.67 | 301.25 | 301.04 | -0.29 | 301.41 | 301.23 | 300.99 | -0.29 |
| 79 | 165.0 | 299.92 | 299.92 | 299.92 | 0.00 | 300.96 | 300.30 | 300.23 | -0.05 |
| 80 | 170.0 | 300.02 | 299.98 | 300.00 | 0.02 | 300.88 | 300.21 | 300.15 | -0.03 |
| 81 | 175.0 | 299.97 | 300.00 | 299.99 | -0.02 | 300.85 | 300.20 | 300.14 | -0.03 |
| 82 | 180.0 | 300.01 | 299.98 | 299.99 | 0.02 | 300.90 | 300.20 | 300.14 | -0.03 |
| 83 | 185.0 | 299.97 | 300.00 | 299.99 | -0.02 | 300.92 | 300.20 | 300.15 | -0.02 |
| 84 | 190.0 | 300.00 | 299.98 | 299.99 | 0.01 | 300.87 | 300.20 | 300.14 | -0.03 |
| 85 | 195.0 | 299.98 | 300.00 | 299.99 | -0.01 | 300.85 | 300.20 | 300.14 | -0.03 |
| 86 | 200.0 | 300.00 | 299.99 | 299.99 | 0.01 | 300.90 | 300.20 | 300.14 | -0.03 |
| 87 | 210.0 | 299.98 | 300.00 | 299.99 | -0.01 | 300.92 | 300.20 | 300.15 | -0.02 |
| 88 | 220.0 | 300.00 | 299.99 | 299.99 | 0.01 | 300.86 | 300.20 | 300.14 | -0.03 |
| 89 | 230.0 | 299.98 | 300.00 | 299.99 | -0.01 | 300.84 | 300.20 | 300.14 | -0.03 |
| 90 | 240.0 | 300.00 | 299.99 | 299.99 | 0.01 | 300.91 | 300.20 | 300.15 | -0.03 |
| 91 | 250.0 | 299.98 | 299.99 | 299.99 | -0.01 | 300.92 | 300.20 | 300.15 | -0.02 |
| 92 | 260.0 | 300.00 | 299.99 | 299.99 | 0.01 | 300.86 | 300.20 | 300.14 | -0.03 |
| 93 | 270.0 | 299.98 | 299.99 | 299.99 | -0.01 | 300.84 | 300.20 | 300.14 | -0.03 |
| 94 | 280.0 | 300.00 | 299.99 | 299.99 | 0.01 | 300.90 | 300.20 | 300.15 | -0.03 |
| 95 | 290.0 | 299.98 | 299.99 | 299.99 | -0.01 | 300.92 | 300.20 | 300.15 | -0.02 |
| 96 | 300.0 | 300.00 | 299.99 | 299.99 | 0.01 | 300.86 | 300.20 | 300.14 | -0.03 |
| 97 | 320.0 | 299.98 | 299.99 | 299.99 | 0.00 | 300.80 | 300.20 | 300.14 | -0.04 |
| 98 | 340.0 | 300.00 | 299.99 | 299.99 | 0.01 | 300.88 | 300.20 | 300.14 | -0.03 |
| 99 | 360.0 | 299.98 | 299.99 | 299.99 | 0.00 | 300.97 | 300.20 | 300.15 | -0.02 |
| 100 | 380.0 | 300.00 | 299.99 | 299.99 | 0.01 | 300.95 | 300.20 | 300.15 | -0.02 |
| 101 | 400.0 | 299.98 | 299.99 | 299.99 | 0.00 | 300.84 | 300.20 | 300.14 | -0.03 |
| 102 | 420.0 | 299.99 | 299.99 | 299.99 | 0.00 | 300.80 | 300.20 | 300.14 | -0.04 |
| 103 | 440.0 | 299.98 | 299.99 | 299.99 | 0.00 | 300.87 | 300.20 | 300.14 | -0.03 |
| 104 | 460.0 | 299.99 | 299.99 | 299.99 | 0.00 | 300.96 | 300.20 | 300.15 | -0.02 |
| 105 | 480.0 | 299.98 | 299.99 | 299.99 | 0.00 | 300.95 | 300.20 | 300.15 | -0.02 |
| 106 | 500.0 | 299.99 | 299.99 | 299.99 | 0.00 | 300.84 | 300.20 | 300.14 | -0.03 |

表3. 2 評価断面2の温度

FINAS解と簡易計算値との比較 (コールドショック)

断面2の温度

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|--------|--------|-------|--------|--------|--------|-------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 600.00 | 600.00 | 600.00 | 0.00 | 600.00 | 600.00 | 600.00 | 0.00 |
| 2 | 0.5 | 598.24 | 599.83 | 599.42 | -0.70 | 597.99 | 599.93 | 599.37 | -0.91 |
| 3 | 1.0 | 595.35 | 599.06 | 597.92 | -1.80 | 595.25 | 599.10 | 597.89 | -1.89 |
| 4 | 1.5 | 592.23 | 597.47 | 595.79 | -2.58 | 592.06 | 597.51 | 595.75 | -2.70 |
| 5 | 2.0 | 588.67 | 595.23 | 593.11 | -3.25 | 588.54 | 595.29 | 593.08 | -3.36 |
| 6 | 2.5 | 584.90 | 592.49 | 590.00 | -3.78 | 584.75 | 592.55 | 589.98 | -3.89 |
| 7 | 3.0 | 580.85 | 589.33 | 586.54 | -4.22 | 580.73 | 589.40 | 586.52 | -4.33 |
| 8 | 3.5 | 576.67 | 585.82 | 582.80 | -4.57 | 576.53 | 585.91 | 582.78 | -4.69 |
| 9 | 4.0 | 572.31 | 582.05 | 578.83 | -4.86 | 572.19 | 582.14 | 578.81 | -4.98 |
| 10 | 4.5 | 567.85 | 578.04 | 574.66 | -5.10 | 567.72 | 578.15 | 574.65 | -5.21 |
| 11 | 5.0 | 563.28 | 573.86 | 570.35 | -5.29 | 563.16 | 573.98 | 570.33 | -5.41 |
| 12 | 6.0 | 556.13 | 565.58 | 562.36 | -4.79 | 556.09 | 565.71 | 562.38 | -4.85 |
| 13 | 7.0 | 550.06 | 558.21 | 555.48 | -4.09 | 549.87 | 558.45 | 555.46 | -4.29 |
| 14 | 8.0 | 544.19 | 551.77 | 549.22 | -3.81 | 544.07 | 551.97 | 549.20 | -3.93 |
| 15 | 9.0 | 538.72 | 545.79 | 543.42 | -3.54 | 538.54 | 545.99 | 543.37 | -3.69 |
| 16 | 10.0 | 533.35 | 540.16 | 537.88 | -3.41 | 533.19 | 540.35 | 537.82 | -3.52 |
| 17 | 11.0 | 528.15 | 534.75 | 532.54 | -3.30 | 527.94 | 534.94 | 532.46 | -3.42 |
| 18 | 12.0 | 522.99 | 529.47 | 527.30 | -3.24 | 522.77 | 529.67 | 527.22 | -3.35 |
| 19 | 13.0 | 517.91 | 524.30 | 522.16 | -3.20 | 517.65 | 524.49 | 522.06 | -3.30 |
| 20 | 14.0 | 512.84 | 519.18 | 517.06 | -3.17 | 512.57 | 519.39 | 516.95 | -3.28 |
| 21 | 15.0 | 507.80 | 514.10 | 511.99 | -3.15 | 507.52 | 514.32 | 511.88 | -3.26 |
| 22 | 16.0 | 503.42 | 509.20 | 507.24 | -2.90 | 503.23 | 509.40 | 507.16 | -2.93 |
| 23 | 17.0 | 499.46 | 504.70 | 502.94 | -2.62 | 499.22 | 504.95 | 502.86 | -2.71 |
| 24 | 18.0 | 495.59 | 500.58 | 498.91 | -2.50 | 495.38 | 500.82 | 498.82 | -2.55 |
| 25 | 19.0 | 491.89 | 496.66 | 495.05 | -2.38 | 491.65 | 496.90 | 494.96 | -2.45 |
| 26 | 20.0 | 488.22 | 492.88 | 491.32 | -2.33 | 488.00 | 493.12 | 491.23 | -2.38 |
| 27 | 21.0 | 484.63 | 489.19 | 487.66 | -2.28 | 484.40 | 489.44 | 487.57 | -2.33 |
| 28 | 22.0 | 481.06 | 485.56 | 484.06 | -2.25 | 480.83 | 485.83 | 483.96 | -2.31 |
| 29 | 23.0 | 477.52 | 481.98 | 480.49 | -2.23 | 477.28 | 482.26 | 480.39 | -2.30 |
| 30 | 24.0 | 473.98 | 478.42 | 476.94 | -2.22 | 473.76 | 478.72 | 476.85 | -2.29 |
| 31 | 25.0 | 470.47 | 474.88 | 473.40 | -2.21 | 470.25 | 475.19 | 473.31 | -2.29 |
| 32 | 26.0 | 467.17 | 471.40 | 469.98 | -2.12 | 466.97 | 471.72 | 469.90 | -2.18 |
| 33 | 27.0 | 464.01 | 468.06 | 466.70 | -2.03 | 463.79 | 468.41 | 466.63 | -2.11 |
| 34 | 28.0 | 460.88 | 464.85 | 463.52 | -1.98 | 460.68 | 465.21 | 463.45 | -2.07 |
| 35 | 29.0 | 457.81 | 461.70 | 460.40 | -1.94 | 457.60 | 462.07 | 460.33 | -2.04 |
| 36 | 30.0 | 454.75 | 458.61 | 457.32 | -1.92 | 454.54 | 458.99 | 457.25 | -2.02 |
| 37 | 31.0 | 451.72 | 455.54 | 454.26 | -1.91 | 451.50 | 455.94 | 454.20 | -2.00 |
| 38 | 32.0 | 448.69 | 452.49 | 451.22 | -1.90 | 448.49 | 452.91 | 451.17 | -2.00 |
| 39 | 33.0 | 445.68 | 449.46 | 448.20 | -1.89 | 445.48 | 449.89 | 448.14 | -2.00 |
| 40 | 34.0 | 442.67 | 446.44 | 445.18 | -1.89 | 442.46 | 446.88 | 445.13 | -2.00 |
| 41 | 35.0 | 439.66 | 443.43 | 442.17 | -1.88 | 439.45 | 443.88 | 442.12 | -2.00 |
| 42 | 37.0 | 434.18 | 437.62 | 436.47 | -1.72 | 433.99 | 438.07 | 436.39 | -1.83 |
| 43 | 39.0 | 429.02 | 432.26 | 431.18 | -1.61 | 428.78 | 432.70 | 431.07 | -1.75 |
| 44 | 41.0 | 423.93 | 427.13 | 426.05 | -1.60 | 423.71 | 427.56 | 425.93 | -1.72 |
| 45 | 43.0 | 418.91 | 422.05 | 421.00 | -1.57 | 418.69 | 422.50 | 420.87 | -1.70 |
| 46 | 45.0 | 413.88 | 417.02 | 415.97 | -1.57 | 413.67 | 417.49 | 415.85 | -1.70 |
| 47 | 47.5 | 408.34 | 411.09 | 410.16 | -1.38 | 408.07 | 411.58 | 410.06 | -1.49 |
| 48 | 50.0 | 403.19 | 405.76 | 404.90 | -1.28 | 402.98 | 406.26 | 404.78 | -1.41 |
| 49 | 52.5 | 398.12 | 400.67 | 399.81 | -1.27 | 397.89 | 401.16 | 399.69 | -1.39 |
| 50 | 55.0 | 393.11 | 395.62 | 394.78 | -1.25 | 392.81 | 396.13 | 394.65 | -1.38 |
| 51 | 57.5 | 388.09 | 390.61 | 389.77 | -1.26 | 387.80 | 391.13 | 389.64 | -1.38 |
| 52 | 60.0 | 383.10 | 385.60 | 384.76 | -1.25 | 382.85 | 386.14 | 384.64 | -1.38 |
| 53 | 62.5 | 378.09 | 380.59 | 379.76 | -1.25 | 377.86 | 381.16 | 379.64 | -1.39 |
| 54 | 65.0 | 373.09 | 375.59 | 374.75 | -1.25 | 372.83 | 376.18 | 374.64 | -1.39 |

| | | | | | | | | | |
|-----|-------|--------|--------|--------|-------|--------|--------|--------|-------|
| 55 | 67.5 | 308.09 | 370.59 | 369.75 | -1.25 | 367.80 | 371.20 | 369.64 | -1.40 |
| 56 | 70.0 | 363.09 | 365.58 | 364.75 | -1.25 | 362.82 | 366.22 | 364.65 | -1.40 |
| 57 | 73.0 | 358.89 | 360.53 | 359.96 | -0.83 | 358.83 | 361.32 | 360.04 | -0.95 |
| 58 | 76.0 | 355.68 | 356.98 | 356.55 | -0.64 | 355.48 | 357.78 | 356.57 | -0.82 |
| 59 | 79.0 | 352.56 | 353.88 | 353.43 | -0.66 | 352.39 | 354.62 | 353.43 | -0.79 |
| 60 | 82.0 | 349.58 | 350.82 | 350.40 | -0.61 | 349.40 | 351.58 | 350.39 | -0.78 |
| 61 | 85.0 | 346.54 | 347.82 | 347.39 | -0.64 | 346.36 | 348.57 | 347.38 | -0.78 |
| 62 | 88.0 | 343.56 | 344.80 | 344.38 | -0.62 | 343.33 | 345.58 | 344.37 | -0.78 |
| 63 | 91.0 | 340.53 | 341.80 | 341.38 | -0.63 | 340.37 | 342.59 | 341.37 | -0.79 |
| 64 | 94.0 | 337.55 | 338.79 | 338.38 | -0.62 | 337.37 | 339.60 | 338.38 | -0.79 |
| 65 | 97.0 | 334.53 | 335.79 | 335.37 | -0.63 | 334.33 | 336.61 | 335.38 | -0.79 |
| 66 | 100.0 | 331.55 | 332.79 | 332.37 | -0.62 | 331.35 | 333.62 | 332.38 | -0.79 |
| 67 | 105.0 | 328.25 | 328.91 | 328.68 | -0.34 | 328.21 | 329.89 | 328.83 | -0.50 |
| 68 | 110.0 | 325.80 | 326.40 | 326.20 | -0.30 | 325.58 | 327.23 | 326.19 | -0.46 |
| 69 | 115.0 | 323.25 | 323.91 | 323.69 | -0.33 | 323.05 | 324.72 | 323.68 | -0.46 |
| 70 | 120.0 | 320.78 | 321.39 | 321.19 | -0.30 | 320.59 | 322.23 | 321.17 | -0.46 |
| 71 | 125.0 | 318.25 | 318.90 | 318.68 | -0.33 | 318.10 | 319.74 | 318.68 | -0.47 |
| 72 | 130.0 | 315.78 | 316.38 | 316.18 | -0.30 | 315.57 | 317.25 | 316.18 | -0.47 |
| 73 | 135.0 | 313.25 | 313.90 | 313.68 | -0.32 | 313.05 | 314.75 | 313.68 | -0.47 |
| 74 | 140.0 | 310.77 | 311.39 | 311.18 | -0.30 | 310.59 | 312.26 | 311.18 | -0.47 |
| 75 | 145.0 | 308.25 | 308.89 | 308.68 | -0.32 | 308.11 | 309.77 | 308.68 | -0.47 |
| 76 | 150.0 | 305.77 | 306.39 | 306.18 | -0.30 | 305.56 | 307.28 | 306.18 | -0.48 |
| 77 | 155.0 | 303.26 | 303.89 | 303.68 | -0.32 | 303.05 | 304.79 | 303.69 | -0.48 |
| 78 | 160.0 | 300.77 | 301.39 | 301.18 | -0.31 | 300.59 | 302.30 | 301.19 | -0.48 |
| 79 | 165.0 | 299.97 | 300.01 | 299.99 | -0.03 | 300.06 | 301.29 | 300.33 | -0.24 |
| 80 | 170.0 | 300.02 | 300.00 | 300.01 | 0.02 | 299.95 | 301.15 | 300.22 | -0.21 |
| 81 | 175.0 | 299.98 | 300.01 | 299.99 | -0.02 | 299.92 | 301.13 | 300.20 | -0.21 |
| 82 | 180.0 | 300.01 | 299.99 | 300.00 | 0.01 | 299.96 | 301.13 | 300.20 | -0.21 |
| 83 | 185.0 | 299.98 | 300.00 | 299.99 | -0.02 | 299.98 | 301.13 | 300.20 | -0.21 |
| 84 | 190.0 | 300.00 | 299.99 | 299.99 | 0.01 | 299.94 | 301.13 | 300.20 | -0.21 |
| 85 | 195.0 | 299.98 | 300.00 | 299.99 | -0.01 | 299.92 | 301.13 | 300.20 | -0.21 |
| 86 | 200.0 | 300.00 | 299.99 | 299.99 | 0.01 | 299.96 | 301.13 | 300.20 | -0.21 |
| 87 | 210.0 | 299.98 | 300.00 | 299.99 | -0.01 | 299.99 | 301.13 | 300.20 | -0.21 |
| 88 | 220.0 | 300.00 | 299.99 | 299.99 | 0.01 | 299.92 | 301.13 | 300.20 | -0.21 |
| 89 | 230.0 | 299.98 | 299.99 | 299.99 | -0.01 | 299.90 | 301.13 | 300.20 | -0.21 |
| 90 | 240.0 | 300.00 | 299.99 | 299.99 | 0.01 | 299.98 | 301.13 | 300.20 | -0.21 |
| 91 | 250.0 | 299.98 | 299.99 | 299.99 | -0.01 | 299.99 | 301.13 | 300.20 | -0.21 |
| 92 | 260.0 | 300.00 | 299.99 | 299.99 | 0.01 | 299.92 | 301.13 | 300.20 | -0.21 |
| 93 | 270.0 | 299.98 | 299.99 | 299.99 | -0.01 | 299.91 | 301.13 | 300.20 | -0.21 |
| 94 | 280.0 | 300.00 | 299.99 | 299.99 | 0.00 | 299.97 | 301.13 | 300.20 | -0.21 |
| 95 | 290.0 | 299.98 | 299.99 | 299.99 | -0.01 | 299.99 | 301.13 | 300.20 | -0.21 |
| 96 | 300.0 | 300.00 | 299.99 | 299.99 | 0.00 | 299.93 | 301.13 | 300.20 | -0.21 |
| 97 | 320.0 | 299.98 | 299.99 | 299.99 | -0.01 | 299.87 | 301.13 | 300.20 | -0.21 |
| 98 | 340.0 | 300.00 | 299.99 | 299.99 | 0.00 | 299.95 | 301.13 | 300.20 | -0.21 |
| 99 | 360.0 | 299.98 | 299.99 | 299.99 | -0.01 | 300.04 | 301.13 | 300.20 | -0.21 |
| 100 | 380.0 | 299.99 | 299.99 | 299.99 | 0.00 | 300.02 | 301.13 | 300.20 | -0.21 |
| 101 | 400.0 | 299.98 | 299.99 | 299.99 | 0.00 | 299.90 | 301.13 | 300.20 | -0.21 |
| 102 | 420.0 | 299.99 | 299.99 | 299.99 | 0.00 | 299.87 | 301.13 | 300.20 | -0.21 |
| 103 | 440.0 | 299.98 | 299.99 | 299.99 | 0.00 | 299.94 | 301.13 | 300.20 | -0.21 |
| 104 | 460.0 | 299.99 | 299.99 | 299.99 | 0.00 | 300.03 | 301.13 | 300.20 | -0.21 |
| 105 | 480.0 | 299.98 | 299.99 | 299.99 | 0.00 | 300.02 | 301.13 | 300.20 | -0.21 |
| 106 | 500.0 | 299.99 | 299.99 | 299.99 | 0.00 | 299.91 | 301.13 | 300.20 | -0.21 |

表 3. 3 評価断面3の温度

FINAS解と簡易計算値との比較 (コールドショック)

断面3の温度

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|--------|--------|-------|--------|--------|--------|-------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 600.00 | 600.00 | 600.00 | 0.00 | 600.00 | 600.00 | 600.00 | 0.0 |
| 2 | 0.5 | 598.14 | 599.91 | 599.51 | -0.71 | 597.87 | 599.98 | 599.49 | -0.91 |
| 3 | 1.0 | 595.07 | 599.41 | 598.20 | -1.98 | 594.93 | 599.46 | 598.18 | -2.09 |
| 4 | 1.5 | 591.80 | 598.24 | 596.27 | -3.05 | 591.59 | 598.25 | 596.25 | -3.15 |
| 5 | 2.0 | 588.15 | 596.41 | 593.84 | -3.95 | 587.98 | 596.43 | 593.82 | -4.05 |
| 6 | 2.5 | 584.34 | 594.08 | 590.99 | -4.70 | 584.15 | 594.11 | 590.97 | -4.81 |
| 7 | 3.0 | 580.30 | 591.32 | 587.80 | -5.34 | 580.12 | 591.36 | 587.79 | -5.45 |
| 8 | 3.5 | 576.14 | 588.22 | 584.33 | -5.88 | 575.93 | 588.26 | 584.32 | -6.00 |
| 9 | 4.0 | 571.82 | 584.82 | 580.62 | -6.33 | 571.62 | 584.88 | 580.62 | -6.46 |
| 10 | 4.5 | 567.43 | 581.18 | 576.72 | -6.72 | 567.21 | 581.25 | 576.72 | -6.85 |
| 11 | 5.0 | 562.92 | 577.35 | 572.66 | -7.05 | 562.70 | 577.41 | 572.66 | -7.19 |
| 12 | 6.0 | 556.03 | 569.53 | 565.01 | -6.72 | 555.90 | 569.62 | 565.04 | -6.81 |
| 13 | 7.0 | 550.26 | 562.29 | 558.29 | -5.95 | 549.95 | 562.50 | 558.32 | -6.24 |
| 14 | 8.0 | 544.54 | 555.88 | 552.13 | -5.61 | 544.32 | 556.07 | 552.16 | -5.84 |
| 15 | 9.0 | 539.16 | 549.92 | 546.35 | -5.32 | 538.90 | 550.10 | 546.37 | -5.57 |
| 16 | 10.0 | 533.84 | 544.26 | 540.82 | -5.14 | 533.61 | 544.44 | 540.84 | -5.39 |
| 17 | 11.0 | 528.67 | 538.82 | 535.46 | -5.01 | 528.40 | 538.99 | 535.48 | -5.27 |
| 18 | 12.0 | 523.52 | 533.52 | 530.22 | -4.93 | 523.25 | 533.68 | 530.23 | -5.19 |
| 19 | 13.0 | 518.44 | 528.32 | 525.05 | -4.87 | 518.15 | 528.48 | 525.06 | -5.14 |
| 20 | 14.0 | 513.37 | 523.18 | 519.94 | -4.84 | 513.08 | 523.34 | 519.95 | -5.11 |
| 21 | 15.0 | 508.34 | 518.08 | 514.87 | -4.81 | 508.03 | 518.25 | 514.88 | -5.09 |
| 22 | 16.0 | 504.00 | 513.12 | 510.07 | -4.53 | 503.79 | 513.25 | 510.11 | -4.73 |
| 23 | 17.0 | 500.08 | 508.50 | 505.70 | -4.17 | 499.81 | 508.68 | 505.74 | -4.43 |
| 24 | 18.0 | 496.21 | 504.24 | 501.58 | -3.97 | 495.97 | 504.42 | 501.63 | -4.22 |
| 25 | 19.0 | 492.50 | 500.21 | 497.65 | -3.81 | 492.23 | 500.38 | 497.69 | -4.07 |
| 26 | 20.0 | 488.82 | 496.32 | 493.84 | -3.71 | 488.56 | 496.50 | 493.88 | -3.96 |
| 27 | 21.0 | 485.21 | 492.54 | 490.11 | -3.63 | 484.94 | 492.72 | 490.16 | -3.89 |
| 28 | 22.0 | 481.61 | 488.84 | 486.45 | -3.57 | 481.34 | 489.02 | 486.50 | -3.83 |
| 29 | 23.0 | 478.05 | 485.19 | 482.83 | -3.52 | 477.77 | 485.37 | 482.88 | -3.79 |
| 30 | 24.0 | 474.50 | 481.57 | 479.24 | -3.49 | 474.22 | 481.76 | 479.29 | -3.76 |
| 31 | 25.0 | 470.97 | 477.99 | 475.67 | -3.47 | 470.69 | 478.18 | 475.72 | -3.74 |
| 32 | 26.0 | 467.66 | 474.46 | 472.20 | -3.36 | 467.41 | 474.64 | 472.27 | -3.62 |
| 33 | 27.0 | 464.51 | 471.74 | 468.88 | -3.23 | 464.23 | 471.25 | 468.95 | -3.51 |
| 34 | 28.0 | 461.37 | 467.76 | 465.65 | -3.15 | 461.11 | 467.97 | 465.72 | -3.44 |
| 35 | 29.0 | 458.29 | 464.55 | 462.48 | -3.09 | 458.02 | 464.77 | 462.55 | -3.38 |
| 36 | 30.0 | 455.22 | 461.40 | 459.36 | -3.05 | 454.94 | 461.61 | 459.42 | -3.34 |
| 37 | 31.0 | 452.18 | 458.29 | 456.27 | -3.02 | 451.89 | 458.50 | 456.33 | -3.31 |
| 38 | 32.0 | 449.14 | 455.20 | 453.20 | -2.99 | 448.87 | 455.41 | 453.26 | -3.29 |
| 39 | 33.0 | 446.11 | 452.14 | 450.15 | -2.97 | 445.84 | 452.34 | 450.21 | -3.27 |
| 40 | 34.0 | 443.09 | 449.08 | 447.10 | -2.96 | 442.82 | 449.29 | 447.17 | -3.26 |
| 41 | 35.0 | 440.07 | 446.04 | 444.07 | -2.95 | 439.80 | 446.25 | 444.15 | -3.25 |
| 42 | 37.0 | 434.60 | 440.15 | 438.31 | -2.75 | 434.34 | 440.37 | 438.35 | -3.10 |
| 43 | 39.0 | 429.44 | 434.67 | 432.94 | -2.58 | 429.13 | 434.89 | 432.97 | -2.97 |
| 44 | 41.0 | 424.31 | 429.44 | 427.75 | -2.53 | 424.06 | 429.65 | 427.78 | -2.91 |
| 45 | 43.0 | 419.27 | 424.30 | 422.64 | -2.48 | 419.03 | 424.52 | 422.68 | -2.88 |
| 46 | 45.0 | 414.23 | 419.22 | 417.57 | -2.47 | 414.00 | 419.45 | 417.62 | -2.86 |
| 47 | 47.5 | 408.70 | 413.18 | 411.68 | -2.22 | 408.43 | 413.41 | 411.77 | -2.60 |
| 48 | 50.0 | 403.54 | 407.71 | 406.33 | -2.05 | 403.33 | 407.97 | 406.41 | -2.47 |
| 49 | 52.5 | 398.44 | 402.53 | 401.17 | -2.02 | 398.23 | 402.78 | 401.26 | -2.43 |
| 50 | 55.0 | 393.41 | 397.41 | 396.09 | -1.97 | 393.15 | 397.68 | 396.18 | -2.41 |
| 51 | 57.5 | 388.37 | 392.36 | 391.04 | -1.97 | 388.14 | 392.64 | 391.15 | -2.41 |
| 52 | 60.0 | 383.36 | 387.31 | 386.01 | -1.95 | 383.18 | 387.62 | 386.13 | -2.40 |
| 53 | 62.5 | 378.35 | 382.29 | 380.99 | -1.95 | 378.19 | 382.62 | 381.13 | -2.41 |
| 54 | 65.0 | 373.34 | 377.27 | 375.97 | -1.94 | 373.16 | 377.62 | 376.13 | -2.42 |

| | | | | | | | | | |
|-----|-------|--------|--------|--------|-------|--------|--------|--------|-------|
| 55 | 67.5 | 368.33 | 372.26 | 370.96 | -1.93 | 368.14 | 372.62 | 371.14 | -2.43 |
| 56 | 70.0 | 363.33 | 367.24 | 365.95 | -1.93 | 363.17 | 367.63 | 366.14 | -2.43 |
| 57 | 73.0 | 359.18 | 362.01 | 361.05 | -1.42 | 359.26 | 362.50 | 361.42 | -1.85 |
| 58 | 76.0 | 355.95 | 358.20 | 357.47 | -1.10 | 355.89 | 358.74 | 357.80 | -1.64 |
| 59 | 79.0 | 352.77 | 354.97 | 354.23 | -1.09 | 352.76 | 355.44 | 354.56 | -1.55 |
| 60 | 82.0 | 349.76 | 351.81 | 351.13 | -1.00 | 349.75 | 352.31 | 351.46 | -1.52 |
| 61 | 85.0 | 346.70 | 348.76 | 348.07 | -1.02 | 346.69 | 349.24 | 348.41 | -1.51 |
| 62 | 88.0 | 343.71 | 345.70 | 345.04 | -0.98 | 343.66 | 346.21 | 345.38 | -1.50 |
| 63 | 91.0 | 340.67 | 342.68 | 342.02 | -0.99 | 340.69 | 343.20 | 342.37 | -1.50 |
| 64 | 94.0 | 337.68 | 339.66 | 339.00 | -0.97 | 337.70 | 340.19 | 339.37 | -1.50 |
| 65 | 97.0 | 334.66 | 336.65 | 335.99 | -0.98 | 334.66 | 337.19 | 336.37 | -1.51 |
| 66 | 100.0 | 331.67 | 333.63 | 332.98 | -0.97 | 331.69 | 334.19 | 333.37 | -1.51 |
| 67 | 105.0 | 328.40 | 329.60 | 329.19 | -0.60 | 328.59 | 330.27 | 329.72 | -1.12 |
| 68 | 110.0 | 325.91 | 326.92 | 326.59 | -0.49 | 325.94 | 327.49 | 327.00 | -1.04 |
| 69 | 115.0 | 323.33 | 324.39 | 324.03 | -0.53 | 323.39 | 324.92 | 324.44 | -1.03 |
| 70 | 120.0 | 320.86 | 321.83 | 321.51 | -0.47 | 320.93 | 322.40 | 321.92 | -1.02 |
| 71 | 125.0 | 318.31 | 319.33 | 318.99 | -0.50 | 318.45 | 319.90 | 319.42 | -1.02 |
| 72 | 130.0 | 315.84 | 316.81 | 316.49 | -0.47 | 315.91 | 317.40 | 316.92 | -1.03 |
| 73 | 135.0 | 313.31 | 314.31 | 313.98 | -0.49 | 313.40 | 314.91 | 314.43 | -1.04 |
| 74 | 140.0 | 310.83 | 311.80 | 311.48 | -0.47 | 310.94 | 312.41 | 311.93 | -1.04 |
| 75 | 145.0 | 308.31 | 309.31 | 308.98 | -0.49 | 308.46 | 309.92 | 309.44 | -1.04 |
| 76 | 150.0 | 305.83 | 306.80 | 306.48 | -0.48 | 305.93 | 307.43 | 306.95 | -1.05 |
| 77 | 155.0 | 303.31 | 304.30 | 303.97 | -0.49 | 303.41 | 304.93 | 304.45 | -1.06 |
| 78 | 160.0 | 300.83 | 301.80 | 301.47 | -0.48 | 300.95 | 302.44 | 301.96 | -1.06 |
| 79 | 165.0 | 300.06 | 300.27 | 300.19 | -0.11 | 300.44 | 301.22 | 300.97 | -0.71 |
| 80 | 170.0 | 300.07 | 300.10 | 300.09 | -0.01 | 300.30 | 300.97 | 300.77 | -0.65 |
| 81 | 175.0 | 299.99 | 300.07 | 300.04 | -0.05 | 300.25 | 300.90 | 300.71 | -0.63 |
| 82 | 180.0 | 300.03 | 300.02 | 300.02 | 0.01 | 300.29 | 300.87 | 300.69 | -0.62 |
| 83 | 185.0 | 299.98 | 300.03 | 300.01 | -0.02 | 300.30 | 300.86 | 300.69 | -0.61 |
| 84 | 190.0 | 300.01 | 300.00 | 300.00 | 0.01 | 300.26 | 300.85 | 300.68 | -0.61 |
| 85 | 195.0 | 299.98 | 300.01 | 300.00 | -0.02 | 300.24 | 300.85 | 300.68 | -0.61 |
| 86 | 200.0 | 300.00 | 300.00 | 300.00 | 0.01 | 300.29 | 300.85 | 300.68 | -0.61 |
| 87 | 210.0 | 299.98 | 300.00 | 299.99 | -0.01 | 300.31 | 300.85 | 300.68 | -0.61 |
| 88 | 220.0 | 300.00 | 299.99 | 299.99 | 0.01 | 300.25 | 300.85 | 300.68 | -0.61 |
| 89 | 230.0 | 299.98 | 300.00 | 299.99 | -0.01 | 300.23 | 300.85 | 300.68 | -0.62 |
| 90 | 240.0 | 300.00 | 299.99 | 299.99 | 0.00 | 300.30 | 300.85 | 300.68 | -0.61 |
| 91 | 250.0 | 299.98 | 300.00 | 299.99 | -0.01 | 300.32 | 300.85 | 300.68 | -0.61 |
| 92 | 260.0 | 300.00 | 299.99 | 299.99 | 0.00 | 300.25 | 300.85 | 300.68 | -0.61 |
| 93 | 270.0 | 299.98 | 299.99 | 299.99 | -0.01 | 300.24 | 300.85 | 300.68 | -0.61 |
| 94 | 280.0 | 300.00 | 299.99 | 299.99 | 0.00 | 300.30 | 300.85 | 300.68 | -0.61 |
| 95 | 290.0 | 299.98 | 299.99 | 299.99 | -0.01 | 300.32 | 300.85 | 300.68 | -0.61 |
| 96 | 300.0 | 299.99 | 299.99 | 299.99 | 0.00 | 300.26 | 300.85 | 300.68 | -0.61 |
| 97 | 320.0 | 299.98 | 299.99 | 299.99 | 0.00 | 300.20 | 300.85 | 300.68 | -0.62 |
| 98 | 340.0 | 299.99 | 299.99 | 299.99 | 0.00 | 300.28 | 300.85 | 300.68 | -0.61 |
| 99 | 360.0 | 299.98 | 299.99 | 299.99 | 0.00 | 300.36 | 300.85 | 300.68 | -0.61 |
| 100 | 380.0 | 299.99 | 299.99 | 299.99 | 0.00 | 300.34 | 300.85 | 300.68 | -0.61 |
| 101 | 400.0 | 299.98 | 299.99 | 299.99 | 0.00 | 300.23 | 300.85 | 300.68 | -0.61 |
| 102 | 420.0 | 299.99 | 299.99 | 299.99 | 0.00 | 300.20 | 300.85 | 300.68 | -0.62 |
| 103 | 440.0 | 299.98 | 299.99 | 299.99 | 0.00 | 300.26 | 300.85 | 300.68 | -0.61 |
| 104 | 460.0 | 299.99 | 299.99 | 299.99 | 0.00 | 300.36 | 300.85 | 300.68 | -0.61 |
| 105 | 480.0 | 299.98 | 299.99 | 299.99 | 0.00 | 300.34 | 300.85 | 300.68 | -0.61 |
| 106 | 500.0 | 299.99 | 299.99 | 299.99 | 0.00 | 300.23 | 300.85 | 300.68 | -0.61 |

表3. 4 評価断面4の温度

FINAS解と簡易計算値との比較 (コールドショック)

断面4の温度

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|--------|--------|--------|--------|--------|--------|--------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 600.00 | 600.00 | 600.00 | 0.00 | 600.00 | 600.00 | 600.00 | 0.00 |
| 2 | 0.5 | 598.19 | 600.00 | 599.79 | -0.49 | 597.92 | 600.00 | 599.77 | -0.55 |
| 3 | 1.0 | 595.21 | 599.99 | 599.24 | -1.61 | 595.07 | 600.00 | 599.23 | -1.67 |
| 4 | 1.5 | 592.08 | 599.96 | 598.44 | -3.01 | 591.88 | 599.98 | 598.43 | -3.07 |
| 5 | 2.0 | 588.64 | 599.88 | 597.42 | -4.58 | 588.48 | 599.91 | 597.42 | -4.63 |
| 6 | 2.5 | 585.12 | 599.70 | 596.21 | -6.21 | 584.93 | 599.72 | 596.21 | -6.26 |
| 7 | 3.0 | 581.44 | 599.39 | 594.82 | -7.86 | 581.27 | 599.41 | 594.83 | -7.91 |
| 8 | 3.5 | 577.72 | 598.92 | 593.28 | -9.50 | 577.51 | 598.95 | 593.29 | -9.54 |
| 9 | 4.0 | 573.88 | 598.31 | 591.58 | -11.11 | 573.68 | 598.32 | 591.59 | -11.15 |
| 10 | 4.5 | 570.01 | 597.53 | 589.74 | -12.68 | 569.79 | 597.54 | 589.76 | -12.71 |
| 11 | 5.0 | 566.07 | 596.59 | 587.77 | -14.21 | 565.84 | 596.59 | 587.79 | -14.23 |
| 12 | 6.0 | 560.29 | 594.27 | 583.82 | -16.36 | 560.14 | 594.24 | 583.85 | -16.33 |
| 13 | 7.0 | 555.57 | 591.43 | 579.98 | -17.53 | 555.22 | 591.36 | 580.00 | -17.55 |
| 14 | 8.0 | 550.77 | 588.22 | 576.11 | -18.39 | 550.47 | 588.14 | 576.13 | -18.41 |
| 15 | 9.0 | 546.14 | 584.82 | 572.20 | -19.06 | 545.77 | 584.73 | 572.23 | -19.10 |
| 16 | 10.0 | 541.45 | 581.29 | 568.25 | -19.66 | 541.09 | 581.20 | 568.27 | -19.71 |
| 17 | 11.0 | 536.80 | 577.68 | 564.24 | -20.21 | 536.41 | 577.57 | 564.26 | -20.26 |
| 18 | 12.0 | 532.09 | 573.99 | 560.19 | -20.73 | 531.72 | 573.86 | 560.21 | -20.78 |
| 19 | 13.0 | 527.41 | 570.24 | 556.09 | -21.22 | 527.01 | 570.08 | 556.11 | -21.27 |
| 20 | 14.0 | 522.69 | 566.42 | 551.95 | -21.68 | 522.28 | 566.25 | 551.96 | -21.73 |
| 21 | 15.0 | 517.97 | 562.55 | 547.76 | -22.12 | 517.54 | 562.35 | 547.78 | -22.17 |
| 22 | 16.0 | 513.89 | 558.62 | 543.65 | -22.33 | 513.57 | 558.41 | 543.68 | -22.33 |
| 23 | 17.0 | 510.18 | 554.67 | 539.67 | -22.27 | 509.80 | 554.43 | 539.69 | -22.28 |
| 24 | 18.0 | 506.47 | 550.72 | 535.77 | -22.16 | 506.11 | 550.47 | 535.79 | -22.17 |
| 25 | 19.0 | 502.85 | 546.82 | 531.93 | -22.04 | 502.46 | 546.56 | 531.96 | -22.05 |
| 26 | 20.0 | 499.23 | 542.97 | 528.15 | -21.93 | 498.84 | 542.70 | 528.18 | -21.94 |
| 27 | 21.0 | 495.65 | 539.18 | 524.42 | -21.83 | 495.24 | 538.90 | 524.45 | -21.85 |
| 28 | 22.0 | 492.06 | 535.45 | 520.72 | -21.75 | 491.66 | 535.16 | 520.75 | -21.77 |
| 29 | 23.0 | 488.51 | 531.75 | 517.07 | -21.69 | 488.09 | 531.46 | 517.10 | -21.71 |
| 30 | 24.0 | 484.95 | 528.11 | 513.44 | -21.65 | 484.54 | 527.80 | 513.48 | -21.67 |
| 31 | 25.0 | 481.42 | 524.49 | 509.85 | -21.61 | 481.00 | 524.18 | 509.88 | -21.64 |
| 32 | 26.0 | 478.10 | 520.92 | 506.32 | -21.52 | 477.72 | 520.58 | 506.35 | -21.53 |
| 33 | 27.0 | 474.93 | 517.38 | 502.86 | -21.36 | 474.52 | 517.02 | 502.89 | -21.37 |
| 34 | 28.0 | 471.76 | 513.88 | 499.46 | -21.20 | 471.36 | 513.51 | 499.50 | -21.20 |
| 35 | 29.0 | 468.64 | 510.43 | 496.11 | -21.04 | 468.22 | 510.05 | 496.15 | -21.05 |
| 36 | 30.0 | 465.52 | 507.04 | 492.81 | -20.90 | 465.10 | 506.64 | 492.84 | -20.91 |
| 37 | 31.0 | 462.43 | 503.69 | 489.54 | -20.78 | 461.99 | 503.28 | 489.58 | -20.78 |
| 38 | 32.0 | 459.34 | 500.39 | 486.31 | -20.67 | 458.90 | 499.97 | 486.35 | -20.68 |
| 39 | 33.0 | 456.27 | 497.13 | 483.11 | -20.58 | 455.83 | 496.69 | 483.15 | -20.58 |
| 40 | 34.0 | 453.20 | 493.91 | 479.94 | -20.51 | 452.77 | 493.46 | 479.97 | -20.50 |
| 41 | 35.0 | 450.15 | 490.72 | 476.79 | -20.44 | 449.71 | 490.26 | 476.83 | -20.43 |
| 42 | 37.0 | 444.59 | 484.45 | 470.68 | -20.14 | 444.12 | 483.97 | 470.71 | -20.18 |
| 43 | 39.0 | 439.31 | 478.33 | 464.82 | -19.73 | 438.79 | 477.84 | 464.84 | -19.80 |
| 44 | 41.0 | 434.03 | 472.41 | 459.12 | -19.40 | 433.55 | 471.91 | 459.15 | -19.46 |
| 45 | 43.0 | 428.85 | 466.67 | 453.57 | -19.13 | 428.35 | 466.17 | 453.60 | -19.19 |
| 46 | 45.0 | 423.68 | 461.09 | 448.12 | -18.91 | 423.20 | 460.57 | 448.16 | -18.98 |
| 47 | 47.5 | 417.98 | 454.31 | 441.63 | -18.44 | 417.52 | 453.76 | 441.66 | -18.47 |
| 48 | 50.0 | 412.62 | 447.80 | 435.49 | -17.85 | 412.12 | 447.25 | 435.52 | -17.92 |
| 49 | 52.5 | 407.28 | 441.59 | 429.59 | -17.41 | 406.80 | 441.03 | 429.62 | -17.46 |
| 50 | 55.0 | 402.05 | 435.65 | 423.89 | -17.05 | 401.54 | 435.08 | 423.92 | -17.10 |
| 51 | 57.5 | 396.85 | 429.91 | 418.34 | -16.78 | 396.35 | 429.32 | 418.36 | -16.82 |
| 52 | 60.0 | 391.70 | 424.33 | 412.90 | -16.56 | 391.19 | 423.73 | 412.93 | -16.59 |
| 53 | 62.5 | 386.57 | 418.87 | 407.56 | -16.39 | 386.06 | 418.26 | 407.59 | -16.41 |
| 54 | 65.0 | 381.48 | 413.52 | 402.29 | -16.26 | 380.95 | 412.90 | 402.33 | -16.27 |

| | | | | | | | | | |
|-----|-------|--------|--------|--------|--------|--------|--------|--------|--------|
| 55 | 67.5 | 376.40 | 408.24 | 397.08 | -16.16 | 375.86 | 407.60 | 397.12 | -16.16 |
| 56 | 70.0 | 371.35 | 403.03 | 391.92 | -16.08 | 370.79 | 402.36 | 391.95 | -16.07 |
| 57 | 73.0 | 367.04 | 396.93 | 386.26 | -15.32 | 366.67 | 396.21 | 386.34 | -15.16 |
| 58 | 76.0 | 363.49 | 391.26 | 381.32 | -14.23 | 362.97 | 390.58 | 381.38 | -14.17 |
| 59 | 79.0 | 359.89 | 386.19 | 376.79 | -13.47 | 359.44 | 385.52 | 376.86 | -13.39 |
| 60 | 82.0 | 356.52 | 381.58 | 372.60 | -12.84 | 356.01 | 380.88 | 372.66 | -12.76 |
| 61 | 85.0 | 353.16 | 377.28 | 368.64 | -12.35 | 352.67 | 376.58 | 368.71 | -12.26 |
| 62 | 88.0 | 349.93 | 373.24 | 364.88 | -11.95 | 349.40 | 372.53 | 364.95 | -11.85 |
| 63 | 91.0 | 346.70 | 369.40 | 361.26 | -11.62 | 346.18 | 368.66 | 361.33 | -11.52 |
| 64 | 94.0 | 343.54 | 365.70 | 357.75 | -11.35 | 343.00 | 364.94 | 357.82 | -11.23 |
| 65 | 97.0 | 340.38 | 362.12 | 354.33 | -11.13 | 339.84 | 361.34 | 354.40 | -11.00 |
| 66 | 100.0 | 337.28 | 358.63 | 350.97 | -10.94 | 336.72 | 357.84 | 351.04 | -10.81 |
| 67 | 105.0 | 333.71 | 353.16 | 346.06 | -10.05 | 333.28 | 352.35 | 346.17 | -9.83 |
| 68 | 110.0 | 330.80 | 348.41 | 341.99 | -9.08 | 330.22 | 347.67 | 342.07 | -9.00 |
| 69 | 115.0 | 327.84 | 344.38 | 338.35 | -8.53 | 327.33 | 343.60 | 338.43 | -8.39 |
| 70 | 120.0 | 325.11 | 340.73 | 335.02 | -8.06 | 324.53 | 339.94 | 335.09 | -7.94 |
| 71 | 125.0 | 322.35 | 337.33 | 331.87 | -7.72 | 321.79 | 336.54 | 331.94 | -7.59 |
| 72 | 130.0 | 319.72 | 334.12 | 328.86 | -7.43 | 319.10 | 333.32 | 328.93 | -7.30 |
| 73 | 135.0 | 317.05 | 331.04 | 325.94 | -7.20 | 316.44 | 330.22 | 326.01 | -7.07 |
| 74 | 140.0 | 314.46 | 328.04 | 323.09 | -7.00 | 313.81 | 327.21 | 323.15 | -6.87 |
| 75 | 145.0 | 311.84 | 325.11 | 320.29 | -6.83 | 311.20 | 324.26 | 320.35 | -6.70 |
| 76 | 150.0 | 309.28 | 322.24 | 317.52 | -6.68 | 308.59 | 321.38 | 317.58 | -6.56 |
| 77 | 155.0 | 306.68 | 319.40 | 314.78 | -6.54 | 305.99 | 318.54 | 314.84 | -6.43 |
| 78 | 160.0 | 304.13 | 316.60 | 312.07 | -6.42 | 303.41 | 315.73 | 312.12 | -6.31 |
| 79 | 165.0 | 303.16 | 314.01 | 309.94 | -5.68 | 302.65 | 313.07 | 310.07 | -5.38 |
| 80 | 170.0 | 302.81 | 312.03 | 308.57 | -4.81 | 302.16 | 311.17 | 308.68 | -4.66 |
| 81 | 175.0 | 302.40 | 310.68 | 307.56 | -4.34 | 301.81 | 309.80 | 307.68 | -4.13 |
| 82 | 180.0 | 302.20 | 309.66 | 306.82 | -3.91 | 301.56 | 308.76 | 306.93 | -3.73 |
| 83 | 185.0 | 301.97 | 308.85 | 306.24 | -3.61 | 301.36 | 307.94 | 306.34 | -3.41 |
| 84 | 190.0 | 301.85 | 308.21 | 305.78 | -3.34 | 301.19 | 307.29 | 305.87 | -3.16 |
| 85 | 195.0 | 301.70 | 307.66 | 305.39 | -3.13 | 301.05 | 306.75 | 305.48 | -2.96 |
| 86 | 200.0 | 301.61 | 307.20 | 305.06 | -2.94 | 300.94 | 306.30 | 305.14 | -2.78 |
| 87 | 210.0 | 301.41 | 306.41 | 304.50 | -2.62 | 300.75 | 305.54 | 304.59 | -2.49 |
| 88 | 220.0 | 301.29 | 305.77 | 304.05 | -2.36 | 300.57 | 304.92 | 304.13 | -2.26 |
| 89 | 230.0 | 301.14 | 305.23 | 303.66 | -2.14 | 300.43 | 304.39 | 303.74 | -2.05 |
| 90 | 240.0 | 301.06 | 304.75 | 303.33 | -1.95 | 300.32 | 303.92 | 303.40 | -1.87 |
| 91 | 250.0 | 300.95 | 304.33 | 303.04 | -1.78 | 300.22 | 303.50 | 303.09 | -1.72 |
| 92 | 260.0 | 300.88 | 303.96 | 302.77 | -1.62 | 300.12 | 303.11 | 302.82 | -1.58 |
| 93 | 270.0 | 300.79 | 303.62 | 302.54 | -1.49 | 300.04 | 302.77 | 302.58 | -1.47 |
| 94 | 280.0 | 300.74 | 303.32 | 302.33 | -1.36 | 299.98 | 302.47 | 302.37 | -1.36 |
| 95 | 290.0 | 300.66 | 303.05 | 302.13 | -1.25 | 299.93 | 302.21 | 302.18 | -1.27 |
| 96 | 300.0 | 300.62 | 302.80 | 301.96 | -1.15 | 299.89 | 301.97 | 302.00 | -1.17 |
| 97 | 320.0 | 300.51 | 302.37 | 301.66 | -0.98 | 299.83 | 301.55 | 301.71 | -1.01 |
| 98 | 340.0 | 300.44 | 302.01 | 301.41 | -0.83 | 299.80 | 301.22 | 301.46 | -0.87 |
| 99 | 360.0 | 300.36 | 301.71 | 301.20 | -0.71 | 299.77 | 300.93 | 301.24 | -0.76 |
| 100 | 380.0 | 300.32 | 301.46 | 301.02 | -0.60 | 299.76 | 300.70 | 301.06 | -0.66 |
| 101 | 400.0 | 300.26 | 301.25 | 300.87 | -0.52 | 299.76 | 300.51 | 300.91 | -0.59 |
| 102 | 420.0 | 300.23 | 301.07 | 300.75 | -0.44 | 299.77 | 300.34 | 300.79 | -0.52 |
| 103 | 440.0 | 300.19 | 300.91 | 300.64 | -0.38 | 299.77 | 300.20 | 300.68 | -0.45 |
| 104 | 460.0 | 300.17 | 300.78 | 300.55 | -0.33 | 299.77 | 300.06 | 300.58 | -0.37 |
| 105 | 480.0 | 300.13 | 300.67 | 300.47 | -0.28 | 299.78 | 299.93 | 300.50 | -0.29 |
| 106 | 500.0 | 300.12 | 300.58 | 300.40 | -0.24 | 299.78 | 299.80 | 300.43 | -0.21 |

表3. 5 評価断面5の温度

FINAS解と簡易計算値との比較 (コールドショック)

断面5の温度

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|--------|--------|--------|--------|--------|--------|--------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 600.00 | 600.00 | 600.00 | 0.00 | 600.00 | 600.00 | 600.00 | 0.00 |
| 2 | 0.5 | 598.33 | 600.00 | 599.81 | -0.44 | 597.99 | 600.00 | 599.80 | -0.49 |
| 3 | 1.0 | 595.35 | 600.00 | 599.34 | -1.46 | 595.19 | 600.00 | 599.34 | -1.51 |
| 4 | 1.5 | 592.28 | 599.99 | 598.67 | -2.76 | 592.05 | 600.00 | 598.66 | -2.82 |
| 5 | 2.0 | 588.88 | 599.97 | 597.81 | -4.27 | 588.70 | 599.98 | 597.80 | -4.32 |
| 6 | 2.5 | 585.40 | 599.91 | 596.79 | -5.88 | 585.20 | 599.93 | 596.79 | -5.95 |
| 7 | 3.0 | 581.77 | 599.80 | 595.62 | -7.57 | 581.58 | 599.82 | 595.62 | -7.64 |
| 8 | 3.5 | 578.07 | 599.62 | 594.32 | -9.30 | 577.87 | 599.63 | 594.33 | -9.37 |
| 9 | 4.0 | 574.28 | 599.35 | 592.90 | -11.05 | 574.09 | 599.36 | 592.91 | -11.12 |
| 10 | 4.5 | 570.44 | 598.98 | 591.37 | -12.79 | 570.25 | 598.99 | 591.37 | -12.86 |
| 11 | 5.0 | 566.54 | 598.52 | 589.73 | -14.53 | 566.36 | 598.52 | 589.73 | -14.60 |
| 12 | 6.0 | 560.76 | 597.31 | 586.47 | -17.27 | 560.73 | 597.29 | 586.49 | -17.30 |
| 13 | 7.0 | 556.15 | 595.72 | 583.34 | -19.13 | 555.91 | 595.67 | 583.33 | -19.21 |
| 14 | 8.0 | 551.43 | 593.82 | 580.21 | -20.66 | 551.29 | 593.73 | 580.19 | -20.73 |
| 15 | 9.0 | 546.97 | 591.69 | 577.06 | -21.97 | 546.75 | 591.59 | 577.04 | -22.05 |
| 16 | 10.0 | 542.42 | 589.40 | 573.89 | -23.16 | 542.26 | 589.29 | 573.87 | -23.24 |
| 17 | 11.0 | 537.97 | 587.01 | 570.68 | -24.27 | 537.78 | 586.88 | 570.66 | -24.35 |
| 18 | 12.0 | 533.47 | 584.51 | 567.44 | -25.32 | 533.30 | 584.38 | 567.41 | -25.39 |
| 19 | 13.0 | 529.01 | 581.94 | 564.15 | -26.31 | 528.83 | 581.80 | 564.12 | -26.39 |
| 20 | 14.0 | 524.51 | 579.30 | 560.83 | -27.27 | 524.35 | 579.15 | 560.79 | -27.36 |
| 21 | 15.0 | 520.03 | 576.58 | 557.46 | -28.20 | 519.86 | 576.43 | 557.42 | -28.28 |
| 22 | 16.0 | 516.16 | 573.81 | 554.14 | -28.90 | 516.12 | 573.65 | 554.11 | -28.94 |
| 23 | 17.0 | 512.69 | 570.98 | 550.93 | -29.34 | 512.60 | 570.81 | 550.89 | -29.39 |
| 24 | 18.0 | 509.20 | 568.12 | 547.77 | -29.69 | 509.15 | 567.94 | 547.73 | -29.73 |
| 25 | 19.0 | 505.82 | 565.25 | 544.66 | -29.99 | 505.75 | 565.05 | 544.62 | -30.04 |
| 26 | 20.0 | 502.42 | 562.38 | 541.58 | -30.27 | 502.37 | 562.18 | 541.54 | -30.32 |
| 27 | 21.0 | 499.07 | 559.52 | 538.53 | -30.54 | 499.02 | 559.32 | 538.49 | -30.59 |
| 28 | 22.0 | 495.71 | 556.67 | 535.49 | -30.81 | 495.67 | 556.47 | 535.46 | -30.86 |
| 29 | 23.0 | 492.37 | 553.84 | 532.47 | -31.08 | 492.33 | 553.64 | 532.44 | -31.13 |
| 30 | 24.0 | 489.03 | 551.02 | 529.47 | -31.35 | 489.00 | 550.82 | 529.43 | -31.41 |
| 31 | 25.0 | 485.70 | 548.22 | 526.47 | -31.63 | 485.67 | 548.01 | 526.43 | -31.68 |
| 32 | 26.0 | 482.58 | 545.42 | 523.51 | -31.84 | 482.59 | 545.20 | 523.48 | -31.88 |
| 33 | 27.0 | 479.60 | 542.63 | 520.60 | -31.97 | 479.58 | 542.40 | 520.57 | -32.02 |
| 34 | 28.0 | 476.61 | 539.85 | 517.73 | -32.08 | 476.60 | 539.62 | 517.70 | -32.14 |
| 35 | 29.0 | 473.67 | 537.08 | 514.89 | -32.19 | 473.65 | 536.85 | 514.85 | -32.25 |
| 36 | 30.0 | 470.72 | 534.34 | 512.07 | -32.30 | 470.71 | 534.10 | 512.04 | -32.36 |
| 37 | 31.0 | 467.79 | 531.62 | 509.27 | -32.41 | 467.77 | 531.38 | 509.24 | -32.47 |
| 38 | 32.0 | 464.86 | 528.92 | 506.49 | -32.53 | 464.84 | 528.67 | 506.46 | -32.59 |
| 39 | 33.0 | 461.95 | 526.24 | 503.72 | -32.65 | 461.92 | 525.99 | 503.69 | -32.72 |
| 40 | 34.0 | 459.03 | 523.57 | 500.97 | -32.78 | 459.01 | 523.32 | 500.94 | -32.85 |
| 41 | 35.0 | 456.12 | 520.92 | 498.22 | -32.92 | 456.09 | 520.66 | 498.19 | -32.99 |
| 42 | 37.0 | 450.82 | 515.66 | 492.86 | -33.01 | 450.75 | 515.39 | 492.82 | -33.13 |
| 43 | 39.0 | 445.79 | 510.46 | 487.68 | -32.96 | 445.67 | 510.19 | 487.62 | -33.11 |
| 44 | 41.0 | 440.74 | 505.36 | 482.60 | -32.93 | 440.64 | 505.10 | 482.53 | -33.08 |
| 45 | 43.0 | 435.77 | 500.36 | 477.60 | -32.92 | 435.65 | 500.10 | 477.54 | -33.09 |
| 46 | 45.0 | 430.79 | 495.45 | 472.67 | -32.95 | 430.68 | 495.18 | 472.60 | -33.12 |
| 47 | 47.5 | 425.29 | 489.41 | 466.73 | -32.77 | 425.22 | 489.13 | 466.66 | -32.91 |
| 48 | 50.0 | 420.11 | 483.53 | 461.05 | -32.42 | 419.99 | 483.25 | 460.97 | -32.59 |
| 49 | 52.5 | 414.94 | 477.82 | 455.54 | -32.14 | 414.83 | 477.54 | 455.46 | -32.32 |
| 50 | 55.0 | 409.84 | 472.28 | 450.17 | -31.92 | 409.72 | 472.01 | 450.07 | -32.11 |
| 51 | 57.5 | 404.75 | 466.89 | 444.89 | -31.76 | 404.64 | 466.61 | 444.78 | -31.95 |
| 52 | 60.0 | 399.71 | 461.60 | 439.69 | -31.64 | 399.58 | 461.32 | 439.57 | -31.83 |
| 53 | 62.5 | 394.66 | 456.41 | 434.55 | -31.56 | 394.54 | 456.11 | 434.42 | -31.76 |
| 54 | 65.0 | 389.65 | 451.29 | 429.47 | -31.51 | 389.52 | 450.99 | 429.33 | -31.71 |

| | | | | | | | | | |
|-----|-------|--------|--------|--------|--------|--------|--------|--------|--------|
| 55 | 67.5 | 384.63 | 446.23 | 424.42 | -31.48 | 384.51 | 445.91 | 424.28 | -31.68 |
| 56 | 70.0 | 379.63 | 441.22 | 419.42 | -31.48 | 379.51 | 440.88 | 419.27 | -31.67 |
| 57 | 73.0 | 375.35 | 435.30 | 413.85 | -30.82 | 375.44 | 434.92 | 413.74 | -30.88 |
| 58 | 76.0 | 371.84 | 429.62 | 408.87 | -29.73 | 371.77 | 429.23 | 408.73 | -29.88 |
| 59 | 79.0 | 368.24 | 424.31 | 404.22 | -28.83 | 368.25 | 423.93 | 404.08 | -28.98 |
| 60 | 82.0 | 364.87 | 419.37 | 399.83 | -28.04 | 364.82 | 418.96 | 399.68 | -28.20 |
| 61 | 85.0 | 361.46 | 414.69 | 395.63 | -27.37 | 361.44 | 414.25 | 395.47 | -27.52 |
| 62 | 88.0 | 358.17 | 410.22 | 391.58 | -26.78 | 358.12 | 409.75 | 391.42 | -26.92 |
| 63 | 91.0 | 354.85 | 405.94 | 387.65 | -26.26 | 354.83 | 405.43 | 387.49 | -26.40 |
| 64 | 94.0 | 351.61 | 401.80 | 383.83 | -25.80 | 351.57 | 401.26 | 383.66 | -25.94 |
| 65 | 97.0 | 348.36 | 397.78 | 380.10 | -25.40 | 348.33 | 397.21 | 379.92 | -25.53 |
| 66 | 100.0 | 345.17 | 393.86 | 376.43 | -25.03 | 345.11 | 393.27 | 376.25 | -25.16 |
| 67 | 105.0 | 341.43 | 387.60 | 370.93 | -23.85 | 341.48 | 387.00 | 370.78 | -23.91 |
| 68 | 110.0 | 338.34 | 381.88 | 366.16 | -22.48 | 338.23 | 381.32 | 365.98 | -22.65 |
| 69 | 115.0 | 335.17 | 376.76 | 361.77 | -21.46 | 335.11 | 376.18 | 361.59 | -21.60 |
| 70 | 120.0 | 332.22 | 372.04 | 357.68 | -20.55 | 332.08 | 371.44 | 357.48 | -20.72 |
| 71 | 125.0 | 329.24 | 367.61 | 353.79 | -19.79 | 329.13 | 367.01 | 353.59 | -19.95 |
| 72 | 130.0 | 326.39 | 363.42 | 350.07 | -19.11 | 326.23 | 362.80 | 349.86 | -19.27 |
| 73 | 135.0 | 323.50 | 359.41 | 346.48 | -18.51 | 323.38 | 358.78 | 346.27 | -18.67 |
| 74 | 140.0 | 320.72 | 355.55 | 343.00 | -17.96 | 320.56 | 354.90 | 342.78 | -18.12 |
| 75 | 145.0 | 317.91 | 351.81 | 339.61 | -17.47 | 317.77 | 351.15 | 339.38 | -17.63 |
| 76 | 150.0 | 315.17 | 348.18 | 336.29 | -17.02 | 314.99 | 347.50 | 336.06 | -17.18 |
| 77 | 155.0 | 312.41 | 344.65 | 333.04 | -16.61 | 312.24 | 343.94 | 332.81 | -16.76 |
| 78 | 160.0 | 309.71 | 341.19 | 329.85 | -16.23 | 309.50 | 340.46 | 329.61 | -16.37 |
| 79 | 165.0 | 308.57 | 337.90 | 327.19 | -15.23 | 308.57 | 337.10 | 327.02 | -15.18 |
| 80 | 170.0 | 308.06 | 335.02 | 325.17 | -13.99 | 307.93 | 334.27 | 324.98 | -14.06 |
| 81 | 175.0 | 307.44 | 332.64 | 323.46 | -13.07 | 307.40 | 331.89 | 323.27 | -13.10 |
| 82 | 180.0 | 307.04 | 330.60 | 321.99 | -12.23 | 306.94 | 329.82 | 321.80 | -12.27 |
| 83 | 185.0 | 306.58 | 328.79 | 320.69 | -11.52 | 306.53 | 328.00 | 320.50 | -11.54 |
| 84 | 190.0 | 306.25 | 327.18 | 319.53 | -10.87 | 306.17 | 326.37 | 319.33 | -10.89 |
| 85 | 195.0 | 305.88 | 325.71 | 318.48 | -10.29 | 305.83 | 324.89 | 318.28 | -10.31 |
| 86 | 200.0 | 305.61 | 324.38 | 317.52 | -9.75 | 305.52 | 323.52 | 317.31 | -9.77 |
| 87 | 210.0 | 305.03 | 322.00 | 315.80 | -8.80 | 304.96 | 321.10 | 315.60 | -8.83 |
| 88 | 220.0 | 304.58 | 319.94 | 314.32 | -7.98 | 304.47 | 319.00 | 314.11 | -8.00 |
| 89 | 230.0 | 304.14 | 318.14 | 313.02 | -7.26 | 304.05 | 317.17 | 312.80 | -7.28 |
| 90 | 240.0 | 303.80 | 316.54 | 311.87 | -6.62 | 303.69 | 315.55 | 311.64 | -6.65 |
| 91 | 250.0 | 303.45 | 315.11 | 310.85 | -6.05 | 303.37 | 314.13 | 310.61 | -6.08 |
| 92 | 260.0 | 303.18 | 313.83 | 309.93 | -5.54 | 303.09 | 312.86 | 309.69 | -5.58 |
| 93 | 270.0 | 302.89 | 312.68 | 309.10 | -5.08 | 302.84 | 311.73 | 308.86 | -5.12 |
| 94 | 280.0 | 302.67 | 311.64 | 308.35 | -4.66 | 302.60 | 310.72 | 308.11 | -4.72 |
| 95 | 290.0 | 302.44 | 310.70 | 307.67 | -4.29 | 302.38 | 309.80 | 307.44 | -4.35 |
| 96 | 300.0 | 302.26 | 309.84 | 307.06 | -3.94 | 302.19 | 308.95 | 306.82 | -4.02 |
| 97 | 320.0 | 301.90 | 308.35 | 305.99 | -3.35 | 301.85 | 307.51 | 305.77 | -3.45 |
| 98 | 340.0 | 301.63 | 307.10 | 305.09 | -2.85 | 301.55 | 306.31 | 304.89 | -2.96 |
| 99 | 360.0 | 301.37 | 306.05 | 304.34 | -2.43 | 301.28 | 305.27 | 304.13 | -2.55 |
| 100 | 380.0 | 301.18 | 305.17 | 303.71 | -2.08 | 301.06 | 304.40 | 303.50 | -2.21 |
| 101 | 400.0 | 301.00 | 304.43 | 303.17 | -1.78 | 300.87 | 303.65 | 302.96 | -1.91 |
| 102 | 420.0 | 300.87 | 303.79 | 302.72 | -1.52 | 300.70 | 303.01 | 302.51 | -1.67 |
| 103 | 440.0 | 300.73 | 303.25 | 302.33 | -1.31 | 300.55 | 302.48 | 302.12 | -1.45 |
| 104 | 460.0 | 300.64 | 302.80 | 302.00 | -1.13 | 300.42 | 302.01 | 301.78 | -1.27 |
| 105 | 480.0 | 300.53 | 302.40 | 301.72 | -0.97 | 300.33 | 301.63 | 301.50 | -1.11 |
| 106 | 500.0 | 300.47 | 302.07 | 301.48 | -0.83 | 300.27 | 301.31 | 301.26 | -0.98 |

表3. 6 評価断面6の温度

FINAS解と簡易計算値との比較 (コールドショック)

断面6の温度

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|--------|--------|--------|--------|--------|--------|--------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 600.00 | 600.00 | 600.00 | 0.00 | 600.00 | 600.00 | 600.00 | 0.00 |
| 2 | 0.5 | 598.33 | 600.00 | 599.94 | -0.16 | 598.01 | 600.00 | 599.94 | -0.18 |
| 3 | 1.0 | 595.37 | 600.00 | 599.79 | -0.57 | 595.22 | 600.00 | 599.79 | -0.58 |
| 4 | 1.5 | 592.28 | 600.00 | 599.58 | -1.13 | 592.06 | 600.00 | 599.58 | -1.15 |
| 5 | 2.0 | 588.84 | 600.00 | 599.31 | -1.84 | 588.67 | 600.00 | 599.31 | -1.85 |
| 6 | 2.5 | 585.31 | 600.00 | 598.98 | -2.66 | 585.12 | 600.00 | 598.99 | -2.67 |
| 7 | 3.0 | 581.61 | 600.00 | 598.62 | -3.58 | 581.44 | 600.00 | 598.62 | -3.59 |
| 8 | 3.5 | 577.85 | 600.00 | 598.21 | -4.59 | 577.67 | 600.00 | 598.21 | -4.60 |
| 9 | 4.0 | 573.99 | 600.00 | 597.76 | -5.69 | 573.82 | 600.00 | 597.77 | -5.69 |
| 10 | 4.5 | 570.07 | 600.00 | 597.26 | -6.86 | 569.90 | 600.00 | 597.28 | -6.86 |
| 11 | 5.0 | 566.09 | 599.99 | 596.74 | -8.10 | 565.93 | 600.00 | 596.75 | -8.10 |
| 12 | 6.0 | 560.13 | 599.98 | 595.66 | -10.50 | 560.12 | 600.00 | 595.69 | -10.50 |
| 13 | 7.0 | 555.36 | 599.95 | 594.58 | -12.74 | 555.14 | 599.97 | 594.62 | -12.76 |
| 14 | 8.0 | 550.52 | 599.89 | 593.46 | -14.94 | 550.38 | 599.92 | 593.50 | -14.97 |
| 15 | 9.0 | 545.93 | 599.78 | 592.27 | -17.11 | 545.71 | 599.82 | 592.31 | -17.15 |
| 16 | 10.0 | 541.27 | 599.63 | 591.02 | -19.26 | 541.09 | 599.68 | 591.06 | -19.31 |
| 17 | 11.0 | 536.71 | 599.43 | 589.70 | -21.38 | 536.50 | 599.48 | 589.74 | -21.44 |
| 18 | 12.0 | 532.10 | 599.16 | 588.30 | -23.49 | 531.91 | 599.22 | 588.35 | -23.55 |
| 19 | 13.0 | 527.54 | 598.84 | 586.85 | -25.57 | 527.33 | 598.90 | 586.90 | -25.64 |
| 20 | 14.0 | 522.94 | 598.45 | 585.32 | -27.63 | 522.75 | 598.52 | 585.37 | -27.71 |
| 21 | 15.0 | 518.37 | 598.00 | 583.73 | -29.67 | 518.16 | 598.08 | 583.79 | -29.75 |
| 22 | 16.0 | 514.41 | 597.49 | 582.11 | -31.61 | 514.32 | 597.58 | 582.18 | -31.68 |
| 23 | 17.0 | 510.86 | 596.92 | 580.48 | -33.41 | 510.70 | 597.02 | 580.55 | -33.49 |
| 24 | 18.0 | 507.30 | 596.29 | 578.82 | -35.13 | 507.18 | 596.40 | 578.90 | -35.22 |
| 25 | 19.0 | 503.87 | 595.61 | 577.13 | -36.76 | 503.71 | 595.71 | 577.21 | -36.86 |
| 26 | 20.0 | 500.41 | 594.86 | 575.41 | -38.34 | 500.28 | 594.97 | 575.49 | -38.44 |
| 27 | 21.0 | 497.02 | 594.07 | 573.66 | -39.85 | 496.88 | 594.17 | 573.75 | -39.95 |
| 28 | 22.0 | 493.61 | 593.21 | 571.88 | -41.31 | 493.49 | 593.32 | 571.98 | -41.41 |
| 29 | 23.0 | 490.24 | 592.31 | 570.08 | -42.72 | 490.11 | 592.42 | 570.18 | -42.82 |
| 30 | 24.0 | 486.85 | 591.36 | 568.25 | -44.08 | 486.74 | 591.47 | 568.36 | -44.19 |
| 31 | 25.0 | 483.49 | 590.36 | 566.40 | -45.41 | 483.37 | 590.47 | 566.52 | -45.52 |
| 32 | 26.0 | 480.34 | 589.32 | 564.54 | -46.67 | 480.26 | 589.42 | 564.66 | -46.78 |
| 33 | 27.0 | 477.33 | 588.24 | 562.67 | -47.87 | 477.22 | 588.34 | 562.79 | -47.98 |
| 34 | 28.0 | 474.32 | 587.12 | 560.79 | -49.01 | 474.23 | 587.21 | 560.91 | -49.12 |
| 35 | 29.0 | 471.36 | 585.96 | 558.89 | -50.10 | 471.25 | 586.04 | 559.02 | -50.22 |
| 36 | 30.0 | 468.39 | 584.76 | 556.99 | -51.15 | 468.29 | 584.84 | 557.12 | -51.28 |
| 37 | 31.0 | 465.45 | 583.53 | 555.07 | -52.17 | 465.35 | 583.61 | 555.20 | -52.29 |
| 38 | 32.0 | 462.51 | 582.27 | 553.14 | -53.15 | 462.41 | 582.34 | 553.28 | -53.28 |
| 39 | 33.0 | 459.58 | 580.98 | 551.20 | -54.10 | 459.48 | 581.05 | 551.34 | -54.23 |
| 40 | 34.0 | 456.65 | 579.65 | 549.25 | -55.02 | 456.55 | 579.72 | 549.40 | -55.16 |
| 41 | 35.0 | 453.73 | 578.30 | 547.29 | -55.91 | 453.63 | 578.37 | 547.44 | -56.06 |
| 42 | 37.0 | 448.41 | 575.52 | 543.38 | -57.55 | 448.25 | 575.59 | 543.53 | -57.72 |
| 43 | 39.0 | 443.38 | 572.64 | 539.47 | -59.00 | 443.15 | 572.73 | 539.62 | -59.19 |
| 44 | 41.0 | 438.33 | 569.68 | 535.56 | -60.32 | 438.13 | 569.77 | 535.72 | -60.52 |
| 45 | 43.0 | 433.37 | 566.64 | 531.64 | -61.54 | 433.14 | 566.74 | 531.81 | -61.74 |
| 46 | 45.0 | 428.39 | 563.53 | 527.72 | -62.67 | 428.18 | 563.64 | 527.90 | -62.88 |
| 47 | 47.5 | 422.91 | 559.56 | 522.86 | -63.87 | 422.72 | 559.66 | 523.04 | -64.08 |
| 48 | 50.0 | 417.76 | 555.51 | 518.06 | -64.82 | 417.52 | 555.61 | 518.24 | -65.04 |
| 49 | 52.5 | 412.62 | 551.40 | 513.29 | -65.63 | 412.40 | 551.50 | 513.48 | -65.85 |
| 50 | 55.0 | 407.55 | 547.24 | 508.56 | -66.33 | 407.32 | 547.34 | 508.76 | -66.55 |
| 51 | 57.5 | 402.50 | 543.04 | 503.87 | -66.95 | 402.28 | 543.15 | 504.06 | -67.16 |
| 52 | 60.0 | 397.48 | 538.81 | 499.20 | -67.50 | 397.26 | 538.93 | 499.40 | -67.72 |
| 53 | 62.5 | 392.47 | 534.57 | 494.56 | -68.01 | 392.26 | 534.68 | 494.76 | -68.23 |
| 54 | 65.0 | 387.48 | 530.32 | 489.94 | -68.48 | 387.26 | 530.43 | 490.15 | -68.70 |

| | | | | | | | | | |
|-----|-------|--------|--------|--------|--------|--------|--------|--------|--------|
| 55 | 67.5 | 382.49 | 526.06 | 485.35 | -68.93 | 382.27 | 526.17 | 485.55 | -69.16 |
| 56 | 70.0 | 377.51 | 521.79 | 480.77 | -69.35 | 377.29 | 521.90 | 480.97 | -69.59 |
| 57 | 73.0 | 373.27 | 516.66 | 475.42 | -69.51 | 373.26 | 516.76 | 475.63 | -69.71 |
| 58 | 76.0 | 369.83 | 511.53 | 470.28 | -69.25 | 369.67 | 511.61 | 470.47 | -69.46 |
| 59 | 79.0 | 366.31 | 506.41 | 465.27 | -68.79 | 366.23 | 506.47 | 465.45 | -68.99 |
| 60 | 82.0 | 363.01 | 501.33 | 460.40 | -68.19 | 362.88 | 501.36 | 460.58 | -68.40 |
| 61 | 85.0 | 359.68 | 496.31 | 455.67 | -67.53 | 359.58 | 496.32 | 455.84 | -67.74 |
| 62 | 88.0 | 356.45 | 491.37 | 451.06 | -66.82 | 356.32 | 491.36 | 451.23 | -67.03 |
| 63 | 91.0 | 353.20 | 486.51 | 446.56 | -66.10 | 353.09 | 486.49 | 446.73 | -66.31 |
| 64 | 94.0 | 350.03 | 481.74 | 442.17 | -65.37 | 349.88 | 481.70 | 442.33 | -65.59 |
| 65 | 97.0 | 346.83 | 477.05 | 437.87 | -64.67 | 346.69 | 477.00 | 438.03 | -64.88 |
| 66 | 100.0 | 343.69 | 472.44 | 433.66 | -63.98 | 343.52 | 472.40 | 433.82 | -64.19 |
| 67 | 105.0 | 340.04 | 464.95 | 426.97 | -62.50 | 340.00 | 464.90 | 427.14 | -62.69 |
| 68 | 110.0 | 337.06 | 457.69 | 420.68 | -60.69 | 336.87 | 457.62 | 420.84 | -60.90 |
| 69 | 115.0 | 333.99 | 450.69 | 414.72 | -58.84 | 333.87 | 450.59 | 414.88 | -59.05 |
| 70 | 120.0 | 331.14 | 443.97 | 409.07 | -56.99 | 330.96 | 443.84 | 409.23 | -57.21 |
| 71 | 125.0 | 328.23 | 437.54 | 403.69 | -55.23 | 328.11 | 437.38 | 403.85 | -55.45 |
| 72 | 130.0 | 325.45 | 431.38 | 398.55 | -53.55 | 325.29 | 431.21 | 398.70 | -53.78 |
| 73 | 135.0 | 322.63 | 425.47 | 393.61 | -51.97 | 322.50 | 425.29 | 393.76 | -52.20 |
| 74 | 140.0 | 319.90 | 419.80 | 388.86 | -50.48 | 319.74 | 419.61 | 389.01 | -50.73 |
| 75 | 145.0 | 317.13 | 414.35 | 384.28 | -49.09 | 316.99 | 414.14 | 384.42 | -49.34 |
| 76 | 150.0 | 314.43 | 409.09 | 379.84 | -47.78 | 314.26 | 408.87 | 379.98 | -48.04 |
| 77 | 155.0 | 311.71 | 404.01 | 375.53 | -46.56 | 311.54 | 403.78 | 375.68 | -46.82 |
| 78 | 160.0 | 309.04 | 399.10 | 371.34 | -45.41 | 308.85 | 398.84 | 371.49 | -45.67 |
| 79 | 165.0 | 307.94 | 394.35 | 367.42 | -43.96 | 307.98 | 391.06 | 367.58 | -44.16 |
| 80 | 170.0 | 307.50 | 389.75 | 363.81 | -42.17 | 307.42 | 389.43 | 363.96 | -42.38 |
| 81 | 175.0 | 306.96 | 385.34 | 360.46 | -40.32 | 306.97 | 385.00 | 360.62 | -40.52 |
| 82 | 180.0 | 306.62 | 381.17 | 357.36 | -38.47 | 306.59 | 380.81 | 357.52 | -38.68 |
| 83 | 185.0 | 306.21 | 377.23 | 354.48 | -36.68 | 306.25 | 376.85 | 354.65 | -36.89 |
| 84 | 190.0 | 305.93 | 373.52 | 351.81 | -34.97 | 305.94 | 373.13 | 351.97 | -35.18 |
| 85 | 195.0 | 305.60 | 370.02 | 349.32 | -33.34 | 305.66 | 369.63 | 349.47 | -33.55 |
| 86 | 200.0 | 305.36 | 366.74 | 346.98 | -31.79 | 305.40 | 366.34 | 347.14 | -32.01 |
| 87 | 210.0 | 304.84 | 360.72 | 342.73 | -28.95 | 304.92 | 360.33 | 342.91 | -29.18 |
| 88 | 220.0 | 304.44 | 355.36 | 338.96 | -26.40 | 304.50 | 354.96 | 339.14 | -26.64 |
| 89 | 230.0 | 304.04 | 350.57 | 335.60 | -24.12 | 304.13 | 350.15 | 335.79 | -24.36 |
| 90 | 240.0 | 303.72 | 346.28 | 332.59 | -22.07 | 303.80 | 345.84 | 332.77 | -22.31 |
| 91 | 250.0 | 303.39 | 342.41 | 329.88 | -20.22 | 303.51 | 341.96 | 330.06 | -20.47 |
| 92 | 260.0 | 303.13 | 338.92 | 327.42 | -18.55 | 303.25 | 338.46 | 327.60 | -18.80 |
| 93 | 270.0 | 302.86 | 335.76 | 325.20 | -17.04 | 303.02 | 335.28 | 325.38 | -17.29 |
| 94 | 280.0 | 302.65 | 332.88 | 323.18 | -15.67 | 302.81 | 332.38 | 323.35 | -15.91 |
| 95 | 290.0 | 302.42 | 330.27 | 321.34 | -14.43 | 302.60 | 329.73 | 321.51 | -14.66 |
| 96 | 300.0 | 302.25 | 327.89 | 319.67 | -13.29 | 302.41 | 327.31 | 319.83 | -13.51 |
| 97 | 320.0 | 301.90 | 323.71 | 316.73 | -11.30 | 302.07 | 323.15 | 316.92 | -11.55 |
| 98 | 340.0 | 301.63 | 320.21 | 314.27 | -9.63 | 301.77 | 319.67 | 314.48 | -9.90 |
| 99 | 360.0 | 301.38 | 317.27 | 312.19 | -8.23 | 301.49 | 316.67 | 312.37 | -8.49 |
| 100 | 380.0 | 301.19 | 314.78 | 310.43 | -7.04 | 301.28 | 314.21 | 310.62 | -7.33 |
| 101 | 400.0 | 301.01 | 312.67 | 308.95 | -6.04 | 301.10 | 312.09 | 309.11 | -6.33 |
| 102 | 420.0 | 300.88 | 310.88 | 307.68 | -5.18 | 300.95 | 310.30 | 307.83 | -5.48 |
| 103 | 440.0 | 300.74 | 309.35 | 306.60 | -4.45 | 300.82 | 308.78 | 306.74 | -4.76 |
| 104 | 460.0 | 300.65 | 308.04 | 305.68 | -3.83 | 300.70 | 307.46 | 305.80 | -4.13 |
| 105 | 480.0 | 300.54 | 306.92 | 304.89 | -3.30 | 300.61 | 306.36 | 305.01 | -3.60 |
| 106 | 500.0 | 300.48 | 305.97 | 304.21 | -2.84 | 300.55 | 305.39 | 304.31 | -3.13 |

表3. 7 評価断面7の温度

FINAS解と簡易計算値との比較 (コールドショック)

断面7の温度

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|--------|--------|--------|--------|--------|--------|--------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 600.00 | 600.00 | 600.00 | 0.00 | 600.00 | 600.00 | 600.00 | 0.00 |
| 2 | 0.5 | 598.37 | 600.00 | 599.92 | -0.21 | 598.04 | 600.00 | 599.92 | -0.23 |
| 3 | 1.0 | 595.44 | 600.00 | 599.75 | -0.68 | 595.27 | 600.00 | 599.74 | -0.70 |
| 4 | 1.5 | 592.38 | 600.00 | 599.50 | -1.31 | 592.15 | 600.00 | 599.50 | -1.32 |
| 5 | 2.0 | 588.99 | 600.00 | 599.20 | -2.07 | 588.80 | 600.00 | 599.20 | -2.08 |
| 6 | 2.5 | 585.50 | 600.00 | 598.86 | -2.94 | 585.30 | 600.00 | 598.86 | -2.95 |
| 7 | 3.0 | 581.85 | 600.00 | 598.47 | -3.91 | 581.67 | 600.00 | 598.47 | -3.92 |
| 8 | 3.5 | 578.14 | 600.00 | 598.04 | -4.95 | 577.96 | 600.00 | 598.05 | -4.96 |
| 9 | 4.0 | 574.33 | 600.00 | 597.58 | -6.07 | 574.16 | 600.00 | 597.59 | -6.08 |
| 10 | 4.5 | 570.46 | 600.00 | 597.08 | -7.26 | 570.30 | 600.00 | 597.09 | -7.26 |
| 11 | 5.0 | 566.54 | 600.00 | 596.56 | -8.51 | 566.39 | 600.00 | 596.57 | -8.50 |
| 12 | 6.0 | 560.66 | 600.00 | 595.54 | -10.84 | 560.69 | 600.00 | 595.56 | -10.82 |
| 13 | 7.0 | 555.98 | 600.00 | 594.56 | -12.98 | 555.81 | 600.00 | 594.59 | -12.97 |
| 14 | 8.0 | 551.21 | 600.00 | 593.57 | -15.07 | 551.16 | 600.00 | 593.61 | -15.06 |
| 15 | 9.0 | 546.71 | 600.00 | 592.57 | -17.15 | 546.59 | 600.00 | 592.61 | -17.14 |
| 16 | 10.0 | 542.14 | 600.00 | 591.54 | -19.23 | 542.08 | 600.00 | 591.59 | -19.22 |
| 17 | 11.0 | 537.68 | 600.00 | 590.48 | -21.31 | 537.58 | 600.00 | 590.54 | -21.31 |
| 18 | 12.0 | 533.17 | 599.99 | 589.40 | -23.40 | 533.09 | 600.00 | 589.46 | -23.40 |
| 19 | 13.0 | 528.70 | 599.99 | 588.28 | -25.51 | 528.61 | 600.00 | 588.35 | -25.51 |
| 20 | 14.0 | 524.20 | 599.98 | 587.14 | -27.62 | 524.13 | 600.00 | 587.22 | -27.64 |
| 21 | 15.0 | 519.72 | 599.97 | 585.97 | -29.75 | 519.65 | 600.00 | 586.05 | -29.77 |
| 22 | 16.0 | 515.85 | 599.96 | 584.80 | -31.79 | 515.90 | 600.00 | 584.89 | -31.81 |
| 23 | 17.0 | 512.39 | 599.94 | 583.65 | -33.73 | 512.39 | 599.98 | 583.75 | -33.75 |
| 24 | 18.0 | 508.93 | 599.91 | 582.50 | -35.61 | 508.96 | 599.96 | 582.61 | -35.63 |
| 25 | 19.0 | 505.57 | 599.88 | 581.35 | -37.45 | 505.59 | 599.93 | 581.46 | -37.47 |
| 26 | 20.0 | 502.21 | 599.84 | 580.18 | -39.26 | 502.25 | 599.88 | 580.30 | -39.27 |
| 27 | 21.0 | 498.89 | 599.78 | 579.01 | -41.04 | 498.93 | 599.83 | 579.14 | -41.05 |
| 28 | 22.0 | 495.57 | 599.72 | 577.83 | -42.79 | 495.62 | 599.77 | 577.96 | -42.81 |
| 29 | 23.0 | 492.28 | 599.64 | 576.64 | -44.53 | 492.32 | 599.69 | 576.77 | -44.55 |
| 30 | 24.0 | 488.98 | 599.55 | 575.43 | -46.24 | 489.03 | 599.60 | 575.57 | -46.26 |
| 31 | 25.0 | 485.70 | 599.44 | 574.21 | -47.93 | 485.75 | 599.49 | 574.35 | -47.96 |
| 32 | 26.0 | 482.63 | 599.32 | 572.99 | -49.58 | 482.72 | 599.37 | 573.14 | -49.60 |
| 33 | 27.0 | 479.70 | 599.18 | 571.78 | -51.17 | 479.78 | 599.22 | 571.93 | -51.19 |
| 34 | 28.0 | 476.77 | 599.02 | 570.55 | -52.73 | 476.86 | 599.06 | 570.71 | -52.75 |
| 35 | 29.0 | 473.89 | 598.84 | 569.33 | -54.25 | 473.97 | 598.89 | 569.49 | -54.27 |
| 36 | 30.0 | 471.00 | 598.65 | 568.10 | -55.75 | 471.10 | 598.69 | 568.26 | -55.77 |
| 37 | 31.0 | 468.13 | 598.44 | 566.85 | -57.22 | 468.23 | 598.47 | 567.02 | -57.24 |
| 38 | 32.0 | 465.27 | 598.20 | 565.61 | -58.67 | 465.37 | 598.24 | 565.78 | -58.70 |
| 39 | 33.0 | 462.41 | 597.95 | 564.35 | -60.10 | 462.52 | 597.98 | 564.52 | -60.13 |
| 40 | 34.0 | 459.56 | 597.68 | 563.08 | -61.50 | 459.66 | 597.70 | 563.26 | -61.54 |
| 41 | 35.0 | 456.71 | 597.39 | 561.81 | -62.89 | 456.82 | 597.40 | 561.99 | -62.93 |
| 42 | 37.0 | 451.53 | 596.74 | 559.27 | -65.52 | 451.59 | 596.74 | 559.46 | -65.57 |
| 43 | 39.0 | 446.63 | 596.01 | 556.74 | -67.98 | 446.65 | 596.00 | 556.93 | -68.04 |
| 44 | 41.0 | 441.72 | 595.21 | 554.20 | -70.32 | 441.77 | 595.19 | 554.39 | -70.39 |
| 45 | 43.0 | 436.89 | 594.32 | 551.64 | -72.57 | 436.92 | 594.30 | 551.84 | -72.64 |
| 46 | 45.0 | 432.05 | 593.35 | 549.06 | -74.74 | 432.10 | 593.34 | 549.27 | -74.82 |
| 47 | 47.5 | 426.71 | 592.04 | 545.86 | -77.22 | 426.83 | 592.03 | 546.08 | -77.29 |
| 48 | 50.0 | 421.71 | 590.61 | 542.69 | -79.44 | 421.77 | 590.60 | 542.91 | -79.53 |
| 49 | 52.5 | 416.71 | 589.06 | 539.51 | -81.52 | 416.79 | 589.07 | 539.74 | -81.61 |
| 50 | 55.0 | 411.78 | 587.41 | 536.33 | -83.46 | 411.86 | 587.43 | 536.56 | -83.56 |
| 51 | 57.5 | 406.86 | 585.66 | 533.13 | -85.30 | 406.96 | 585.68 | 533.37 | -85.40 |
| 52 | 60.0 | 401.97 | 583.81 | 529.92 | -87.03 | 402.07 | 583.83 | 530.16 | -87.14 |
| 53 | 62.5 | 397.09 | 581.87 | 526.69 | -88.69 | 397.20 | 581.89 | 526.93 | -88.80 |
| 54 | 65.0 | 392.22 | 579.84 | 523.44 | -90.28 | 392.33 | 579.85 | 523.69 | -90.39 |

| | | | | | | | | | |
|-----|-------|--------|--------|--------|--------|--------|--------|--------|--------|
| 55 | 67.5 | 387.36 | 577.73 | 520.17 | -91.80 | 387.47 | 577.73 | 520.42 | -91.91 |
| 56 | 70.0 | 382.50 | 575.54 | 516.88 | -93.26 | 382.63 | 575.55 | 517.14 | -93.38 |
| 57 | 73.0 | 378.38 | 572.82 | 513.04 | -94.58 | 378.73 | 572.83 | 513.32 | -94.67 |
| 58 | 76.0 | 375.04 | 570.00 | 509.34 | -95.45 | 375.25 | 570.03 | 509.61 | -95.58 |
| 59 | 79.0 | 371.63 | 567.10 | 505.70 | -96.11 | 371.92 | 567.12 | 505.97 | -96.24 |
| 60 | 82.0 | 368.42 | 564.12 | 502.11 | -96.59 | 368.67 | 564.13 | 502.38 | -96.73 |
| 61 | 85.0 | 365.17 | 561.05 | 498.56 | -96.94 | 365.46 | 561.07 | 498.82 | -97.08 |
| 62 | 88.0 | 362.02 | 557.93 | 495.04 | -97.18 | 362.29 | 557.94 | 495.30 | -97.33 |
| 63 | 91.0 | 358.84 | 554.73 | 491.55 | -97.34 | 359.15 | 554.74 | 491.81 | -97.49 |
| 64 | 94.0 | 355.74 | 551.49 | 488.08 | -97.42 | 356.02 | 551.48 | 488.34 | -97.58 |
| 65 | 97.0 | 352.60 | 548.20 | 484.62 | -97.44 | 352.90 | 548.19 | 484.89 | -97.62 |
| 66 | 100.0 | 349.52 | 544.88 | 481.19 | -97.42 | 349.79 | 544.87 | 481.46 | -97.60 |
| 67 | 105.0 | 345.93 | 539.28 | 475.66 | -96.92 | 346.34 | 539.29 | 475.95 | -97.08 |
| 68 | 110.0 | 343.01 | 533.62 | 470.36 | -95.96 | 343.27 | 533.65 | 470.63 | -96.16 |
| 69 | 115.0 | 339.98 | 527.93 | 465.18 | -94.83 | 340.30 | 527.96 | 465.46 | -95.03 |
| 70 | 120.0 | 337.15 | 522.23 | 460.12 | -93.56 | 337.41 | 522.25 | 460.40 | -93.78 |
| 71 | 125.0 | 334.25 | 516.54 | 455.17 | -92.23 | 334.55 | 516.54 | 455.45 | -92.46 |
| 72 | 130.0 | 331.47 | 510.87 | 450.31 | -90.85 | 331.72 | 510.88 | 450.59 | -91.09 |
| 73 | 135.0 | 328.65 | 505.24 | 445.54 | -89.46 | 328.92 | 505.26 | 445.82 | -89.71 |
| 74 | 140.0 | 325.91 | 499.67 | 440.85 | -88.06 | 326.13 | 499.70 | 441.13 | -88.32 |
| 75 | 145.0 | 323.12 | 494.17 | 436.24 | -86.69 | 323.37 | 494.20 | 436.51 | -86.94 |
| 76 | 150.0 | 320.40 | 488.74 | 431.70 | -85.32 | 320.63 | 488.77 | 431.97 | -85.58 |
| 77 | 155.0 | 317.65 | 483.39 | 427.22 | -83.99 | 317.91 | 483.42 | 427.49 | -84.24 |
| 78 | 160.0 | 314.95 | 478.11 | 422.82 | -82.69 | 315.19 | 478.14 | 423.07 | -82.92 |
| 79 | 165.0 | 313.79 | 472.92 | 418.63 | -81.03 | 314.27 | 472.95 | 418.91 | -81.19 |
| 80 | 170.0 | 313.29 | 467.80 | 414.70 | -79.01 | 313.63 | 467.83 | 414.95 | -79.19 |
| 81 | 175.0 | 312.66 | 462.77 | 410.91 | -76.92 | 313.09 | 462.80 | 411.17 | -77.07 |
| 82 | 180.0 | 312.24 | 457.82 | 407.28 | -74.75 | 312.60 | 457.85 | 407.53 | -74.91 |
| 83 | 185.0 | 311.74 | 452.96 | 403.78 | -72.58 | 312.16 | 452.99 | 404.02 | -72.73 |
| 84 | 190.0 | 311.36 | 448.20 | 400.41 | -70.41 | 311.73 | 448.21 | 400.64 | -70.55 |
| 85 | 195.0 | 310.93 | 443.55 | 397.15 | -68.27 | 311.33 | 443.55 | 397.37 | -68.40 |
| 86 | 200.0 | 310.59 | 439.02 | 394.01 | -66.16 | 310.94 | 439.02 | 394.22 | -66.29 |
| 87 | 210.0 | 309.87 | 430.32 | 388.03 | -62.09 | 310.22 | 430.33 | 388.23 | -62.22 |
| 88 | 220.0 | 309.25 | 422.12 | 382.43 | -58.21 | 309.58 | 422.12 | 382.62 | -58.35 |
| 89 | 230.0 | 308.63 | 414.41 | 377.20 | -54.55 | 308.97 | 414.39 | 377.38 | -54.69 |
| 90 | 240.0 | 308.10 | 407.18 | 372.30 | -51.11 | 308.39 | 407.11 | 372.47 | -51.24 |
| 91 | 250.0 | 307.57 | 400.39 | 367.71 | -47.88 | 307.86 | 400.29 | 367.87 | -48.00 |
| 92 | 260.0 | 307.10 | 394.02 | 363.41 | -44.84 | 307.37 | 393.91 | 363.57 | -44.96 |
| 93 | 270.0 | 306.63 | 388.06 | 359.39 | -42.00 | 306.93 | 387.94 | 359.54 | -42.11 |
| 94 | 280.0 | 306.23 | 382.47 | 355.62 | -39.34 | 306.52 | 382.34 | 355.76 | -39.43 |
| 95 | 290.0 | 305.81 | 377.24 | 352.09 | -36.84 | 306.13 | 377.10 | 352.22 | -36.92 |
| 96 | 300.0 | 305.46 | 372.34 | 348.78 | -34.50 | 305.75 | 372.18 | 348.90 | -34.57 |
| 97 | 320.0 | 304.77 | 363.44 | 342.77 | -30.26 | 305.07 | 363.37 | 342.98 | -30.36 |
| 98 | 340.0 | 304.20 | 355.63 | 337.51 | -26.53 | 304.46 | 355.60 | 337.75 | -26.66 |
| 99 | 360.0 | 303.66 | 348.78 | 332.89 | -23.27 | 303.90 | 348.62 | 333.07 | -23.35 |
| 100 | 380.0 | 303.23 | 342.77 | 328.83 | -20.40 | 303.42 | 342.61 | 329.05 | -20.50 |
| 101 | 400.0 | 302.81 | 337.50 | 325.28 | -17.89 | 302.98 | 337.22 | 325.44 | -17.94 |
| 102 | 420.0 | 302.48 | 332.88 | 322.16 | -15.68 | 302.61 | 332.51 | 322.31 | -15.71 |
| 103 | 440.0 | 302.16 | 328.83 | 319.43 | -13.75 | 302.29 | 328.39 | 319.57 | -13.77 |
| 104 | 460.0 | 301.90 | 325.27 | 317.03 | -12.06 | 302.00 | 324.71 | 317.13 | -12.03 |
| 105 | 480.0 | 301.65 | 322.15 | 314.93 | -10.57 | 301.77 | 321.58 | 315.03 | -10.55 |
| 106 | 500.0 | 301.46 | 319.42 | 313.08 | -9.27 | 301.57 | 318.80 | 313.14 | -9.22 |

表4. 1(1) 評価断面1の応力テンソル成分1

FINAS解と簡易計算値との比較 (コールドショック)

断面1の応力成分1

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|--------|--------|--------|---------|---------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.0094 | 0.0013 | 0.0042 | 0.0027 | 0.0070 | 0.0009 | 0.0051 | 0.0025 |
| 3 | 1.0 | 0.0073 | 0.0042 | 0.0095 | 0.0027 | 0.0109 | 0.0027 | 0.0098 | 0.0032 |
| 4 | 1.5 | 0.0107 | 0.0069 | 0.0132 | 0.0027 | 0.0151 | 0.0043 | 0.0137 | 0.0037 |
| 5 | 2.0 | 0.0101 | 0.0089 | 0.0164 | 0.0030 | 0.0142 | 0.0043 | 0.0167 | 0.0037 |
| 6 | 2.5 | 0.0121 | 0.0108 | 0.0188 | 0.0029 | 0.0115 | 0.0034 | 0.0189 | 0.0037 |
| 7 | 3.0 | 0.0117 | 0.0121 | 0.0208 | 0.0030 | 0.0123 | 0.0025 | 0.0206 | 0.0038 |
| 8 | 3.5 | 0.0131 | 0.0130 | 0.0224 | 0.0031 | 0.0120 | 0.0013 | 0.0219 | 0.0036 |
| 9 | 4.0 | 0.0128 | 0.0135 | 0.0236 | 0.0032 | 0.0064 | -0.0014 | 0.0226 | 0.0031 |
| 10 | 4.5 | 0.0137 | 0.0143 | 0.0246 | 0.0031 | -0.0001 | -0.0042 | 0.0231 | 0.0023 |
| 11 | 5.0 | 0.0136 | 0.0146 | 0.0254 | 0.0032 | -0.0034 | -0.0069 | 0.0235 | 0.0017 |
| 12 | 6.0 | 0.0080 | 0.0137 | 0.0221 | 0.0014 | -0.0133 | -0.0133 | 0.0193 | -0.0014 |
| 13 | 7.0 | 0.0096 | 0.0113 | 0.0187 | 0.0020 | -0.0247 | -0.0200 | 0.0155 | -0.0029 |
| 14 | 8.0 | 0.0072 | 0.0104 | 0.0172 | 0.0016 | -0.0309 | -0.0246 | 0.0129 | -0.0042 |
| 15 | 9.0 | 0.0084 | 0.0099 | 0.0160 | 0.0017 | -0.0366 | -0.0285 | 0.0113 | -0.0054 |
| 16 | 10.0 | 0.0076 | 0.0093 | 0.0154 | 0.0017 | -0.0407 | -0.0312 | 0.0104 | -0.0063 |
| 17 | 11.0 | 0.0080 | 0.0093 | 0.0149 | 0.0016 | -0.0421 | -0.0339 | 0.0098 | -0.0068 |
| 18 | 12.0 | 0.0073 | 0.0088 | 0.0146 | 0.0017 | -0.0444 | -0.0367 | 0.0095 | -0.0074 |
| 19 | 13.0 | 0.0080 | 0.0088 | 0.0145 | 0.0016 | -0.0481 | -0.0394 | 0.0092 | -0.0080 |
| 20 | 14.0 | 0.0077 | 0.0086 | 0.0144 | 0.0017 | -0.0527 | -0.0422 | 0.0089 | -0.0087 |
| 21 | 15.0 | 0.0081 | 0.0086 | 0.0143 | 0.0017 | -0.0569 | -0.0449 | 0.0086 | -0.0094 |
| 22 | 16.0 | 0.0056 | 0.0080 | 0.0129 | 0.0011 | -0.0655 | -0.0482 | 0.0067 | -0.0105 |
| 23 | 17.0 | 0.0067 | 0.0073 | 0.0117 | 0.0012 | -0.0702 | -0.0511 | 0.0055 | -0.0111 |
| 24 | 18.0 | 0.0055 | 0.0069 | 0.0111 | 0.0011 | -0.0737 | -0.0536 | 0.0047 | -0.0116 |
| 25 | 19.0 | 0.0062 | 0.0066 | 0.0106 | 0.0011 | -0.0759 | -0.0557 | 0.0043 | -0.0119 |
| 26 | 20.0 | 0.0057 | 0.0066 | 0.0104 | 0.0011 | -0.0779 | -0.0576 | 0.0039 | -0.0121 |
| 27 | 21.0 | 0.0062 | 0.0064 | 0.0102 | 0.0011 | -0.0843 | -0.0595 | 0.0035 | -0.0129 |
| 28 | 22.0 | 0.0061 | 0.0062 | 0.0101 | 0.0012 | -0.0856 | -0.0614 | 0.0034 | -0.0131 |
| 29 | 23.0 | 0.0063 | 0.0062 | 0.0101 | 0.0011 | -0.0874 | -0.0634 | 0.0033 | -0.0134 |
| 30 | 24.0 | 0.0059 | 0.0062 | 0.0100 | 0.0011 | -0.0945 | -0.0653 | 0.0029 | -0.0142 |
| 31 | 25.0 | 0.0064 | 0.0058 | 0.0100 | 0.0012 | -0.1014 | -0.0672 | 0.0026 | -0.0150 |
| 32 | 26.0 | 0.0054 | 0.0058 | 0.0095 | 0.0009 | -0.1015 | -0.0693 | 0.0021 | -0.0151 |
| 33 | 27.0 | 0.0058 | 0.0053 | 0.0091 | 0.0010 | -0.1034 | -0.0713 | 0.0016 | -0.0154 |
| 34 | 28.0 | 0.0051 | 0.0051 | 0.0089 | 0.0010 | -0.1104 | -0.0731 | 0.0011 | -0.0163 |
| 35 | 29.0 | 0.0056 | 0.0049 | 0.0087 | 0.0010 | -0.1143 | -0.0748 | 0.0008 | -0.0168 |
| 36 | 30.0 | 0.0053 | 0.0051 | 0.0087 | 0.0010 | -0.1125 | -0.0765 | 0.0007 | -0.0166 |
| 37 | 31.0 | 0.0055 | 0.0049 | 0.0086 | 0.0010 | -0.1141 | -0.0781 | 0.0006 | -0.0169 |
| 38 | 32.0 | 0.0053 | 0.0049 | 0.0086 | 0.0010 | -0.1213 | -0.0798 | 0.0003 | -0.0178 |
| 39 | 33.0 | 0.0057 | 0.0049 | 0.0085 | 0.0010 | -0.1259 | -0.0814 | 0.0000 | -0.0184 |
| 40 | 34.0 | 0.0053 | 0.0049 | 0.0085 | 0.0010 | -0.1249 | -0.0831 | 0.0000 | -0.0183 |
| 41 | 35.0 | 0.0053 | 0.0049 | 0.0085 | 0.0009 | -0.1266 | -0.0847 | -0.0001 | -0.0186 |
| 42 | 37.0 | 0.0044 | 0.0044 | 0.0077 | 0.0008 | -0.1486 | -0.0875 | -0.0018 | -0.0212 |
| 43 | 39.0 | 0.0050 | 0.0040 | 0.0072 | 0.0009 | -0.1516 | -0.0898 | -0.0022 | -0.0217 |
| 44 | 41.0 | 0.0048 | 0.0040 | 0.0072 | 0.0009 | -0.1698 | -0.0926 | -0.0032 | -0.0240 |
| 45 | 43.0 | 0.0052 | 0.0038 | 0.0071 | 0.0009 | -0.1838 | -0.0953 | -0.0039 | -0.0256 |
| 46 | 45.0 | 0.0048 | 0.0038 | 0.0071 | 0.0009 | -0.1885 | -0.0981 | -0.0041 | -0.0261 |
| 47 | 47.5 | 0.0045 | 0.0033 | 0.0061 | 0.0007 | -0.1516 | -0.1024 | -0.0039 | -0.0224 |
| 48 | 50.0 | 0.0046 | 0.0029 | 0.0057 | 0.0008 | -0.1963 | -0.1056 | -0.0060 | -0.0276 |
| 49 | 52.5 | 0.0046 | 0.0031 | 0.0057 | 0.0007 | -0.1923 | -0.1084 | -0.0060 | -0.0272 |
| 50 | 55.0 | 0.0046 | 0.0029 | 0.0056 | 0.0008 | -0.1746 | -0.1111 | -0.0054 | -0.0252 |
| 51 | 57.5 | 0.0044 | 0.0031 | 0.0057 | 0.0007 | -0.1799 | -0.1139 | -0.0056 | -0.0259 |
| 52 | 60.0 | 0.0046 | 0.0031 | 0.0057 | 0.0008 | -0.2053 | -0.1166 | -0.0068 | -0.0289 |
| 53 | 62.5 | 0.0045 | 0.0033 | 0.0057 | 0.0007 | -0.2157 | -0.1194 | -0.0073 | -0.0303 |
| 54 | 65.0 | 0.0044 | 0.0033 | 0.0057 | 0.0007 | -0.2069 | -0.1221 | -0.0070 | -0.0294 |

| | | | | | | | | | |
|-----|-------|--------|---------|---------|---------|---------|---------|---------|---------|
| 55 | 67.5 | 0.0042 | 0.0033 | 0.0057 | 0.0007 | -0.1997 | -0.1249 | -0.0067 | -0.0287 |
| 56 | 70.0 | 0.0044 | 0.0033 | 0.0057 | 0.0007 | -0.2156 | -0.1276 | -0.0075 | -0.0306 |
| 57 | 73.0 | 0.0026 | 0.0022 | 0.0036 | 0.0002 | -0.2359 | -0.1317 | -0.0104 | -0.0330 |
| 58 | 76.0 | 0.0034 | 0.0017 | 0.0029 | 0.0005 | -0.2164 | -0.1334 | -0.0100 | -0.0310 |
| 59 | 79.0 | 0.0027 | 0.0020 | 0.0030 | 0.0002 | -0.2196 | -0.1350 | -0.0102 | -0.0314 |
| 60 | 82.0 | 0.0034 | 0.0017 | 0.0028 | 0.0005 | -0.2421 | -0.1367 | -0.0112 | -0.0340 |
| 61 | 85.0 | 0.0029 | 0.0017 | 0.0030 | 0.0003 | -0.2298 | -0.1383 | -0.0107 | -0.0326 |
| 62 | 88.0 | 0.0032 | 0.0015 | 0.0029 | 0.0004 | -0.2198 | -0.1400 | -0.0103 | -0.0315 |
| 63 | 91.0 | 0.0029 | 0.0015 | 0.0029 | 0.0003 | -0.2419 | -0.1416 | -0.0113 | -0.0341 |
| 64 | 94.0 | 0.0031 | 0.0015 | 0.0029 | 0.0004 | -0.2458 | -0.1433 | -0.0115 | -0.0347 |
| 65 | 97.0 | 0.0029 | 0.0017 | 0.0029 | 0.0003 | -0.2285 | -0.1449 | -0.0108 | -0.0327 |
| 66 | 100.0 | 0.0034 | 0.0017 | 0.0029 | 0.0004 | -0.2439 | -0.1466 | -0.0115 | -0.0346 |
| 67 | 105.0 | 0.0020 | 0.0007 | 0.0015 | 0.0001 | -0.2615 | -0.1489 | -0.0137 | -0.0367 |
| 68 | 110.0 | 0.0026 | 0.0006 | 0.0014 | 0.0003 | -0.2457 | -0.1503 | -0.0131 | -0.0349 |
| 69 | 115.0 | 0.0019 | 0.0007 | 0.0015 | 0.0001 | -0.2375 | -0.1517 | -0.0128 | -0.0340 |
| 70 | 120.0 | 0.0024 | 0.0008 | 0.0014 | 0.0002 | -0.2608 | -0.1531 | -0.0138 | -0.0367 |
| 71 | 125.0 | 0.0019 | 0.0006 | 0.0015 | 0.0001 | -0.2693 | -0.1544 | -0.0142 | -0.0377 |
| 72 | 130.0 | 0.0020 | 0.0008 | 0.0014 | 0.0002 | -0.2547 | -0.1558 | -0.0136 | -0.0361 |
| 73 | 135.0 | 0.0017 | 0.0009 | 0.0015 | 0.0001 | -0.2495 | -0.1572 | -0.0134 | -0.0356 |
| 74 | 140.0 | 0.0022 | 0.0008 | 0.0014 | 0.0001 | -0.2698 | -0.1586 | -0.0143 | -0.0380 |
| 75 | 145.0 | 0.0018 | 0.0008 | 0.0015 | 0.0001 | -0.2806 | -0.1599 | -0.0148 | -0.0393 |
| 76 | 150.0 | 0.0022 | 0.0006 | 0.0014 | 0.0002 | -0.2633 | -0.1613 | -0.0141 | -0.0373 |
| 77 | 155.0 | 0.0020 | 0.0006 | 0.0015 | 0.0002 | -0.2576 | -0.1627 | -0.0139 | -0.0368 |
| 78 | 160.0 | 0.0024 | 0.0006 | 0.0014 | 0.0002 | -0.2796 | -0.1640 | -0.0149 | -0.0393 |
| 79 | 165.0 | 0.0010 | -0.0002 | 0.0000 | -0.0001 | -0.2896 | -0.1650 | -0.0163 | -0.0406 |
| 80 | 170.0 | 0.0019 | -0.0002 | 0.0000 | 0.0001 | -0.2723 | -0.1650 | -0.0155 | -0.0386 |
| 81 | 175.0 | 0.0012 | -0.0002 | 0.0001 | 0.0000 | -0.2623 | -0.1650 | -0.0151 | -0.0374 |
| 82 | 180.0 | 0.0017 | -0.0003 | 0.0000 | 0.0001 | -0.2836 | -0.1650 | -0.0160 | -0.0398 |
| 83 | 185.0 | 0.0010 | -0.0002 | 0.0001 | 0.0000 | -0.2934 | -0.1650 | -0.0164 | -0.0410 |
| 84 | 190.0 | 0.0016 | -0.0003 | 0.0000 | 0.0000 | -0.2716 | -0.1650 | -0.0155 | -0.0385 |
| 85 | 195.0 | 0.0010 | -0.0003 | 0.0001 | 0.0000 | -0.2620 | -0.1650 | -0.0151 | -0.0373 |
| 86 | 200.0 | 0.0014 | -0.0005 | 0.0000 | 0.0000 | -0.2834 | -0.1650 | -0.0160 | -0.0398 |
| 87 | 210.0 | 0.0010 | -0.0003 | 0.0001 | 0.0000 | -0.2960 | -0.1650 | -0.0165 | -0.0413 |
| 88 | 220.0 | 0.0014 | -0.0003 | 0.0000 | 0.0000 | -0.2651 | -0.1650 | -0.0152 | -0.0377 |
| 89 | 230.0 | 0.0010 | -0.0003 | 0.0000 | 0.0000 | -0.2559 | -0.1650 | -0.0148 | -0.0366 |
| 90 | 240.0 | 0.0014 | -0.0003 | 0.0000 | 0.0000 | -0.2899 | -0.1650 | -0.0163 | -0.0406 |
| 91 | 250.0 | 0.0010 | -0.0005 | 0.0000 | 0.0000 | -0.2970 | -0.1650 | -0.0166 | -0.0414 |
| 92 | 260.0 | 0.0014 | -0.0005 | 0.0000 | 0.0001 | -0.2650 | -0.1650 | -0.0152 | -0.0377 |
| 93 | 270.0 | 0.0012 | -0.0005 | 0.0000 | 0.0001 | -0.2582 | -0.1650 | -0.0149 | -0.0369 |
| 94 | 280.0 | 0.0017 | -0.0005 | 0.0000 | 0.0001 | -0.2874 | -0.1650 | -0.0162 | -0.0403 |
| 95 | 290.0 | 0.0012 | -0.0005 | 0.0000 | 0.0000 | -0.2971 | -0.1650 | -0.0166 | -0.0414 |
| 96 | 300.0 | 0.0014 | -0.0005 | 0.0000 | 0.0000 | -0.2677 | -0.1650 | -0.0153 | -0.0380 |
| 97 | 320.0 | 0.0008 | -0.0007 | 0.0000 | 0.0000 | -0.2404 | -0.1650 | -0.0142 | -0.0349 |
| 98 | 340.0 | 0.0010 | -0.0007 | -0.0001 | 0.0000 | -0.2785 | -0.1650 | -0.0158 | -0.0392 |
| 99 | 360.0 | 0.0006 | -0.0007 | 0.0000 | 0.0000 | -0.3197 | -0.1650 | -0.0175 | -0.0440 |
| 100 | 380.0 | 0.0012 | -0.0007 | 0.0000 | 0.0000 | -0.3080 | -0.1650 | -0.0170 | -0.0426 |
| 101 | 400.0 | 0.0010 | -0.0007 | 0.0000 | 0.0000 | -0.2555 | -0.1650 | -0.0148 | -0.0366 |
| 102 | 420.0 | 0.0012 | -0.0009 | 0.0000 | 0.0001 | -0.2397 | -0.1650 | -0.0142 | -0.0348 |
| 103 | 440.0 | 0.0008 | -0.0011 | 0.0000 | 0.0001 | -0.2712 | -0.1650 | -0.0155 | -0.0384 |
| 104 | 460.0 | 0.0014 | -0.0011 | -0.0001 | 0.0001 | -0.3158 | -0.1650 | -0.0173 | -0.0435 |
| 105 | 480.0 | 0.0012 | -0.0011 | 0.0000 | 0.0001 | -0.3080 | -0.1650 | -0.0170 | -0.0426 |
| 106 | 500.0 | 0.0014 | -0.0011 | -0.0001 | 0.0001 | -0.2577 | -0.1650 | -0.0149 | -0.0369 |

表4. 1(2) 評価断面1の応力テンソル成分2

FINAS解と簡易計算値との比較 (コールドショック)

断面1の応力成分2

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|---------|--------|--------|--------|---------|--------|--------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.5728 | -0.1925 | 0.0189 | 0.3471 | 0.6755 | -0.2553 | 0.0232 | 0.4485 |
| 3 | 1.0 | 1.2473 | -0.5360 | 0.0428 | 0.8774 | 1.2886 | -0.5630 | 0.0445 | 0.9220 |
| 4 | 1.5 | 1.7131 | -0.7920 | 0.0590 | 1.2507 | 1.7834 | -0.8139 | 0.0618 | 1.3055 |
| 5 | 2.0 | 2.1205 | -0.9895 | 0.0733 | 1.5602 | 2.1688 | -1.0133 | 0.0754 | 1.6105 |
| 6 | 2.5 | 2.4193 | -1.1523 | 0.0838 | 1.8007 | 2.4723 | -1.1709 | 0.0862 | 1.8529 |
| 7 | 3.0 | 2.6757 | -1.2781 | 0.0927 | 1.9955 | 2.7182 | -1.2966 | 0.0948 | 2.0455 |
| 8 | 3.5 | 2.8646 | -1.3802 | 0.0994 | 2.1477 | 2.9141 | -1.3967 | 0.1016 | 2.1989 |
| 9 | 4.0 | 3.0267 | -1.4607 | 0.1050 | 2.2707 | 3.0620 | -1.4747 | 0.1068 | 2.3203 |
| 10 | 4.5 | 3.1459 | -1.5244 | 0.1093 | 2.3669 | 3.1765 | -1.5371 | 0.1109 | 2.4177 |
| 11 | 5.0 | 3.2490 | -1.5757 | 0.1128 | 2.4449 | 3.2707 | -1.5865 | 0.1143 | 2.4958 |
| 12 | 6.0 | 2.8077 | -1.4186 | 0.0981 | 2.1683 | 2.7919 | -1.4176 | 0.0979 | 2.1912 |
| 13 | 7.0 | 2.3902 | -1.1772 | 0.0831 | 1.8136 | 2.4220 | -1.2402 | 0.0847 | 1.9168 |
| 14 | 8.0 | 2.2031 | -1.0872 | 0.0768 | 1.6780 | 2.1872 | -1.1305 | 0.0762 | 1.7446 |
| 15 | 9.0 | 2.0427 | -1.0061 | 0.0710 | 1.5502 | 2.0345 | -1.0616 | 0.0708 | 1.6357 |
| 16 | 10.0 | 1.9689 | -0.9630 | 0.0685 | 1.4913 | 1.9366 | -1.0185 | 0.0675 | 1.5650 |
| 17 | 11.0 | 1.9043 | -0.9348 | 0.0662 | 1.4431 | 1.8752 | -0.9916 | 0.0654 | 1.5197 |
| 18 | 12.0 | 1.8768 | -0.9158 | 0.0652 | 1.4190 | 1.8360 | -0.9745 | 0.0642 | 1.4908 |
| 19 | 13.0 | 1.8498 | -0.9062 | 0.0643 | 1.4002 | 1.8088 | -0.9636 | 0.0635 | 1.4713 |
| 20 | 14.0 | 1.8407 | -0.8979 | 0.0640 | 1.3908 | 1.7879 | -0.9577 | 0.0628 | 1.4586 |
| 21 | 15.0 | 1.8284 | -0.8945 | 0.0636 | 1.3832 | 1.7723 | -0.9546 | 0.0624 | 1.4502 |
| 22 | 16.0 | 1.6518 | -0.8217 | 0.0576 | 1.2636 | 1.5529 | -0.8565 | 0.0549 | 1.2925 |
| 23 | 17.0 | 1.4928 | -0.7341 | 0.0519 | 1.1328 | 1.4093 | -0.7888 | 0.0501 | 1.1860 |
| 24 | 18.0 | 1.4209 | -0.6969 | 0.0495 | 1.0779 | 1.3175 | -0.7471 | 0.0471 | 1.1192 |
| 25 | 19.0 | 1.3582 | -0.6670 | 0.0472 | 1.0296 | 1.2584 | -0.7217 | 0.0452 | 1.0773 |
| 26 | 20.0 | 1.3310 | -0.6499 | 0.0463 | 1.0065 | 1.2198 | -0.7066 | 0.0440 | 1.0509 |
| 27 | 21.0 | 1.3047 | -0.6390 | 0.0454 | 0.9879 | 1.1879 | -0.6975 | 0.0430 | 1.0338 |
| 28 | 22.0 | 1.2955 | -0.6318 | 0.0451 | 0.9787 | 1.1719 | -0.6920 | 0.0426 | 1.0235 |
| 29 | 23.0 | 1.2837 | -0.6280 | 0.0446 | 0.9713 | 1.1603 | -0.6889 | 0.0424 | 1.0168 |
| 30 | 24.0 | 1.2810 | -0.6251 | 0.0445 | 0.9679 | 1.1441 | -0.6874 | 0.0420 | 1.0118 |
| 31 | 25.0 | 1.2753 | -0.6240 | 0.0443 | 0.9648 | 1.1303 | -0.6871 | 0.0417 | 1.0086 |
| 32 | 26.0 | 1.2172 | -0.5997 | 0.0423 | 0.9249 | 1.0603 | -0.6552 | 0.0393 | 0.9570 |
| 33 | 27.0 | 1.1633 | -0.5705 | 0.0404 | 0.8810 | 1.0117 | -0.6334 | 0.0377 | 0.9218 |
| 34 | 28.0 | 1.1401 | -0.5583 | 0.0396 | 0.8627 | 0.9725 | -0.6201 | 0.0365 | 0.8989 |
| 35 | 29.0 | 1.1186 | -0.5482 | 0.0388 | 0.8465 | 0.9480 | -0.6122 | 0.0358 | 0.8847 |
| 36 | 30.0 | 1.1100 | -0.5425 | 0.0386 | 0.8389 | 0.9381 | -0.6079 | 0.0355 | 0.8766 |
| 37 | 31.0 | 1.1006 | -0.5386 | 0.0382 | 0.8325 | 0.9278 | -0.6055 | 0.0352 | 0.8712 |
| 38 | 32.0 | 1.0983 | -0.5363 | 0.0381 | 0.8296 | 0.9125 | -0.6042 | 0.0348 | 0.8669 |
| 39 | 33.0 | 1.0939 | -0.5348 | 0.0380 | 0.8270 | 0.9026 | -0.6037 | 0.0346 | 0.8643 |
| 40 | 34.0 | 1.0933 | -0.5339 | 0.0380 | 0.8259 | 0.9014 | -0.6040 | 0.0346 | 0.8634 |
| 41 | 35.0 | 1.0909 | -0.5335 | 0.0379 | 0.8248 | 0.8972 | -0.6045 | 0.0345 | 0.8627 |
| 42 | 37.0 | 0.9863 | -0.4869 | 0.0342 | 0.7500 | 0.7466 | -0.5591 | 0.0297 | 0.7800 |
| 43 | 39.0 | 0.9299 | -0.4533 | 0.0322 | 0.7015 | 0.6898 | -0.5360 | 0.0281 | 0.7405 |
| 44 | 41.0 | 0.9223 | -0.4517 | 0.0320 | 0.6979 | 0.6433 | -0.5279 | 0.0267 | 0.7229 |
| 45 | 43.0 | 0.9093 | -0.4437 | 0.0315 | 0.6863 | 0.6140 | -0.5260 | 0.0258 | 0.7153 |
| 46 | 45.0 | 0.9124 | -0.4456 | 0.0316 | 0.6893 | 0.6029 | -0.5261 | 0.0257 | 0.7126 |
| 47 | 47.5 | 0.7838 | -0.3880 | 0.0272 | 0.5965 | 0.5216 | -0.4587 | 0.0224 | 0.6121 |
| 48 | 50.0 | 0.7384 | -0.3581 | 0.0255 | 0.5549 | 0.4124 | -0.4381 | 0.0192 | 0.5733 |
| 49 | 52.5 | 0.7338 | -0.3604 | 0.0254 | 0.5557 | 0.4051 | -0.4334 | 0.0189 | 0.5634 |
| 50 | 55.0 | 0.7268 | -0.3532 | 0.0252 | 0.5468 | 0.4247 | -0.4331 | 0.0196 | 0.5625 |
| 51 | 57.5 | 0.7289 | -0.3570 | 0.0253 | 0.5512 | 0.4142 | -0.4345 | 0.0194 | 0.5620 |
| 52 | 60.0 | 0.7264 | -0.3540 | 0.0252 | 0.5473 | 0.3765 | -0.4358 | 0.0184 | 0.5587 |
| 53 | 62.5 | 0.7278 | -0.3563 | 0.0253 | 0.5500 | 0.3606 | -0.4374 | 0.0180 | 0.5578 |
| 54 | 65.0 | 0.7265 | -0.3547 | 0.0252 | 0.5480 | 0.3716 | -0.4394 | 0.0184 | 0.5598 |

| | | | | | | | | | |
|-----|-------|---------|---------|---------|---------|---------|---------|---------|---------|
| 55 | 67.5 | 0.7272 | -0.3558 | 0.0253 | 0.5496 | 0.3803 | -0.4412 | 0.0188 | 0.5616 |
| 56 | 70.0 | 0.7270 | -0.3551 | 0.0253 | 0.5486 | 0.3568 | -0.4428 | 0.0182 | 0.5598 |
| 57 | 73.0 | 0.4487 | -0.2293 | 0.0157 | 0.3480 | 0.0515 | -0.3045 | 0.0079 | 0.3435 |
| 58 | 76.0 | 0.3667 | -0.1736 | 0.0127 | 0.2708 | 0.0075 | -0.2710 | 0.0064 | 0.2916 |
| 59 | 79.0 | 0.3757 | -0.1878 | 0.0131 | 0.2877 | -0.0152 | -0.2629 | 0.0058 | 0.2768 |
| 60 | 82.0 | 0.3576 | -0.1716 | 0.0124 | 0.2662 | -0.0522 | -0.2617 | 0.0048 | 0.2704 |
| 61 | 85.0 | 0.3706 | -0.1834 | 0.0129 | 0.2818 | -0.0373 | -0.2628 | 0.0053 | 0.2723 |
| 62 | 88.0 | 0.3594 | -0.1744 | 0.0125 | 0.2691 | -0.0242 | -0.2640 | 0.0058 | 0.2743 |
| 63 | 91.0 | 0.3684 | -0.1811 | 0.0128 | 0.2790 | -0.0560 | -0.2647 | 0.0049 | 0.2712 |
| 64 | 94.0 | 0.3604 | -0.1762 | 0.0125 | 0.2711 | -0.0622 | -0.2657 | 0.0047 | 0.2710 |
| 65 | 97.0 | 0.3670 | -0.1801 | 0.0128 | 0.2775 | -0.0388 | -0.2670 | 0.0055 | 0.2741 |
| 66 | 100.0 | 0.3617 | -0.1772 | 0.0126 | 0.2724 | -0.0611 | -0.2678 | 0.0049 | 0.2721 |
| 67 | 105.0 | 0.1797 | -0.0920 | 0.0063 | 0.1393 | -0.2637 | -0.1786 | -0.0021 | 0.1301 |
| 68 | 110.0 | 0.1750 | -0.0827 | 0.0060 | 0.1280 | -0.2606 | -0.1715 | -0.0020 | 0.1192 |
| 69 | 115.0 | 0.1904 | -0.0961 | 0.0066 | 0.1462 | -0.2521 | -0.1716 | -0.0017 | 0.1194 |
| 70 | 120.0 | 0.1758 | -0.0841 | 0.0060 | 0.1299 | -0.2852 | -0.1721 | -0.0026 | 0.1160 |
| 71 | 125.0 | 0.1889 | -0.0943 | 0.0066 | 0.1443 | -0.2978 | -0.1728 | -0.0030 | 0.1150 |
| 72 | 130.0 | 0.1769 | -0.0856 | 0.0061 | 0.1318 | -0.2781 | -0.1739 | -0.0023 | 0.1177 |
| 73 | 135.0 | 0.1877 | -0.0927 | 0.0065 | 0.1426 | -0.2714 | -0.1749 | -0.0021 | 0.1188 |
| 74 | 140.0 | 0.1782 | -0.0867 | 0.0062 | 0.1331 | -0.3004 | -0.1754 | -0.0029 | 0.1159 |
| 75 | 145.0 | 0.1869 | -0.0917 | 0.0065 | 0.1413 | -0.3162 | -0.1761 | -0.0033 | 0.1146 |
| 76 | 150.0 | 0.1791 | -0.0872 | 0.0062 | 0.1340 | -0.2927 | -0.1773 | -0.0026 | 0.1176 |
| 77 | 155.0 | 0.1862 | -0.0906 | 0.0065 | 0.1404 | -0.2854 | -0.1783 | -0.0023 | 0.1189 |
| 78 | 160.0 | 0.1796 | -0.0877 | 0.0062 | 0.1348 | -0.3167 | -0.1788 | -0.0032 | 0.1157 |
| 79 | 165.0 | -0.0011 | -0.0030 | 0.0000 | 0.0023 | -0.4682 | -0.1091 | -0.0084 | 0.0063 |
| 80 | 170.0 | -0.0070 | 0.0070 | -0.0003 | -0.0095 | -0.4575 | -0.1022 | -0.0080 | -0.0023 |
| 81 | 175.0 | 0.0092 | -0.0069 | 0.0003 | 0.0092 | -0.4454 | -0.1018 | -0.0076 | -0.0018 |
| 82 | 180.0 | -0.0062 | 0.0051 | -0.0003 | -0.0078 | -0.4751 | -0.1015 | -0.0085 | -0.0051 |
| 83 | 185.0 | 0.0077 | -0.0052 | 0.0003 | 0.0070 | -0.4888 | -0.1013 | -0.0089 | -0.0067 |
| 84 | 190.0 | -0.0046 | 0.0035 | -0.0002 | -0.0058 | -0.4584 | -0.1016 | -0.0080 | -0.0032 |
| 85 | 195.0 | 0.0065 | -0.0037 | 0.0002 | 0.0055 | -0.4449 | -0.1018 | -0.0076 | -0.0017 |
| 86 | 200.0 | -0.0038 | 0.0025 | -0.0002 | -0.0043 | -0.4748 | -0.1015 | -0.0085 | -0.0051 |
| 87 | 210.0 | 0.0058 | -0.0030 | 0.0002 | 0.0046 | -0.4924 | -0.1012 | -0.0090 | -0.0071 |
| 88 | 220.0 | -0.0035 | 0.0019 | -0.0002 | -0.0038 | -0.4492 | -0.1018 | -0.0077 | -0.0022 |
| 89 | 230.0 | 0.0053 | -0.0026 | 0.0002 | 0.0040 | -0.4364 | -0.1019 | -0.0073 | -0.0008 |
| 90 | 240.0 | -0.0030 | 0.0014 | -0.0002 | -0.0032 | -0.4839 | -0.1013 | -0.0088 | -0.0061 |
| 91 | 250.0 | 0.0049 | -0.0026 | 0.0001 | 0.0035 | -0.4938 | -0.1012 | -0.0091 | -0.0072 |
| 92 | 260.0 | -0.0027 | 0.0008 | -0.0002 | -0.0029 | -0.4491 | -0.1018 | -0.0077 | -0.0022 |
| 93 | 270.0 | 0.0049 | -0.0021 | 0.0001 | 0.0030 | -0.4397 | -0.1019 | -0.0074 | -0.0011 |
| 94 | 280.0 | -0.0023 | 0.0007 | -0.0002 | -0.0027 | -0.4804 | -0.1014 | -0.0087 | -0.0057 |
| 95 | 290.0 | 0.0043 | -0.0018 | 0.0001 | 0.0024 | -0.4939 | -0.1012 | -0.0091 | -0.0073 |
| 96 | 300.0 | -0.0024 | 0.0006 | -0.0002 | -0.0025 | -0.4529 | -0.1017 | -0.0078 | -0.0026 |
| 97 | 320.0 | 0.0038 | -0.0014 | 0.0001 | 0.0021 | -0.4147 | -0.1022 | -0.0067 | 0.0017 |
| 98 | 340.0 | -0.0025 | 0.0006 | -0.0002 | -0.0024 | -0.4680 | -0.1015 | -0.0083 | -0.0043 |
| 99 | 360.0 | 0.0034 | -0.0013 | 0.0001 | 0.0020 | -0.5256 | -0.1008 | -0.0100 | -0.0108 |
| 100 | 380.0 | -0.0024 | 0.0006 | -0.0001 | -0.0022 | -0.5092 | -0.1010 | -0.0095 | -0.0090 |
| 101 | 400.0 | 0.0035 | -0.0012 | 0.0001 | 0.0019 | -0.4358 | -0.1019 | -0.0073 | -0.0007 |
| 102 | 420.0 | -0.0025 | 0.0001 | -0.0001 | -0.0021 | -0.4137 | -0.1022 | -0.0067 | 0.0018 |
| 103 | 440.0 | 0.0030 | -0.0013 | 0.0000 | 0.0018 | -0.4578 | -0.1017 | -0.0080 | -0.0032 |
| 104 | 460.0 | -0.0025 | 0.0000 | -0.0002 | -0.0018 | -0.5201 | -0.1009 | -0.0099 | -0.0102 |
| 105 | 480.0 | 0.0031 | -0.0013 | 0.0001 | 0.0017 | -0.5092 | -0.1010 | -0.0095 | -0.0090 |
| 106 | 500.0 | -0.0025 | 0.0000 | -0.0002 | -0.0018 | -0.4389 | -0.1019 | -0.0074 | -0.0010 |

表4. 1(3) 評価断面1の応力テンソル成分3

FINAS解と簡易計算値との比較 (コールドショック)

断面1の応力成分3

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|---------|--------|--------|--------|---------|--------|--------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.5728 | -0.1925 | 0.0167 | 0.3464 | 0.6754 | -0.2553 | 0.0203 | 0.4478 |
| 3 | 1.0 | 1.2472 | -0.5359 | 0.0371 | 0.8761 | 1.2885 | -0.5630 | 0.0385 | 0.9207 |
| 4 | 1.5 | 1.7131 | -0.7919 | 0.0508 | 1.2491 | 1.7834 | -0.8139 | 0.0532 | 1.3038 |
| 5 | 2.0 | 2.1205 | -0.9895 | 0.0631 | 1.5582 | 2.1688 | -1.0133 | 0.0649 | 1.6084 |
| 6 | 2.5 | 2.4193 | -1.1522 | 0.0720 | 1.7985 | 2.4723 | -1.1708 | 0.0741 | 1.8505 |
| 7 | 3.0 | 2.6756 | -1.2780 | 0.0797 | 1.9930 | 2.7182 | -1.2965 | 0.0814 | 2.0430 |
| 8 | 3.5 | 2.8646 | -1.3801 | 0.0853 | 2.1450 | 2.9141 | -1.3966 | 0.0872 | 2.1961 |
| 9 | 4.0 | 3.0267 | -1.4606 | 0.0902 | 2.2680 | 3.0620 | -1.4746 | 0.0916 | 2.3175 |
| 10 | 4.5 | 3.1459 | -1.5244 | 0.0938 | 2.3640 | 3.1765 | -1.5370 | 0.0951 | 2.4147 |
| 11 | 5.0 | 3.2490 | -1.5756 | 0.0968 | 2.4419 | 3.2707 | -1.5863 | 0.0980 | 2.4928 |
| 12 | 6.0 | 2.8077 | -1.4186 | 0.0839 | 2.1658 | 2.7920 | -1.4175 | 0.0835 | 2.1887 |
| 13 | 7.0 | 2.3902 | -1.1771 | 0.0713 | 1.8114 | 2.4221 | -1.2401 | 0.0722 | 1.9146 |
| 14 | 8.0 | 2.2032 | -1.0871 | 0.0658 | 1.6760 | 2.1874 | -1.1303 | 0.0648 | 1.7426 |
| 15 | 9.0 | 2.0428 | -1.0060 | 0.0609 | 1.5484 | 2.0348 | -1.0614 | 0.0602 | 1.6339 |
| 16 | 10.0 | 1.9690 | -0.9629 | 0.0588 | 1.4895 | 1.9369 | -1.0182 | 0.0573 | 1.5632 |
| 17 | 11.0 | 1.9043 | -0.9348 | 0.0568 | 1.4414 | 1.8755 | -0.9913 | 0.0555 | 1.5180 |
| 18 | 12.0 | 1.8769 | -0.9158 | 0.0560 | 1.4173 | 1.8363 | -0.9743 | 0.0545 | 1.4892 |
| 19 | 13.0 | 1.8498 | -0.9062 | 0.0551 | 1.3986 | 1.8091 | -0.9634 | 0.0539 | 1.4697 |
| 20 | 14.0 | 1.8407 | -0.8978 | 0.0549 | 1.3892 | 1.7883 | -0.9575 | 0.0534 | 1.4570 |
| 21 | 15.0 | 1.8285 | -0.8945 | 0.0545 | 1.3815 | 1.7727 | -0.9543 | 0.0530 | 1.4486 |
| 22 | 16.0 | 1.6519 | -0.8216 | 0.0493 | 1.2621 | 1.5533 | -0.8562 | 0.0466 | 1.2911 |
| 23 | 17.0 | 1.4929 | -0.7340 | 0.0445 | 1.1315 | 1.4098 | -0.7885 | 0.0424 | 1.1848 |
| 24 | 18.0 | 1.4209 | -0.6969 | 0.0424 | 1.0766 | 1.3180 | -0.7468 | 0.0399 | 1.1181 |
| 25 | 19.0 | 1.3582 | -0.6669 | 0.0405 | 1.0284 | 1.2589 | -0.7214 | 0.0383 | 1.0762 |
| 26 | 20.0 | 1.3310 | -0.6499 | 0.0397 | 1.0054 | 1.2203 | -0.7063 | 0.0373 | 1.0499 |
| 27 | 21.0 | 1.3048 | -0.6390 | 0.0389 | 0.9867 | 1.1884 | -0.6972 | 0.0364 | 1.0328 |
| 28 | 22.0 | 1.2955 | -0.6317 | 0.0387 | 0.9776 | 1.1724 | -0.6916 | 0.0361 | 1.0225 |
| 29 | 23.0 | 1.2837 | -0.6280 | 0.0383 | 0.9701 | 1.1608 | -0.6885 | 0.0359 | 1.0159 |
| 30 | 24.0 | 1.2811 | -0.6251 | 0.0382 | 0.9667 | 1.1447 | -0.6870 | 0.0355 | 1.0108 |
| 31 | 25.0 | 1.2754 | -0.6240 | 0.0380 | 0.9636 | 1.1308 | -0.6867 | 0.0352 | 1.0076 |
| 32 | 26.0 | 1.2172 | -0.5997 | 0.0363 | 0.9238 | 1.0609 | -0.6548 | 0.0332 | 0.9561 |
| 33 | 27.0 | 1.1634 | -0.5705 | 0.0346 | 0.8799 | 1.0123 | -0.6330 | 0.0319 | 0.9210 |
| 34 | 28.0 | 1.1402 | -0.5582 | 0.0340 | 0.8617 | 0.9731 | -0.6197 | 0.0308 | 0.8981 |
| 35 | 29.0 | 1.1186 | -0.5482 | 0.0333 | 0.8455 | 0.9486 | -0.6118 | 0.0302 | 0.8840 |
| 36 | 30.0 | 1.1100 | -0.5424 | 0.0331 | 0.8379 | 0.9387 | -0.6075 | 0.0299 | 0.8758 |
| 37 | 31.0 | 1.1006 | -0.5386 | 0.0328 | 0.8315 | 0.9284 | -0.6051 | 0.0297 | 0.8705 |
| 38 | 32.0 | 1.0983 | -0.5363 | 0.0327 | 0.8286 | 0.9132 | -0.6038 | 0.0293 | 0.8662 |
| 39 | 33.0 | 1.0939 | -0.5348 | 0.0326 | 0.8260 | 0.9033 | -0.6033 | 0.0291 | 0.8636 |
| 40 | 34.0 | 1.0933 | -0.5339 | 0.0325 | 0.8249 | 0.9021 | -0.6036 | 0.0292 | 0.8627 |
| 41 | 35.0 | 1.0909 | -0.5335 | 0.0325 | 0.8239 | 0.8979 | -0.6041 | 0.0291 | 0.8620 |
| 42 | 37.0 | 0.9862 | -0.4869 | 0.0293 | 0.7491 | 0.7473 | -0.5587 | 0.0248 | 0.7794 |
| 43 | 39.0 | 0.9299 | -0.4533 | 0.0276 | 0.7006 | 0.6906 | -0.5355 | 0.0234 | 0.7400 |
| 44 | 41.0 | 0.9223 | -0.4517 | 0.0274 | 0.6971 | 0.6441 | -0.5275 | 0.0222 | 0.7224 |
| 45 | 43.0 | 0.9093 | -0.4437 | 0.0270 | 0.6854 | 0.6147 | -0.5255 | 0.0214 | 0.7148 |
| 46 | 45.0 | 0.9123 | -0.4456 | 0.0271 | 0.6884 | 0.6037 | -0.5256 | 0.0212 | 0.7122 |
| 47 | 47.5 | 0.7837 | -0.3881 | 0.0232 | 0.5958 | 0.5224 | -0.4582 | 0.0187 | 0.6118 |
| 48 | 50.0 | 0.7383 | -0.3582 | 0.0219 | 0.5543 | 0.4132 | -0.4377 | 0.0157 | 0.5731 |
| 49 | 52.5 | 0.7338 | -0.3604 | 0.0218 | 0.5551 | 0.4060 | -0.4329 | 0.0155 | 0.5631 |
| 50 | 55.0 | 0.7267 | -0.3532 | 0.0215 | 0.5461 | 0.4255 | -0.4326 | 0.0162 | 0.5623 |
| 51 | 57.5 | 0.7288 | -0.3570 | 0.0216 | 0.5506 | 0.4151 | -0.4339 | 0.0160 | 0.5617 |
| 52 | 60.0 | 0.7263 | -0.3540 | 0.0216 | 0.5467 | 0.3774 | -0.4353 | 0.0150 | 0.5585 |
| 53 | 62.5 | 0.7277 | -0.3563 | 0.0216 | 0.5494 | 0.3616 | -0.4369 | 0.0146 | 0.5575 |
| 54 | 65.0 | 0.7265 | -0.3547 | 0.0216 | 0.5474 | 0.3726 | -0.4388 | 0.0151 | 0.5596 |

| | | | | | | | | | |
|-----|-------|---------|---------|---------|---------|---------|---------|---------|---------|
| 55 | 67.5 | 0.7272 | -0.3558 | 0.0216 | 0.5489 | 0.3813 | -0.4407 | 0.0154 | 0.5614 |
| 56 | 70.0 | 0.7270 | -0.3552 | 0.0217 | 0.5479 | 0.3578 | -0.4422 | 0.0148 | 0.5596 |
| 57 | 73.0 | 0.4486 | -0.2293 | 0.0134 | 0.3476 | 0.0525 | -0.3039 | 0.0059 | 0.3436 |
| 58 | 76.0 | 0.3666 | -0.1737 | 0.0109 | 0.2705 | 0.0085 | -0.2704 | 0.0048 | 0.2917 |
| 59 | 79.0 | 0.3757 | -0.1879 | 0.0112 | 0.2874 | -0.0142 | -0.2623 | 0.0043 | 0.2770 |
| 60 | 82.0 | 0.3576 | -0.1717 | 0.0106 | 0.2659 | -0.0512 | -0.2611 | 0.0033 | 0.2706 |
| 61 | 85.0 | 0.3705 | -0.1835 | 0.0110 | 0.2814 | -0.0363 | -0.2621 | 0.0039 | 0.2725 |
| 62 | 88.0 | 0.3594 | -0.1745 | 0.0107 | 0.2688 | -0.0231 | -0.2634 | 0.0043 | 0.2745 |
| 63 | 91.0 | 0.3683 | -0.1811 | 0.0110 | 0.2787 | -0.0549 | -0.2641 | 0.0034 | 0.2714 |
| 64 | 94.0 | 0.3604 | -0.1762 | 0.0107 | 0.2708 | -0.0611 | -0.2650 | 0.0033 | 0.2712 |
| 65 | 97.0 | 0.3670 | -0.1801 | 0.0109 | 0.2771 | -0.0377 | -0.2664 | 0.0041 | 0.2743 |
| 66 | 100.0 | 0.3617 | -0.1773 | 0.0107 | 0.2720 | -0.0599 | -0.2672 | 0.0035 | 0.2723 |
| 67 | 105.0 | 0.1797 | -0.0921 | 0.0054 | 0.1391 | -0.2626 | -0.1780 | -0.0026 | 0.1305 |
| 68 | 110.0 | 0.1749 | -0.0827 | 0.0052 | 0.1279 | -0.2594 | -0.1708 | -0.0024 | 0.1196 |
| 69 | 115.0 | 0.1903 | -0.0961 | 0.0056 | 0.1461 | -0.2509 | -0.1709 | -0.0021 | 0.1198 |
| 70 | 120.0 | 0.1757 | -0.0842 | 0.0052 | 0.1298 | -0.2840 | -0.1714 | -0.0030 | 0.1164 |
| 71 | 125.0 | 0.1889 | -0.0944 | 0.0056 | 0.1441 | -0.2966 | -0.1721 | -0.0033 | 0.1154 |
| 72 | 130.0 | 0.1769 | -0.0857 | 0.0052 | 0.1316 | -0.2768 | -0.1733 | -0.0027 | 0.1181 |
| 73 | 135.0 | 0.1876 | -0.0928 | 0.0055 | 0.1424 | -0.2702 | -0.1742 | -0.0025 | 0.1192 |
| 74 | 140.0 | 0.1782 | -0.0867 | 0.0052 | 0.1329 | -0.2991 | -0.1748 | -0.0033 | 0.1164 |
| 75 | 145.0 | 0.1869 | -0.0917 | 0.0055 | 0.1412 | -0.3150 | -0.1754 | -0.0037 | 0.1150 |
| 76 | 150.0 | 0.1790 | -0.0873 | 0.0053 | 0.1339 | -0.2914 | -0.1766 | -0.0029 | 0.1181 |
| 77 | 155.0 | 0.1862 | -0.0907 | 0.0055 | 0.1402 | -0.2841 | -0.1776 | -0.0027 | 0.1193 |
| 78 | 160.0 | 0.1795 | -0.0877 | 0.0053 | 0.1346 | -0.3154 | -0.1781 | -0.0035 | 0.1162 |
| 79 | 165.0 | -0.0012 | -0.0031 | -0.0001 | 0.0023 | -0.4669 | -0.1084 | -0.0080 | 0.0069 |
| 80 | 170.0 | -0.0071 | 0.0069 | -0.0003 | -0.0095 | -0.4562 | -0.1015 | -0.0076 | -0.0017 |
| 81 | 175.0 | 0.0092 | -0.0070 | 0.0002 | 0.0092 | -0.4441 | -0.1011 | -0.0072 | -0.0012 |
| 82 | 180.0 | -0.0063 | 0.0050 | -0.0003 | -0.0077 | -0.4738 | -0.1007 | -0.0081 | -0.0046 |
| 83 | 185.0 | 0.0077 | -0.0053 | 0.0002 | 0.0070 | -0.4875 | -0.1006 | -0.0085 | -0.0061 |
| 84 | 190.0 | -0.0046 | 0.0035 | -0.0002 | -0.0058 | -0.4571 | -0.1009 | -0.0076 | -0.0027 |
| 85 | 195.0 | 0.0065 | -0.0037 | 0.0001 | 0.0055 | -0.4436 | -0.1011 | -0.0072 | -0.0011 |
| 86 | 200.0 | -0.0038 | 0.0024 | -0.0002 | -0.0042 | -0.4736 | -0.1007 | -0.0081 | -0.0045 |
| 87 | 210.0 | 0.0058 | -0.0031 | 0.0001 | 0.0046 | -0.4912 | -0.1005 | -0.0086 | -0.0065 |
| 88 | 220.0 | -0.0035 | 0.0018 | -0.0002 | -0.0038 | -0.4480 | -0.1010 | -0.0073 | -0.0016 |
| 89 | 230.0 | 0.0053 | -0.0026 | 0.0001 | 0.0040 | -0.4351 | -0.1012 | -0.0069 | -0.0002 |
| 90 | 240.0 | -0.0031 | 0.0013 | -0.0002 | -0.0032 | -0.4827 | -0.1006 | -0.0083 | -0.0056 |
| 91 | 250.0 | 0.0048 | -0.0027 | 0.0000 | 0.0035 | -0.4925 | -0.1005 | -0.0086 | -0.0067 |
| 92 | 260.0 | -0.0027 | 0.0007 | -0.0002 | -0.0029 | -0.4479 | -0.1010 | -0.0073 | -0.0016 |
| 93 | 270.0 | 0.0048 | -0.0022 | 0.0000 | 0.0030 | -0.4384 | -0.1012 | -0.0070 | -0.0005 |
| 94 | 280.0 | -0.0023 | 0.0006 | -0.0002 | -0.0027 | -0.4791 | -0.1007 | -0.0082 | -0.0052 |
| 95 | 290.0 | 0.0043 | -0.0019 | 0.0000 | 0.0024 | -0.4926 | -0.1005 | -0.0086 | -0.0067 |
| 96 | 300.0 | -0.0025 | 0.0005 | -0.0002 | -0.0025 | -0.4516 | -0.1010 | -0.0074 | -0.0020 |
| 97 | 320.0 | 0.0037 | -0.0014 | 0.0000 | 0.0021 | -0.4134 | -0.1015 | -0.0063 | 0.0023 |
| 98 | 340.0 | -0.0026 | 0.0005 | -0.0002 | -0.0024 | -0.4667 | -0.1008 | -0.0079 | -0.0037 |
| 99 | 360.0 | 0.0033 | -0.0013 | 0.0000 | 0.0020 | -0.5243 | -0.1001 | -0.0096 | -0.0103 |
| 100 | 380.0 | -0.0025 | 0.0005 | -0.0002 | -0.0022 | -0.5079 | -0.1003 | -0.0091 | -0.0084 |
| 101 | 400.0 | 0.0034 | -0.0013 | 0.0000 | 0.0019 | -0.4345 | -0.1012 | -0.0069 | -0.0001 |
| 102 | 420.0 | -0.0025 | 0.0000 | -0.0002 | -0.0021 | -0.4125 | -0.1015 | -0.0062 | 0.0024 |
| 103 | 440.0 | 0.0029 | -0.0014 | 0.0000 | 0.0018 | -0.4565 | -0.1010 | -0.0076 | -0.0026 |
| 104 | 460.0 | -0.0025 | -0.0001 | -0.0002 | -0.0018 | -0.5188 | -0.1002 | -0.0094 | -0.0096 |
| 105 | 480.0 | 0.0030 | -0.0014 | 0.0000 | 0.0017 | -0.5080 | -0.1003 | -0.0091 | -0.0084 |
| 106 | 500.0 | -0.0025 | -0.0001 | -0.0002 | -0.0018 | -0.4376 | -0.1012 | -0.0070 | -0.0005 |

表4. 1(4) 評価断面1の応力テンソル成分4

FINAS解と簡易計算値との比較 (コールドショック)

断面1の応力成分4

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|---------|--------|--------|--------|---------|---------|---------|--------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 3 | 1.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 4 | 1.5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 5 | 2.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 6 | 2.5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 7 | 3.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 8 | 3.5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 9 | 4.0 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 10 | 4.5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0001 | 0.0000 | 0.0000 |
| 11 | 5.0 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0001 | 0.0000 | 0.0000 |
| 12 | 6.0 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0001 | 0.0000 | 0.0000 |
| 13 | 7.0 | -0.0001 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0001 | -0.0001 | 0.0000 |
| 14 | 8.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0001 | -0.0001 | 0.0000 |
| 15 | 9.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0001 | -0.0001 | 0.0000 |
| 16 | 10.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0001 | -0.0001 | 0.0000 |
| 17 | 11.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0001 | -0.0001 | 0.0000 |
| 18 | 12.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0001 | -0.0001 | 0.0000 |
| 19 | 13.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0001 | -0.0001 | 0.0000 |
| 20 | 14.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0001 | -0.0001 | 0.0000 |
| 21 | 15.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0001 | -0.0001 | 0.0000 |
| 22 | 16.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0001 | -0.0001 | 0.0000 |
| 23 | 17.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0001 | -0.0001 | 0.0000 |
| 24 | 18.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0001 | -0.0001 | 0.0000 |
| 25 | 19.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0001 | -0.0001 | 0.0000 |
| 26 | 20.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0002 | -0.0001 | 0.0000 |
| 27 | 21.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0002 | -0.0001 | 0.0000 |
| 28 | 22.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0002 | -0.0001 | 0.0000 |
| 29 | 23.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0002 | -0.0001 | 0.0000 |
| 30 | 24.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0002 | -0.0001 | 0.0000 |
| 31 | 25.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0002 | -0.0001 | 0.0000 |
| 32 | 26.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0002 | -0.0001 | 0.0000 |
| 33 | 27.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0002 | -0.0001 | 0.0000 |
| 34 | 28.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0002 | -0.0001 | 0.0000 |
| 35 | 29.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0002 | -0.0001 | 0.0000 |
| 36 | 30.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0002 | -0.0001 | 0.0000 |
| 37 | 31.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0002 | -0.0001 | 0.0000 |
| 38 | 32.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0002 | -0.0001 | 0.0000 |
| 39 | 33.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0002 | -0.0001 | 0.0000 |
| 40 | 34.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0002 | -0.0001 | 0.0000 |
| 41 | 35.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0002 | -0.0001 | 0.0000 |
| 42 | 37.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0002 | -0.0001 | 0.0000 |
| 43 | 39.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0002 | -0.0001 | 0.0000 |
| 44 | 41.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0002 | -0.0001 | 0.0000 |
| 45 | 43.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0002 | -0.0001 | 0.0000 |
| 46 | 45.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0002 | -0.0001 | 0.0000 |
| 47 | 47.5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0002 | -0.0002 | 0.0000 |
| 48 | 50.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0002 | -0.0002 | 0.0000 |
| 49 | 52.5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0001 | -0.0002 | -0.0002 | 0.0000 |
| 50 | 55.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0002 | -0.0002 | -0.0002 | 0.0000 |
| 51 | 57.5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0002 | -0.0003 | -0.0002 | 0.0000 |
| 52 | 60.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0002 | -0.0003 | -0.0002 | 0.0000 |
| 53 | 62.5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0002 | -0.0003 | -0.0002 | 0.0000 |
| 54 | 65.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | -0.0002 | -0.0003 | -0.0002 | 0.0000 |

表4. 2 (1) 評価断面2の応力テンソル成分1

FINAS解と簡易計算値との比較 (コールドショック)

断面2の応力成分1

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|--------|--------|--------|---------|---------|--------|--------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.0038 | 0.0016 | 0.0244 | 0.0170 | -0.0014 | 0.0010 | 0.0308 | 0.0205 |
| 3 | 1.0 | 0.0005 | 0.0060 | 0.0649 | 0.0428 | -0.0005 | 0.0050 | 0.0680 | 0.0445 |
| 4 | 1.5 | 0.0038 | 0.0100 | 0.0983 | 0.0648 | 0.0002 | 0.0069 | 0.1019 | 0.0672 |
| 5 | 2.0 | 0.0032 | 0.0130 | 0.1288 | 0.0856 | -0.0021 | 0.0095 | 0.1320 | 0.0877 |
| 6 | 2.5 | 0.0059 | 0.0157 | 0.1553 | 0.1038 | -0.0031 | 0.0110 | 0.1588 | 0.1061 |
| 7 | 3.0 | 0.0069 | 0.0177 | 0.1791 | 0.1207 | -0.0013 | 0.0108 | 0.1829 | 0.1230 |
| 8 | 3.5 | 0.0101 | 0.0194 | 0.2003 | 0.1359 | 0.0007 | 0.0101 | 0.2046 | 0.1383 |
| 9 | 4.0 | 0.0121 | 0.0207 | 0.2195 | 0.1499 | 0.0011 | 0.0094 | 0.2242 | 0.1520 |
| 10 | 4.5 | 0.0156 | 0.0219 | 0.2367 | 0.1627 | 0.0022 | 0.0078 | 0.2420 | 0.1646 |
| 11 | 5.0 | 0.0180 | 0.0230 | 0.2524 | 0.1745 | 0.0056 | 0.0059 | 0.2584 | 0.1766 |
| 12 | 6.0 | 0.0224 | 0.0217 | 0.2510 | 0.1762 | 0.0131 | -0.0008 | 0.2562 | 0.1770 |
| 13 | 7.0 | 0.0286 | 0.0183 | 0.2369 | 0.1702 | 0.0195 | -0.0108 | 0.2493 | 0.1729 |
| 14 | 8.0 | 0.0308 | 0.0168 | 0.2335 | 0.1695 | 0.0251 | -0.0210 | 0.2458 | 0.1702 |
| 15 | 9.0 | 0.0343 | 0.0157 | 0.2292 | 0.1682 | 0.0281 | -0.0290 | 0.2440 | 0.1688 |
| 16 | 10.0 | 0.0349 | 0.0146 | 0.2280 | 0.1684 | 0.0310 | -0.0359 | 0.2431 | 0.1681 |
| 17 | 11.0 | 0.0365 | 0.0143 | 0.2267 | 0.1682 | 0.0376 | -0.0417 | 0.2429 | 0.1681 |
| 18 | 12.0 | 0.0365 | 0.0137 | 0.2264 | 0.1687 | 0.0454 | -0.0462 | 0.2429 | 0.1685 |
| 19 | 13.0 | 0.0373 | 0.0135 | 0.2259 | 0.1687 | 0.0535 | -0.0502 | 0.2430 | 0.1692 |
| 20 | 14.0 | 0.0372 | 0.0131 | 0.2259 | 0.1691 | 0.0617 | -0.0548 | 0.2434 | 0.1699 |
| 21 | 15.0 | 0.0377 | 0.0127 | 0.2256 | 0.1690 | 0.0695 | -0.0592 | 0.2438 | 0.1706 |
| 22 | 16.0 | 0.0368 | 0.0119 | 0.2169 | 0.1632 | 0.0739 | -0.0637 | 0.2330 | 0.1640 |
| 23 | 17.0 | 0.0377 | 0.0104 | 0.2054 | 0.1558 | 0.0801 | -0.0677 | 0.2236 | 0.1579 |
| 24 | 18.0 | 0.0363 | 0.0098 | 0.1981 | 0.1506 | 0.0854 | -0.0708 | 0.2163 | 0.1526 |
| 25 | 19.0 | 0.0360 | 0.0095 | 0.1913 | 0.1456 | 0.0916 | -0.0734 | 0.2104 | 0.1483 |
| 26 | 20.0 | 0.0342 | 0.0094 | 0.1860 | 0.1416 | 0.0978 | -0.0757 | 0.2056 | 0.1445 |
| 27 | 21.0 | 0.0340 | 0.0092 | 0.1812 | 0.1377 | 0.1010 | -0.0784 | 0.2016 | 0.1410 |
| 28 | 22.0 | 0.0325 | 0.0091 | 0.1771 | 0.1343 | 0.1087 | -0.0809 | 0.1981 | 0.1385 |
| 29 | 23.0 | 0.0321 | 0.0091 | 0.1734 | 0.1311 | 0.1167 | -0.0835 | 0.1949 | 0.1365 |
| 30 | 24.0 | 0.0308 | 0.0090 | 0.1700 | 0.1282 | 0.1192 | -0.0860 | 0.1920 | 0.1342 |
| 31 | 25.0 | 0.0304 | 0.0089 | 0.1669 | 0.1253 | 0.1213 | -0.0886 | 0.1894 | 0.1319 |
| 32 | 26.0 | 0.0293 | 0.0085 | 0.1612 | 0.1208 | 0.1288 | -0.0914 | 0.1835 | 0.1278 |
| 33 | 27.0 | 0.0289 | 0.0083 | 0.1548 | 0.1158 | 0.1336 | -0.0941 | 0.1782 | 0.1237 |
| 34 | 28.0 | 0.0276 | 0.0081 | 0.1500 | 0.1119 | 0.1336 | -0.0963 | 0.1737 | 0.1197 |
| 35 | 29.0 | 0.0274 | 0.0081 | 0.1455 | 0.1081 | 0.1362 | -0.0984 | 0.1698 | 0.1163 |
| 36 | 30.0 | 0.0261 | 0.0081 | 0.1416 | 0.1048 | 0.1430 | -0.1003 | 0.1665 | 0.1136 |
| 37 | 31.0 | 0.0258 | 0.0082 | 0.1381 | 0.1016 | 0.1474 | -0.1024 | 0.1636 | 0.1110 |
| 38 | 32.0 | 0.0248 | 0.0080 | 0.1349 | 0.0987 | 0.1473 | -0.1043 | 0.1607 | 0.1081 |
| 39 | 33.0 | 0.0245 | 0.0082 | 0.1320 | 0.0960 | 0.1496 | -0.1062 | 0.1582 | 0.1057 |
| 40 | 34.0 | 0.0237 | 0.0085 | 0.1293 | 0.0935 | 0.1561 | -0.1081 | 0.1561 | 0.1038 |
| 41 | 35.0 | 0.0236 | 0.0085 | 0.1268 | 0.0910 | 0.1606 | -0.1101 | 0.1540 | 0.1019 |
| 42 | 37.0 | 0.0225 | 0.0081 | 0.1163 | 0.0826 | 0.1589 | -0.1146 | 0.1446 | 0.0935 |
| 43 | 39.0 | 0.0218 | 0.0080 | 0.1067 | 0.0748 | 0.1674 | -0.1192 | 0.1368 | 0.0871 |
| 44 | 41.0 | 0.0205 | 0.0084 | 0.1007 | 0.0692 | 0.1651 | -0.1224 | 0.1307 | 0.0808 |
| 45 | 43.0 | 0.0200 | 0.0083 | 0.0950 | 0.0640 | 0.1644 | -0.1254 | 0.1258 | 0.0757 |
| 46 | 45.0 | 0.0189 | 0.0088 | 0.0907 | 0.0597 | 0.1704 | -0.1287 | 0.1220 | 0.0720 |
| 47 | 47.5 | 0.0180 | 0.0084 | 0.0783 | 0.0499 | 0.2079 | -0.1336 | 0.1104 | 0.0648 |
| 48 | 50.0 | 0.0168 | 0.0081 | 0.0684 | 0.0417 | 0.1909 | -0.1378 | 0.1015 | 0.0551 |
| 49 | 52.5 | 0.0157 | 0.0084 | 0.0625 | 0.0360 | 0.2029 | -0.1406 | 0.0958 | 0.0499 |
| 50 | 55.0 | 0.0148 | 0.0087 | 0.0570 | 0.0308 | 0.2268 | -0.1433 | 0.0917 | 0.0472 |
| 51 | 57.5 | 0.0144 | 0.0091 | 0.0531 | 0.0268 | 0.2326 | -0.1469 | 0.0884 | 0.0435 |
| 52 | 60.0 | 0.0137 | 0.0092 | 0.0494 | 0.0231 | 0.2227 | -0.1503 | 0.0852 | 0.0387 |
| 53 | 62.5 | 0.0137 | 0.0094 | 0.0466 | 0.0202 | 0.2253 | -0.1537 | 0.0829 | 0.0356 |
| 54 | 65.0 | 0.0134 | 0.0097 | 0.0440 | 0.0174 | 0.2423 | -0.1571 | 0.0815 | 0.0344 |

| | | | | | | | | | |
|-----|-------|---------|--------|---------|---------|--------|---------|---------|---------|
| 55 | 67.5 | 0.0136 | 0.0096 | 0.0419 | 0.0151 | 0.2575 | -0.1604 | 0.0804 | 0.0333 |
| 56 | 70.0 | 0.0135 | 0.0099 | 0.0399 | 0.0130 | 0.2550 | -0.1638 | 0.0789 | 0.0307 |
| 57 | 73.0 | 0.0130 | 0.0084 | 0.0207 | -0.0009 | 0.2525 | -0.1686 | 0.0580 | 0.0151 |
| 58 | 76.0 | 0.0119 | 0.0077 | 0.0066 | -0.0116 | 0.2750 | -0.1709 | 0.0474 | 0.0078 |
| 59 | 79.0 | 0.0101 | 0.0082 | 0.0011 | -0.0171 | 0.2802 | -0.1723 | 0.0403 | 0.0018 |
| 60 | 82.0 | 0.0092 | 0.0084 | -0.0054 | -0.0227 | 0.2705 | -0.1741 | 0.0350 | -0.0041 |
| 61 | 85.0 | 0.0081 | 0.0090 | -0.0082 | -0.0258 | 0.2871 | -0.1759 | 0.0321 | -0.0062 |
| 62 | 88.0 | 0.0080 | 0.0090 | -0.0117 | -0.0290 | 0.3014 | -0.1778 | 0.0302 | -0.0076 |
| 63 | 91.0 | 0.0075 | 0.0094 | -0.0132 | -0.0308 | 0.2903 | -0.1798 | 0.0281 | -0.0109 |
| 64 | 94.0 | 0.0077 | 0.0096 | -0.0151 | -0.0327 | 0.2930 | -0.1817 | 0.0271 | -0.0124 |
| 65 | 97.0 | 0.0074 | 0.0097 | -0.0159 | -0.0337 | 0.3124 | -0.1837 | 0.0270 | -0.0119 |
| 66 | 100.0 | 0.0078 | 0.0098 | -0.0170 | -0.0348 | 0.3067 | -0.1857 | 0.0264 | -0.0135 |
| 67 | 105.0 | 0.0070 | 0.0090 | -0.0305 | -0.0445 | 0.3024 | -0.1902 | 0.0120 | -0.0245 |
| 68 | 110.0 | 0.0060 | 0.0090 | -0.0369 | -0.0498 | 0.3208 | -0.1919 | 0.0075 | -0.0274 |
| 69 | 115.0 | 0.0046 | 0.0093 | -0.0379 | -0.0513 | 0.3336 | -0.1932 | 0.0056 | -0.0285 |
| 70 | 120.0 | 0.0050 | 0.0093 | -0.0402 | -0.0531 | 0.3209 | -0.1949 | 0.0044 | -0.0309 |
| 71 | 125.0 | 0.0045 | 0.0094 | -0.0394 | -0.0528 | 0.3196 | -0.1966 | 0.0044 | -0.0315 |
| 72 | 130.0 | 0.0052 | 0.0095 | -0.0400 | -0.0530 | 0.3359 | -0.1984 | 0.0056 | -0.0298 |
| 73 | 135.0 | 0.0050 | 0.0094 | -0.0386 | -0.0521 | 0.3452 | -0.2002 | 0.0069 | -0.0285 |
| 74 | 140.0 | 0.0056 | 0.0093 | -0.0385 | -0.0517 | 0.3347 | -0.2021 | 0.0076 | -0.0289 |
| 75 | 145.0 | 0.0053 | 0.0093 | -0.0371 | -0.0506 | 0.3313 | -0.2040 | 0.0087 | -0.0285 |
| 76 | 150.0 | 0.0058 | 0.0092 | -0.0366 | -0.0499 | 0.3495 | -0.2059 | 0.0107 | -0.0258 |
| 77 | 155.0 | 0.0056 | 0.0091 | -0.0352 | -0.0487 | 0.3588 | -0.2078 | 0.0123 | -0.0240 |
| 78 | 160.0 | 0.0060 | 0.0090 | -0.0346 | -0.0480 | 0.3468 | -0.2097 | 0.0132 | -0.0243 |
| 79 | 165.0 | 0.0047 | 0.0079 | -0.0463 | -0.0557 | 0.3434 | -0.2116 | 0.0016 | -0.0324 |
| 80 | 170.0 | 0.0038 | 0.0074 | -0.0513 | -0.0594 | 0.3588 | -0.2112 | -0.0019 | -0.0336 |
| 81 | 175.0 | 0.0026 | 0.0076 | -0.0513 | -0.0595 | 0.3669 | -0.2111 | -0.0030 | -0.0337 |
| 82 | 180.0 | 0.0028 | 0.0074 | -0.0527 | -0.0603 | 0.3512 | -0.2112 | -0.0037 | -0.0351 |
| 83 | 185.0 | 0.0022 | 0.0074 | -0.0512 | -0.0590 | 0.3436 | -0.2112 | -0.0034 | -0.0353 |
| 84 | 190.0 | 0.0027 | 0.0074 | -0.0511 | -0.0585 | 0.3606 | -0.2113 | -0.0018 | -0.0325 |
| 85 | 195.0 | 0.0020 | 0.0074 | -0.0492 | -0.0568 | 0.3683 | -0.2115 | -0.0003 | -0.0305 |
| 86 | 200.0 | 0.0027 | 0.0073 | -0.0484 | -0.0557 | 0.3521 | -0.2116 | 0.0005 | -0.0307 |
| 87 | 210.0 | 0.0020 | 0.0071 | -0.0451 | -0.0524 | 0.3426 | -0.2120 | 0.0030 | -0.0286 |
| 88 | 220.0 | 0.0023 | 0.0067 | -0.0428 | -0.0497 | 0.3664 | -0.2123 | 0.0068 | -0.0231 |
| 89 | 230.0 | 0.0018 | 0.0064 | -0.0396 | -0.0464 | 0.3735 | -0.2127 | 0.0098 | -0.0193 |
| 90 | 240.0 | 0.0023 | 0.0062 | -0.0375 | -0.0439 | 0.3473 | -0.2130 | 0.0115 | -0.0191 |
| 91 | 250.0 | 0.0016 | 0.0059 | -0.0347 | -0.0409 | 0.3419 | -0.2133 | 0.0138 | -0.0169 |
| 92 | 260.0 | 0.0019 | 0.0055 | -0.0328 | -0.0386 | 0.3663 | -0.2137 | 0.0170 | -0.0118 |
| 93 | 270.0 | 0.0014 | 0.0052 | -0.0304 | -0.0360 | 0.3715 | -0.2140 | 0.0194 | -0.0088 |
| 94 | 280.0 | 0.0017 | 0.0048 | -0.0287 | -0.0339 | 0.3489 | -0.2143 | 0.0206 | -0.0088 |
| 95 | 290.0 | 0.0010 | 0.0044 | -0.0265 | -0.0316 | 0.3414 | -0.2146 | 0.0222 | -0.0074 |
| 96 | 300.0 | 0.0013 | 0.0041 | -0.0251 | -0.0299 | 0.3638 | -0.2148 | 0.0248 | -0.0031 |
| 97 | 320.0 | 0.0008 | 0.0036 | -0.0217 | -0.0261 | 0.3846 | -0.2153 | 0.0288 | 0.0027 |
| 98 | 340.0 | 0.0009 | 0.0031 | -0.0192 | -0.0231 | 0.3550 | -0.2158 | 0.0305 | 0.0029 |
| 99 | 360.0 | 0.0001 | 0.0026 | -0.0165 | -0.0201 | 0.3231 | -0.2162 | 0.0318 | 0.0026 |
| 100 | 380.0 | 0.0001 | 0.0023 | -0.0147 | -0.0179 | 0.3319 | -0.2165 | 0.0342 | 0.0060 |
| 101 | 400.0 | -0.0005 | 0.0020 | -0.0126 | -0.0155 | 0.3720 | -0.2168 | 0.0376 | 0.0123 |
| 102 | 420.0 | -0.0004 | 0.0015 | -0.0112 | -0.0138 | 0.3839 | -0.2171 | 0.0397 | 0.0154 |
| 103 | 440.0 | -0.0010 | 0.0013 | -0.0096 | -0.0120 | 0.3595 | -0.2174 | 0.0402 | 0.0147 |
| 104 | 460.0 | -0.0011 | 0.0010 | -0.0086 | -0.0107 | 0.3250 | -0.2176 | 0.0402 | 0.0127 |
| 105 | 480.0 | -0.0016 | 0.0009 | -0.0073 | -0.0093 | 0.3309 | -0.2178 | 0.0416 | 0.0146 |
| 106 | 500.0 | -0.0013 | 0.0009 | -0.0066 | -0.0083 | 0.3694 | -0.2180 | 0.0440 | 0.0197 |

表4. 2 (2) 評価断面2の応力テンソル成分2

FINAS解と簡易計算値との比較 (コールドショック)

断面2の応力成分2

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|---------|--------|--------|--------|---------|--------|--------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.7634 | -0.3120 | 0.0146 | 0.4712 | 0.9039 | -0.3981 | 0.0196 | 0.6001 |
| 3 | 1.0 | 1.8412 | -0.9174 | 0.0380 | 1.3030 | 1.9098 | -0.9688 | 0.0399 | 1.3704 |
| 4 | 1.5 | 2.7309 | -1.4680 | 0.0548 | 2.0131 | 2.8250 | -1.5180 | 0.0573 | 2.0864 |
| 5 | 2.0 | 3.5537 | -1.9659 | 0.0706 | 2.6599 | 3.6293 | -2.0214 | 0.0717 | 2.7305 |
| 6 | 2.5 | 4.2546 | -2.4247 | 0.0828 | 3.2346 | 4.3420 | -2.4832 | 0.0839 | 3.3084 |
| 7 | 3.0 | 4.8985 | -2.8417 | 0.0936 | 3.7547 | 4.9820 | -2.9071 | 0.0942 | 3.8293 |
| 8 | 3.5 | 5.4581 | -3.2257 | 0.1025 | 4.2230 | 5.5524 | -3.2974 | 0.1029 | 4.3002 |
| 9 | 4.0 | 5.9744 | -3.5790 | 0.1101 | 4.6497 | 6.0617 | -3.6575 | 0.1105 | 4.7280 |
| 10 | 4.5 | 6.4302 | -3.9055 | 0.1167 | 5.0383 | 6.5227 | -3.9902 | 0.1170 | 5.1185 |
| 11 | 5.0 | 6.8531 | -4.2082 | 0.1221 | 5.3950 | 6.9447 | -4.3008 | 0.1224 | 5.4771 |
| 12 | 6.0 | 6.7400 | -4.3512 | 0.1145 | 5.4521 | 6.7941 | -4.4350 | 0.1118 | 5.4954 |
| 13 | 7.0 | 6.3923 | -4.2192 | 0.1015 | 5.2025 | 6.5534 | -4.4011 | 0.1029 | 5.3563 |
| 14 | 8.0 | 6.2890 | -4.2210 | 0.0969 | 5.1623 | 6.4085 | -4.3916 | 0.0979 | 5.2727 |
| 15 | 9.0 | 6.1818 | -4.2054 | 0.0916 | 5.1001 | 6.3296 | -4.3950 | 0.0950 | 5.2268 |
| 16 | 10.0 | 6.1484 | -4.2109 | 0.0899 | 5.0887 | 6.2873 | -4.4097 | 0.0925 | 5.2039 |
| 17 | 11.0 | 6.1141 | -4.2179 | 0.0876 | 5.0760 | 6.2728 | -4.4275 | 0.0910 | 5.1941 |
| 18 | 12.0 | 6.1083 | -4.2246 | 0.0870 | 5.0769 | 6.2723 | -4.4454 | 0.0898 | 5.1918 |
| 19 | 13.0 | 6.0961 | -4.2323 | 0.0859 | 5.0756 | 6.2770 | -4.4632 | 0.0883 | 5.1930 |
| 20 | 14.0 | 6.0967 | -4.2359 | 0.0858 | 5.0773 | 6.2818 | -4.4803 | 0.0871 | 5.1948 |
| 21 | 15.0 | 6.0891 | -4.2389 | 0.0853 | 5.0754 | 6.2864 | -4.4923 | 0.0863 | 5.1951 |
| 22 | 16.0 | 5.8339 | -4.1166 | 0.0803 | 4.9009 | 5.9787 | -4.3364 | 0.0791 | 4.9667 |
| 23 | 17.0 | 5.5338 | -3.9317 | 0.0741 | 4.6579 | 5.7193 | -4.1822 | 0.0734 | 4.7580 |
| 24 | 18.0 | 5.3380 | -3.8011 | 0.0711 | 4.4987 | 5.5129 | -4.0500 | 0.0693 | 4.5857 |
| 25 | 19.0 | 5.1553 | -3.6785 | 0.0681 | 4.3478 | 5.3446 | -3.9357 | 0.0664 | 4.4407 |
| 26 | 20.0 | 5.0155 | -3.5729 | 0.0664 | 4.2262 | 5.2024 | -3.8355 | 0.0644 | 4.3160 |
| 27 | 21.0 | 4.8846 | -3.4777 | 0.0647 | 4.1146 | 5.0740 | -3.7466 | 0.0630 | 4.2065 |
| 28 | 22.0 | 4.7769 | -3.3901 | 0.0636 | 4.0171 | 4.9680 | -3.6663 | 0.0618 | 4.1097 |
| 29 | 23.0 | 4.6736 | -3.3102 | 0.0625 | 3.9267 | 4.8724 | -3.5929 | 0.0605 | 4.0222 |
| 30 | 24.0 | 4.5851 | -3.2357 | 0.0618 | 3.8450 | 4.7767 | -3.5252 | 0.0592 | 3.9416 |
| 31 | 25.0 | 4.4990 | -3.1668 | 0.0611 | 3.7683 | 4.6887 | -3.4619 | 0.0581 | 3.8666 |
| 32 | 26.0 | 4.3392 | -3.0618 | 0.0588 | 3.6401 | 4.5154 | -3.3486 | 0.0552 | 3.7214 |
| 33 | 27.0 | 4.1675 | -2.9400 | 0.0562 | 3.4940 | 4.3597 | -3.2402 | 0.0528 | 3.5874 |
| 34 | 28.0 | 4.0379 | -2.8408 | 0.0546 | 3.3807 | 4.2193 | -3.1432 | 0.0509 | 3.4698 |
| 35 | 29.0 | 3.9155 | -2.7481 | 0.0532 | 3.2742 | 4.1009 | -3.0562 | 0.0493 | 3.3658 |
| 36 | 30.0 | 3.8129 | -2.6649 | 0.0521 | 3.1817 | 4.0034 | -2.9776 | 0.0481 | 3.2727 |
| 37 | 31.0 | 3.7163 | -2.5877 | 0.0512 | 3.0957 | 3.9117 | -2.9056 | 0.0472 | 3.1877 |
| 38 | 32.0 | 3.6319 | -2.5166 | 0.0504 | 3.0175 | 3.8206 | -2.8390 | 0.0462 | 3.1092 |
| 39 | 33.0 | 3.5508 | -2.4503 | 0.0497 | 2.9446 | 3.7399 | -2.7773 | 0.0452 | 3.0367 |
| 40 | 34.0 | 3.4789 | -2.3882 | 0.0491 | 2.8774 | 3.6725 | -2.7202 | 0.0445 | 2.9697 |
| 41 | 35.0 | 3.4091 | -2.3303 | 0.0485 | 2.8139 | 3.6069 | -2.6669 | 0.0438 | 2.9070 |
| 42 | 37.0 | 3.1173 | -2.1349 | 0.0442 | 2.5763 | 3.3046 | -2.4958 | 0.0387 | 2.6811 |
| 43 | 39.0 | 2.8637 | -1.9418 | 0.0408 | 2.3523 | 3.0718 | -2.3264 | 0.0353 | 2.4757 |
| 44 | 41.0 | 2.6991 | -1.8079 | 0.0393 | 2.2051 | 2.8748 | -2.1905 | 0.0326 | 2.3128 |
| 45 | 43.0 | 2.5429 | -1.6800 | 0.0378 | 2.0625 | 2.7162 | -2.0768 | 0.0308 | 2.1779 |
| 46 | 45.0 | 2.4254 | -1.5780 | 0.0369 | 1.9534 | 2.5937 | -1.9790 | 0.0293 | 2.0632 |
| 47 | 47.5 | 2.0815 | -1.3503 | 0.0317 | 1.6745 | 2.2939 | -1.7401 | 0.0247 | 1.7638 |
| 48 | 50.0 | 1.8204 | -1.1452 | 0.0282 | 1.4399 | 2.0017 | -1.5610 | 0.0212 | 1.5467 |
| 49 | 52.5 | 1.6566 | -1.0119 | 0.0269 | 1.2939 | 1.8360 | -1.4203 | 0.0191 | 1.3836 |
| 50 | 55.0 | 1.5077 | -0.8853 | 0.0255 | 1.1547 | 1.7280 | -1.3081 | 0.0177 | 1.2548 |
| 51 | 57.5 | 1.3989 | -0.7925 | 0.0247 | 1.0551 | 1.6118 | -1.2172 | 0.0166 | 1.1474 |
| 52 | 60.0 | 1.2990 | -0.7064 | 0.0237 | 0.9609 | 1.4871 | -1.1409 | 0.0152 | 1.0552 |
| 53 | 62.5 | 1.2205 | -0.6387 | 0.0231 | 0.8885 | 1.4017 | -1.0785 | 0.0140 | 0.9790 |
| 54 | 65.0 | 1.1490 | -0.5764 | 0.0224 | 0.8206 | 1.3535 | -1.0265 | 0.0135 | 0.9152 |

| | | | | | | | | | |
|-----|-------|---------|---------|---------|---------|---------|---------|---------|---------|
| 55 | 67.5 | 1.0897 | -0.5249 | 0.0219 | 0.7654 | 1.3112 | -0.9815 | 0.0129 | 0.8588 |
| 56 | 70.0 | 1.0360 | -0.4777 | 0.0214 | 0.7141 | 1.2450 | -0.9421 | 0.0119 | 0.8074 |
| 57 | 73.0 | 0.4997 | -0.1629 | 0.0117 | 0.3038 | 0.6527 | -0.5853 | 0.0009 | 0.3434 |
| 58 | 76.0 | 0.1362 | 0.1145 | 0.0062 | -0.0205 | 0.3670 | -0.3572 | -0.0030 | 0.0717 |
| 59 | 79.0 | -0.0223 | 0.2441 | 0.0055 | -0.1586 | 0.1662 | -0.1978 | -0.0053 | -0.1100 |
| 60 | 82.0 | -0.1914 | 0.3852 | 0.0034 | -0.3170 | -0.0028 | -0.0824 | -0.0072 | -0.2420 |
| 61 | 85.0 | -0.2732 | 0.4574 | 0.0033 | -0.3906 | -0.0854 | 0.0011 | -0.0080 | -0.3363 |
| 62 | 88.0 | -0.3654 | 0.5342 | 0.0021 | -0.4774 | -0.1428 | 0.0614 | -0.0085 | -0.4057 |
| 63 | 91.0 | -0.4093 | 0.5749 | 0.0020 | -0.5180 | -0.2239 | 0.1056 | -0.0096 | -0.4592 |
| 64 | 94.0 | -0.4606 | 0.6167 | 0.0013 | -0.5662 | -0.2648 | 0.1367 | -0.0102 | -0.4978 |
| 65 | 97.0 | -0.4831 | 0.6390 | 0.0013 | -0.5878 | -0.2650 | 0.1572 | -0.0101 | -0.5240 |
| 66 | 100.0 | -0.5112 | 0.6614 | 0.0008 | -0.6140 | -0.3011 | 0.1712 | -0.0108 | -0.5448 |
| 67 | 105.0 | -0.8844 | 0.8879 | -0.0058 | -0.9042 | -0.7071 | 0.4142 | -0.0186 | -0.8620 |
| 68 | 110.0 | -1.0463 | 1.0256 | -0.0077 | -1.0574 | -0.8283 | 0.5253 | -0.0198 | -0.9908 |
| 69 | 115.0 | -1.0828 | 1.0589 | -0.0074 | -1.0887 | -0.8823 | 0.5795 | -0.0204 | -1.0528 |
| 70 | 120.0 | -1.1378 | 1.1033 | -0.0084 | -1.1412 | -0.9387 | 0.6008 | -0.0213 | -1.0811 |
| 71 | 125.0 | -1.1217 | 1.0931 | -0.0078 | -1.1258 | -0.9510 | 0.6018 | -0.0217 | -1.0868 |
| 72 | 130.0 | -1.1322 | 1.0993 | -0.0084 | -1.1360 | -0.9174 | 0.5899 | -0.0214 | -1.0772 |
| 73 | 135.0 | -1.1000 | 1.0749 | -0.0078 | -1.1063 | -0.8878 | 0.5706 | -0.0212 | -1.0603 |
| 74 | 140.0 | -1.0921 | 1.0646 | -0.0081 | -1.0988 | -0.8879 | 0.5476 | -0.0216 | -1.0406 |
| 75 | 145.0 | -1.0562 | 1.0370 | -0.0075 | -1.0659 | -0.8722 | 0.5215 | -0.0218 | -1.0172 |
| 76 | 150.0 | -1.0407 | 1.0202 | -0.0077 | -1.0508 | -0.8163 | 0.4931 | -0.0212 | -0.9898 |
| 77 | 155.0 | -1.0053 | 0.9929 | -0.0072 | -1.0186 | -0.7756 | 0.4644 | -0.0209 | -0.9626 |
| 78 | 160.0 | -0.9870 | 0.9736 | -0.0073 | -1.0003 | -0.7724 | 0.4363 | -0.0213 | -0.9376 |
| 79 | 165.0 | -1.3086 | 1.1560 | -0.0134 | -1.2425 | -1.0910 | 0.6299 | -0.0270 | -1.1859 |
| 80 | 170.0 | -1.4342 | 1.2609 | -0.0149 | -1.3608 | -1.1701 | 0.7091 | -0.0280 | -1.2748 |
| 81 | 175.0 | -1.4390 | 1.2679 | -0.0141 | -1.3630 | -1.1954 | 0.7398 | -0.0281 | -1.3072 |
| 82 | 180.0 | -1.4706 | 1.2908 | -0.0150 | -1.3927 | -1.2289 | 0.7429 | -0.0285 | -1.3116 |
| 83 | 185.0 | -1.4325 | 1.2615 | -0.0141 | -1.3566 | -1.2267 | 0.7294 | -0.0286 | -1.2975 |
| 84 | 190.0 | -1.4257 | 1.2513 | -0.0145 | -1.3497 | -1.1696 | 0.7050 | -0.0278 | -1.2700 |
| 85 | 195.0 | -1.3759 | 1.2121 | -0.0137 | -1.3035 | -1.1223 | 0.6750 | -0.0273 | -1.2372 |
| 86 | 200.0 | -1.3534 | 1.1882 | -0.0138 | -1.2815 | -1.1136 | 0.6428 | -0.0275 | -1.2035 |
| 87 | 210.0 | -1.2630 | 1.1133 | -0.0127 | -1.1975 | -1.0511 | 0.5737 | -0.0271 | -1.1298 |
| 88 | 220.0 | -1.1970 | 1.0514 | -0.0124 | -1.1341 | -0.9284 | 0.5025 | -0.0256 | -1.0514 |
| 89 | 230.0 | -1.1102 | 0.9798 | -0.0113 | -1.0536 | -0.8383 | 0.4346 | -0.0247 | -0.9777 |
| 90 | 240.0 | -1.0495 | 0.9227 | -0.0111 | -0.9949 | -0.8113 | 0.3714 | -0.0249 | -0.9114 |
| 91 | 250.0 | -0.9722 | 0.8590 | -0.0101 | -0.9234 | -0.7519 | 0.3112 | -0.0244 | -0.8469 |
| 92 | 260.0 | -0.9188 | 0.8078 | -0.0098 | -0.8710 | -0.6434 | 0.2533 | -0.0230 | -0.7829 |
| 93 | 270.0 | -0.8507 | 0.7522 | -0.0090 | -0.8085 | -0.5735 | 0.1999 | -0.0223 | -0.7250 |
| 94 | 280.0 | -0.8037 | 0.7069 | -0.0088 | -0.7623 | -0.5564 | 0.1509 | -0.0224 | -0.6738 |
| 95 | 290.0 | -0.7444 | 0.6583 | -0.0079 | -0.7075 | -0.5164 | 0.1046 | -0.0221 | -0.6243 |
| 96 | 300.0 | -0.7035 | 0.6186 | -0.0077 | -0.6673 | -0.4266 | 0.0599 | -0.0209 | -0.5747 |
| 97 | 320.0 | -0.6083 | 0.5390 | -0.0066 | -0.5791 | -0.3007 | -0.0189 | -0.0194 | -0.4884 |
| 98 | 340.0 | -0.5385 | 0.4739 | -0.0061 | -0.5112 | -0.2751 | -0.0860 | -0.0195 | -0.4181 |
| 99 | 360.0 | -0.4646 | 0.4124 | -0.0051 | -0.4429 | -0.2620 | -0.1458 | -0.0198 | -0.3559 |
| 100 | 380.0 | -0.4130 | 0.3629 | -0.0048 | -0.3918 | -0.1867 | -0.1985 | -0.0189 | -0.2986 |
| 101 | 400.0 | -0.3553 | 0.3155 | -0.0040 | -0.3386 | -0.0620 | -0.2469 | -0.0171 | -0.2437 |
| 102 | 420.0 | -0.3167 | 0.2774 | -0.0037 | -0.3002 | 0.0054 | -0.2880 | -0.0162 | -0.1987 |
| 103 | 440.0 | -0.2711 | 0.2410 | -0.0031 | -0.2588 | 0.0024 | -0.3223 | -0.0165 | -0.1634 |
| 104 | 460.0 | -0.2431 | 0.2124 | -0.0030 | -0.2301 | -0.0230 | -0.3523 | -0.0172 | -0.1334 |
| 105 | 480.0 | -0.2074 | 0.1841 | -0.0024 | -0.1977 | 0.0181 | -0.3794 | -0.0167 | -0.1038 |
| 106 | 500.0 | -0.1866 | 0.1625 | -0.0023 | -0.1763 | 0.1140 | -0.4051 | -0.0152 | -0.0735 |

表4. 2(3) 評価断面2の応力テンソル成分3

F I N A S解と簡易計算値との比較 (コールドショック)

断面2の応力成分3

| ステップ | 時間(S) | F I N A S解 | | | | 簡易計算値 | | | |
|------|-------|------------|---------|---------|--------|--------|---------|---------|--------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.5855 | -0.2524 | -0.0163 | 0.3704 | 0.6870 | -0.3257 | -0.0163 | 0.4781 |
| 3 | 1.0 | 1.2899 | -0.7335 | -0.0691 | 0.9804 | 1.3266 | -0.7762 | -0.0739 | 1.0299 |
| 4 | 1.5 | 1.7914 | -1.1557 | -0.1416 | 1.4527 | 1.8562 | -1.1997 | -0.1450 | 1.5117 |
| 5 | 2.0 | 2.2408 | -1.5263 | -0.2118 | 1.8675 | 2.2863 | -1.5758 | -0.2167 | 1.9233 |
| 6 | 2.5 | 2.5891 | -1.8560 | -0.2789 | 2.2164 | 2.6442 | -1.9080 | -0.2837 | 2.2746 |
| 7 | 3.0 | 2.9012 | -2.1426 | -0.3392 | 2.5187 | 2.9505 | -2.2012 | -0.3448 | 2.5767 |
| 8 | 3.5 | 3.1505 | -2.3960 | -0.3936 | 2.7777 | 3.2093 | -2.4598 | -0.3991 | 2.8376 |
| 9 | 4.0 | 3.3757 | -2.6191 | -0.4422 | 3.0038 | 3.4259 | -2.6887 | -0.4474 | 3.0639 |
| 10 | 4.5 | 3.5588 | -2.8172 | -0.4856 | 3.2005 | 3.6125 | -2.8917 | -0.4905 | 3.2615 |
| 11 | 5.0 | 3.7257 | -2.9938 | -0.5248 | 3.3740 | 3.7774 | -3.0750 | -0.5291 | 3.4360 |
| 12 | 6.0 | 3.3889 | -2.9773 | -0.5624 | 3.2324 | 3.4195 | -3.0498 | -0.5638 | 3.2630 |
| 13 | 7.0 | 3.0446 | -2.7628 | -0.5468 | 2.9306 | 3.1411 | -2.9127 | -0.5476 | 3.0451 |
| 14 | 8.0 | 2.9109 | -2.6851 | -0.5288 | 2.8316 | 2.9704 | -2.8230 | -0.5296 | 2.9036 |
| 15 | 9.0 | 2.7800 | -2.6154 | -0.5223 | 2.7262 | 2.8637 | -2.7681 | -0.5190 | 2.8120 |
| 16 | 10.0 | 2.7214 | -2.5833 | -0.5184 | 2.6818 | 2.7949 | -2.7417 | -0.5149 | 2.7537 |
| 17 | 11.0 | 2.6640 | -2.5645 | -0.5202 | 2.6430 | 2.7565 | -2.7306 | -0.5139 | 2.7165 |
| 18 | 12.0 | 2.6385 | -2.5546 | -0.5220 | 2.6251 | 2.7351 | -2.7289 | -0.5152 | 2.6937 |
| 19 | 13.0 | 2.6111 | -2.5511 | -0.5253 | 2.6099 | 2.7240 | -2.7336 | -0.5173 | 2.6805 |
| 20 | 14.0 | 2.6008 | -2.5479 | -0.5273 | 2.6025 | 2.7185 | -2.7416 | -0.5184 | 2.6727 |
| 21 | 15.0 | 2.5874 | -2.5468 | -0.5288 | 2.5954 | 2.7169 | -2.7476 | -0.5187 | 2.6674 |
| 22 | 16.0 | 2.4039 | -2.4471 | -0.5194 | 2.4619 | 2.5032 | -2.6205 | -0.5059 | 2.4933 |
| 23 | 17.0 | 2.2321 | -2.3042 | -0.4963 | 2.2969 | 2.3605 | -2.5023 | -0.4825 | 2.3553 |
| 24 | 18.0 | 2.1449 | -2.2118 | -0.4732 | 2.2072 | 2.2640 | -2.4069 | -0.4594 | 2.2523 |
| 25 | 19.0 | 2.0643 | -2.1300 | -0.4542 | 2.1241 | 2.1970 | -2.3303 | -0.4386 | 2.1738 |
| 26 | 20.0 | 2.0185 | -2.0649 | -0.4359 | 2.0674 | 2.1496 | -2.2688 | -0.4197 | 2.1132 |
| 27 | 21.0 | 1.9755 | -2.0088 | -0.4195 | 2.0171 | 2.1103 | -2.2177 | -0.4018 | 2.0651 |
| 28 | 22.0 | 1.9509 | -1.9584 | -0.4032 | 1.9780 | 2.0886 | -2.1739 | -0.3850 | 2.0271 |
| 29 | 23.0 | 1.9265 | -1.9131 | -0.3872 | 1.9428 | 2.0732 | -2.1356 | -0.3689 | 1.9959 |
| 30 | 24.0 | 1.9130 | -1.8705 | -0.3710 | 1.9134 | 2.0545 | -2.1010 | -0.3530 | 1.9692 |
| 31 | 25.0 | 1.8988 | -1.8309 | -0.3547 | 1.8861 | 2.0402 | -2.0679 | -0.3366 | 1.9451 |
| 32 | 26.0 | 1.8322 | -1.7608 | -0.3351 | 1.8189 | 1.9699 | -1.9929 | -0.3158 | 1.8670 |
| 33 | 27.0 | 1.7689 | -1.6775 | -0.3111 | 1.7431 | 1.9206 | -1.9225 | -0.2918 | 1.8024 |
| 34 | 28.0 | 1.7370 | -1.6131 | -0.2875 | 1.6940 | 1.8804 | -1.8615 | -0.2685 | 1.7507 |
| 35 | 29.0 | 1.7068 | -1.5538 | -0.2655 | 1.6483 | 1.8554 | -1.8085 | -0.2465 | 1.7087 |
| 36 | 30.0 | 1.6906 | -1.5018 | -0.2442 | 1.6131 | 1.8455 | -1.7617 | -0.2253 | 1.6738 |
| 37 | 31.0 | 1.6752 | -1.4536 | -0.2238 | 1.5809 | 1.8365 | -1.7194 | -0.2047 | 1.6436 |
| 38 | 32.0 | 1.6676 | -1.4092 | -0.2037 | 1.5534 | 1.8238 | -1.6803 | -0.1847 | 1.6171 |
| 39 | 33.0 | 1.6595 | -1.3672 | -0.1842 | 1.5282 | 1.8176 | -1.6441 | -0.1653 | 1.5937 |
| 40 | 34.0 | 1.6569 | -1.3273 | -0.1649 | 1.5058 | 1.8212 | -1.6103 | -0.1461 | 1.5730 |
| 41 | 35.0 | 1.6534 | -1.2895 | -0.1459 | 1.4847 | 1.8230 | -1.5780 | -0.1271 | 1.5538 |
| 42 | 37.0 | 1.5437 | -1.1491 | -0.1001 | 1.3603 | 1.6862 | -1.4593 | -0.0886 | 1.4317 |
| 43 | 39.0 | 1.4799 | -1.0135 | -0.0497 | 1.2558 | 1.6343 | -1.3456 | -0.0413 | 1.3409 |
| 44 | 41.0 | 1.4655 | -0.9261 | -0.0073 | 1.2050 | 1.5956 | -1.2587 | 0.0016 | 1.2792 |
| 45 | 43.0 | 1.4489 | -0.8404 | 0.0320 | 1.1512 | 1.5761 | -1.1867 | 0.0410 | 1.2331 |
| 46 | 45.0 | 1.4527 | -0.7716 | 0.0693 | 1.1181 | 1.5784 | -1.1236 | 0.0781 | 1.1968 |
| 47 | 47.5 | 1.3211 | -0.6034 | 0.1248 | 0.9689 | 1.5051 | -0.9504 | 0.1366 | 1.0368 |
| 48 | 50.0 | 1.2691 | -0.4585 | 0.1830 | 0.8648 | 1.4093 | -0.8289 | 0.1909 | 0.9433 |
| 49 | 52.5 | 1.2605 | -0.3707 | 0.2286 | 0.8174 | 1.4109 | -0.7363 | 0.2392 | 0.8860 |
| 50 | 55.0 | 1.2539 | -0.2827 | 0.2714 | 0.7668 | 1.4452 | -0.6618 | 0.2826 | 0.8455 |
| 51 | 57.5 | 1.2623 | -0.2163 | 0.3109 | 0.7380 | 1.4519 | -0.5990 | 0.3229 | 0.8125 |
| 52 | 60.0 | 1.2682 | -0.1505 | 0.3475 | 0.7059 | 1.4349 | -0.5434 | 0.3604 | 0.7840 |
| 53 | 62.5 | 1.2806 | -0.0965 | 0.3818 | 0.6851 | 1.4442 | -0.4953 | 0.3954 | 0.7619 |
| 54 | 65.0 | 1.2910 | -0.0441 | 0.4136 | 0.6625 | 1.4795 | -0.4531 | 0.4281 | 0.7443 |

| | | | | | | | | | |
|-----|-------|--------|--------|--------|---------|--------|---------|--------|---------|
| 55 | 67.5 | 1.3043 | 0.0009 | 0.4434 | 0.6465 | 1.5129 | -0.4148 | 0.4590 | 0.7288 |
| 56 | 70.0 | 1.3166 | 0.0440 | 0.4712 | 0.6298 | 1.5156 | -0.3798 | 0.4879 | 0.7139 |
| 57 | 73.0 | 1.0331 | 0.2918 | 0.5310 | 0.3680 | 1.2203 | -0.1015 | 0.5600 | 0.4257 |
| 58 | 76.0 | 0.9286 | 0.4859 | 0.5954 | 0.2084 | 1.1626 | 0.0494 | 0.6159 | 0.3012 |
| 59 | 79.0 | 0.9192 | 0.5581 | 0.6331 | 0.1721 | 1.1343 | 0.1479 | 0.6593 | 0.2335 |
| 60 | 82.0 | 0.8933 | 0.6512 | 0.6699 | 0.1067 | 1.1008 | 0.2207 | 0.6967 | 0.1892 |
| 61 | 85.0 | 0.9077 | 0.6985 | 0.7015 | 0.0932 | 1.1248 | 0.2765 | 0.7297 | 0.1607 |
| 62 | 88.0 | 0.9011 | 0.7561 | 0.7288 | 0.0575 | 1.1517 | 0.3201 | 0.7588 | 0.1410 |
| 63 | 91.0 | 0.9178 | 0.7886 | 0.7529 | 0.0514 | 1.1372 | 0.3550 | 0.7838 | 0.1252 |
| 64 | 94.0 | 0.9182 | 0.8253 | 0.7730 | 0.0310 | 1.1485 | 0.3827 | 0.8056 | 0.1143 |
| 65 | 97.0 | 0.9337 | 0.8474 | 0.7909 | 0.0286 | 1.1887 | 0.4039 | 0.8246 | 0.1078 |
| 66 | 100.0 | 0.9369 | 0.8711 | 0.8054 | 0.0170 | 1.1849 | 0.4210 | 0.8409 | 0.1018 |
| 67 | 105.0 | 0.7487 | 1.0478 | 0.8500 | -0.1637 | 0.9883 | 0.6093 | 0.8924 | -0.0914 |
| 68 | 110.0 | 0.7265 | 1.1357 | 0.8847 | -0.2244 | 0.9870 | 0.6791 | 0.9230 | -0.1418 |
| 69 | 115.0 | 0.7378 | 1.1508 | 0.8980 | -0.2226 | 1.0014 | 0.7145 | 0.9435 | -0.1611 |
| 70 | 120.0 | 0.7282 | 1.1880 | 0.9133 | -0.2498 | 0.9808 | 0.7321 | 0.9574 | -0.1696 |
| 71 | 125.0 | 0.7462 | 1.1839 | 0.9189 | -0.2357 | 0.9817 | 0.7375 | 0.9657 | -0.1707 |
| 72 | 130.0 | 0.7390 | 1.1946 | 0.9217 | -0.2470 | 1.0131 | 0.7342 | 0.9695 | -0.1664 |
| 73 | 135.0 | 0.7537 | 1.1806 | 0.9206 | -0.2305 | 1.0309 | 0.7253 | 0.9699 | -0.1601 |
| 74 | 140.0 | 0.7464 | 1.1780 | 0.9170 | -0.2346 | 1.0133 | 0.7129 | 0.9676 | -0.1539 |
| 75 | 145.0 | 0.7570 | 1.1605 | 0.9118 | -0.2187 | 1.0070 | 0.6975 | 0.9633 | -0.1462 |
| 76 | 150.0 | 0.7496 | 1.1513 | 0.9047 | -0.2189 | 1.0376 | 0.6794 | 0.9575 | -0.1363 |
| 77 | 155.0 | 0.7567 | 1.1325 | 0.8973 | -0.2044 | 1.0516 | 0.6602 | 0.9506 | -0.1269 |
| 78 | 160.0 | 0.7491 | 1.1200 | 0.8885 | -0.2026 | 1.0275 | 0.6407 | 0.9426 | -0.1192 |
| 79 | 165.0 | 0.5467 | 1.2534 | 0.9035 | -0.3681 | 0.8530 | 0.7769 | 0.9660 | -0.2735 |
| 80 | 170.0 | 0.5091 | 1.3060 | 0.9131 | -0.4184 | 0.8375 | 0.8110 | 0.9685 | -0.3102 |
| 81 | 175.0 | 0.5080 | 1.2912 | 0.9046 | -0.4077 | 0.8342 | 0.8188 | 0.9656 | -0.3211 |
| 82 | 180.0 | 0.4849 | 1.3025 | 0.9004 | -0.4284 | 0.7970 | 0.8127 | 0.9584 | -0.3228 |
| 83 | 185.0 | 0.4921 | 1.2748 | 0.8886 | -0.4078 | 0.7775 | 0.7980 | 0.9477 | -0.3187 |
| 84 | 190.0 | 0.4732 | 1.2647 | 0.8756 | -0.4142 | 0.8011 | 0.7765 | 0.9343 | -0.3095 |
| 85 | 195.0 | 0.4785 | 1.2318 | 0.8598 | -0.3926 | 0.8084 | 0.7516 | 0.9188 | -0.2991 |
| 86 | 200.0 | 0.4613 | 1.2115 | 0.8427 | -0.3925 | 0.7736 | 0.7250 | 0.9019 | -0.2895 |
| 87 | 210.0 | 0.4563 | 1.1480 | 0.8063 | -0.3608 | 0.7432 | 0.6676 | 0.8656 | -0.2672 |
| 88 | 220.0 | 0.4307 | 1.0939 | 0.7678 | -0.3468 | 0.7694 | 0.6068 | 0.8276 | -0.2420 |
| 89 | 230.0 | 0.4227 | 1.0303 | 0.7297 | -0.3169 | 0.7654 | 0.5473 | 0.7893 | -0.2191 |
| 90 | 240.0 | 0.3964 | 0.9778 | 0.6916 | -0.3039 | 0.7029 | 0.4907 | 0.7517 | -0.2000 |
| 91 | 250.0 | 0.3868 | 0.9188 | 0.6552 | -0.2774 | 0.6762 | 0.4354 | 0.7149 | -0.1805 |
| 92 | 260.0 | 0.3610 | 0.8696 | 0.6194 | -0.2656 | 0.7015 | 0.3811 | 0.6791 | -0.1598 |
| 93 | 270.0 | 0.3512 | 0.8164 | 0.5857 | -0.2425 | 0.6933 | 0.3302 | 0.6448 | -0.1419 |
| 94 | 280.0 | 0.3272 | 0.7716 | 0.5528 | -0.2321 | 0.6372 | 0.2825 | 0.6118 | -0.1273 |
| 95 | 290.0 | 0.3172 | 0.7237 | 0.5222 | -0.2118 | 0.6077 | 0.2369 | 0.5803 | -0.1126 |
| 96 | 300.0 | 0.2946 | 0.6835 | 0.4922 | -0.2030 | 0.6309 | 0.1925 | 0.5503 | -0.0964 |
| 97 | 320.0 | 0.2708 | 0.6028 | 0.4377 | -0.1731 | 0.6376 | 0.1129 | 0.4955 | -0.0692 |
| 98 | 340.0 | 0.2366 | 0.5346 | 0.3879 | -0.1555 | 0.5588 | 0.0435 | 0.4462 | -0.0492 |
| 99 | 360.0 | 0.2172 | 0.4700 | 0.3441 | -0.1319 | 0.4778 | -0.0193 | 0.4011 | -0.0318 |
| 100 | 380.0 | 0.1878 | 0.4165 | 0.3042 | -0.1193 | 0.4707 | -0.0751 | 0.3618 | -0.0140 |
| 101 | 400.0 | 0.1724 | 0.3653 | 0.2692 | -0.1003 | 0.5201 | -0.1268 | 0.3260 | 0.0046 |
| 102 | 420.0 | 0.1478 | 0.3231 | 0.2375 | -0.0915 | 0.5224 | -0.1713 | 0.2945 | 0.0188 |
| 103 | 440.0 | 0.1365 | 0.2830 | 0.2100 | -0.0764 | 0.4633 | -0.2092 | 0.2666 | 0.0283 |
| 104 | 460.0 | 0.1155 | 0.2503 | 0.1848 | -0.0702 | 0.3883 | -0.2428 | 0.2414 | 0.0357 |
| 105 | 480.0 | 0.1071 | 0.2188 | 0.1633 | -0.0580 | 0.3853 | -0.2731 | 0.2196 | 0.0450 |
| 106 | 500.0 | 0.0898 | 0.1937 | 0.1435 | -0.0540 | 0.4406 | -0.3016 | 0.1999 | 0.0559 |

表4. 2(4) 評価断面2の応力テンソル成分4

F I N A S解と簡易計算値との比較 (コールドショック)

断面2の応力成分4

| ステップ | 時間(S) | F I N A S解 | | | | 簡易計算値 | | | |
|------|-------|------------|--------|---------|---------|---------|---------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.0093 | 0.0024 | 0.0067 | -0.0034 | -0.0107 | 0.0031 | 0.0079 | -0.0043 |
| 3 | 1.0 | -0.0187 | 0.0071 | 0.0226 | -0.0069 | -0.0190 | 0.0075 | 0.0240 | -0.0065 |
| 4 | 1.5 | -0.0250 | 0.0113 | 0.0408 | -0.0078 | -0.0263 | 0.0114 | 0.0421 | -0.0071 |
| 5 | 2.0 | -0.0313 | 0.0150 | 0.0588 | -0.0082 | -0.0326 | 0.0149 | 0.0602 | -0.0067 |
| 6 | 2.5 | -0.0358 | 0.0185 | 0.0761 | -0.0078 | -0.0377 | 0.0180 | 0.0777 | -0.0059 |
| 7 | 3.0 | -0.0399 | 0.0215 | 0.0925 | -0.0071 | -0.0420 | 0.0208 | 0.0943 | -0.0048 |
| 8 | 3.5 | -0.0429 | 0.0243 | 0.1080 | -0.0061 | -0.0455 | 0.0234 | 0.1100 | -0.0034 |
| 9 | 4.0 | -0.0457 | 0.0269 | 0.1226 | -0.0050 | -0.0487 | 0.0258 | 0.1248 | -0.0018 |
| 10 | 4.5 | -0.0477 | 0.0292 | 0.1363 | -0.0037 | -0.0518 | 0.0279 | 0.1388 | -0.0001 |
| 11 | 5.0 | -0.0495 | 0.0314 | 0.1492 | -0.0023 | -0.0547 | 0.0299 | 0.1520 | 0.0018 |
| 12 | 6.0 | -0.0429 | 0.0321 | 0.1628 | 0.0036 | -0.0503 | 0.0298 | 0.1656 | 0.0097 |
| 13 | 7.0 | -0.0377 | 0.0308 | 0.1645 | 0.0077 | -0.0475 | 0.0288 | 0.1696 | 0.0151 |
| 14 | 8.0 | -0.0349 | 0.0306 | 0.1663 | 0.0094 | -0.0469 | 0.0279 | 0.1721 | 0.0188 |
| 15 | 9.0 | -0.0324 | 0.0303 | 0.1680 | 0.0112 | -0.0475 | 0.0273 | 0.1742 | 0.0217 |
| 16 | 10.0 | -0.0313 | 0.0301 | 0.1696 | 0.0122 | -0.0483 | 0.0268 | 0.1764 | 0.0245 |
| 17 | 11.0 | -0.0302 | 0.0300 | 0.1710 | 0.0131 | -0.0500 | 0.0263 | 0.1782 | 0.0267 |
| 18 | 12.0 | -0.0299 | 0.0300 | 0.1722 | 0.0137 | -0.0521 | 0.0259 | 0.1799 | 0.0287 |
| 19 | 13.0 | -0.0293 | 0.0299 | 0.1732 | 0.0142 | -0.0544 | 0.0255 | 0.1813 | 0.0305 |
| 20 | 14.0 | -0.0293 | 0.0299 | 0.1738 | 0.0145 | -0.0566 | 0.0251 | 0.1825 | 0.0322 |
| 21 | 15.0 | -0.0291 | 0.0299 | 0.1742 | 0.0147 | -0.0587 | 0.0246 | 0.1834 | 0.0338 |
| 22 | 16.0 | -0.0264 | 0.0290 | 0.1713 | 0.0157 | -0.0580 | 0.0229 | 0.1799 | 0.0362 |
| 23 | 17.0 | -0.0242 | 0.0275 | 0.1654 | 0.0161 | -0.0581 | 0.0213 | 0.1747 | 0.0377 |
| 24 | 18.0 | -0.0230 | 0.0266 | 0.1599 | 0.0157 | -0.0585 | 0.0200 | 0.1696 | 0.0388 |
| 25 | 19.0 | -0.0219 | 0.0257 | 0.1547 | 0.0153 | -0.0595 | 0.0188 | 0.1647 | 0.0397 |
| 26 | 20.0 | -0.0214 | 0.0250 | 0.1498 | 0.0146 | -0.0610 | 0.0177 | 0.1602 | 0.0404 |
| 27 | 21.0 | -0.0208 | 0.0244 | 0.1453 | 0.0140 | -0.0626 | 0.0167 | 0.1558 | 0.0407 |
| 28 | 22.0 | -0.0205 | 0.0238 | 0.1409 | 0.0133 | -0.0648 | 0.0157 | 0.1516 | 0.0408 |
| 29 | 23.0 | -0.0202 | 0.0233 | 0.1367 | 0.0125 | -0.0672 | 0.0148 | 0.1475 | 0.0409 |
| 30 | 24.0 | -0.0200 | 0.0229 | 0.1326 | 0.0116 | -0.0694 | 0.0140 | 0.1436 | 0.0409 |
| 31 | 25.0 | -0.0198 | 0.0225 | 0.1287 | 0.0108 | -0.0714 | 0.0132 | 0.1398 | 0.0408 |
| 32 | 26.0 | -0.0188 | 0.0218 | 0.1239 | 0.0103 | -0.0726 | 0.0121 | 0.1348 | 0.0410 |
| 33 | 27.0 | -0.0179 | 0.0210 | 0.1183 | 0.0096 | -0.0740 | 0.0111 | 0.1295 | 0.0408 |
| 34 | 28.0 | -0.0174 | 0.0203 | 0.1130 | 0.0087 | -0.0755 | 0.0101 | 0.1243 | 0.0406 |
| 35 | 29.0 | -0.0168 | 0.0198 | 0.1081 | 0.0079 | -0.0771 | 0.0092 | 0.1195 | 0.0404 |
| 36 | 30.0 | -0.0164 | 0.0193 | 0.1034 | 0.0069 | -0.0789 | 0.0084 | 0.1149 | 0.0401 |
| 37 | 31.0 | -0.0161 | 0.0188 | 0.0989 | 0.0060 | -0.0805 | 0.0077 | 0.1106 | 0.0398 |
| 38 | 32.0 | -0.0159 | 0.0185 | 0.0947 | 0.0051 | -0.0820 | 0.0070 | 0.1064 | 0.0395 |
| 39 | 33.0 | -0.0156 | 0.0181 | 0.0906 | 0.0042 | -0.0836 | 0.0063 | 0.1025 | 0.0392 |
| 40 | 34.0 | -0.0154 | 0.0178 | 0.0867 | 0.0033 | -0.0853 | 0.0057 | 0.0987 | 0.0389 |
| 41 | 35.0 | -0.0152 | 0.0175 | 0.0830 | 0.0024 | -0.0869 | 0.0051 | 0.0951 | 0.0387 |
| 42 | 37.0 | -0.0133 | 0.0162 | 0.0734 | 0.0012 | -0.0876 | 0.0034 | 0.0871 | 0.0392 |
| 43 | 39.0 | -0.0121 | 0.0151 | 0.0632 | -0.0006 | -0.0895 | 0.0018 | 0.0777 | 0.0389 |
| 44 | 41.0 | -0.0115 | 0.0143 | 0.0548 | -0.0025 | -0.0917 | 0.0004 | 0.0694 | 0.0384 |
| 45 | 43.0 | -0.0110 | 0.0136 | 0.0470 | -0.0042 | -0.0939 | -0.0007 | 0.0619 | 0.0377 |
| 46 | 45.0 | -0.0107 | 0.0131 | 0.0401 | -0.0059 | -0.0963 | -0.0017 | 0.0551 | 0.0371 |
| 47 | 47.5 | -0.0084 | 0.0117 | 0.0289 | -0.0073 | -0.0988 | -0.0039 | 0.0436 | 0.0367 |
| 48 | 50.0 | -0.0073 | 0.0105 | 0.0175 | -0.0094 | -0.0998 | -0.0055 | 0.0331 | 0.0358 |
| 49 | 52.5 | -0.0067 | 0.0098 | 0.0087 | -0.0115 | -0.1027 | -0.0068 | 0.0241 | 0.0348 |
| 50 | 55.0 | -0.0062 | 0.0092 | 0.0007 | -0.0134 | -0.1057 | -0.0079 | 0.0165 | 0.0342 |
| 51 | 57.5 | -0.0059 | 0.0087 | -0.0060 | -0.0151 | -0.1079 | -0.0089 | 0.0097 | 0.0334 |
| 52 | 60.0 | -0.0055 | 0.0083 | -0.0121 | -0.0166 | -0.1099 | -0.0097 | 0.0038 | 0.0330 |
| 53 | 62.5 | -0.0051 | 0.0081 | -0.0175 | -0.0181 | -0.1123 | -0.0105 | -0.0014 | 0.0327 |
| 54 | 65.0 | -0.0048 | 0.0078 | -0.0223 | -0.0193 | -0.1149 | -0.0112 | -0.0060 | 0.0324 |

| | | | | | | | | | |
|-----|-------|---------|---------|---------|---------|---------|---------|---------|--------|
| 55 | 67.5 | -0.0045 | 0.0076 | -0.0266 | -0.0205 | -0.1174 | -0.0118 | -0.0102 | 0.0323 |
| 56 | 70.0 | -0.0041 | 0.0074 | -0.0306 | -0.0216 | -0.1196 | -0.0125 | -0.0140 | 0.0323 |
| 57 | 73.0 | 0.0004 | 0.0053 | -0.0431 | -0.0218 | -0.1185 | -0.0154 | -0.0286 | 0.0327 |
| 58 | 76.0 | 0.0020 | 0.0034 | -0.0568 | -0.0239 | -0.1199 | -0.0173 | -0.0405 | 0.0316 |
| 59 | 79.0 | 0.0024 | 0.0027 | -0.0652 | -0.0259 | -0.1216 | -0.0186 | -0.0498 | 0.0304 |
| 60 | 82.0 | 0.0029 | 0.0019 | -0.0729 | -0.0274 | -0.1229 | -0.0196 | -0.0571 | 0.0294 |
| 61 | 85.0 | 0.0031 | 0.0016 | -0.0785 | -0.0289 | -0.1248 | -0.0203 | -0.0630 | 0.0287 |
| 62 | 88.0 | 0.0035 | 0.0012 | -0.0833 | -0.0300 | -0.1266 | -0.0209 | -0.0677 | 0.0280 |
| 63 | 91.0 | 0.0037 | 0.0010 | -0.0870 | -0.0311 | -0.1279 | -0.0214 | -0.0714 | 0.0276 |
| 64 | 94.0 | 0.0040 | 0.0009 | -0.0900 | -0.0318 | -0.1294 | -0.0218 | -0.0743 | 0.0274 |
| 65 | 97.0 | 0.0041 | 0.0008 | -0.0923 | -0.0325 | -0.1310 | -0.0222 | -0.0766 | 0.0273 |
| 66 | 100.0 | 0.0044 | 0.0007 | -0.0942 | -0.0330 | -0.1323 | -0.0225 | -0.0783 | 0.0274 |
| 67 | 105.0 | 0.0074 | -0.0008 | -0.1034 | -0.0333 | -0.1313 | -0.0246 | -0.0886 | 0.0278 |
| 68 | 110.0 | 0.0077 | -0.0017 | -0.1110 | -0.0348 | -0.1329 | -0.0256 | -0.0950 | 0.0270 |
| 69 | 115.0 | 0.0077 | -0.0018 | -0.1138 | -0.0357 | -0.1347 | -0.0262 | -0.0987 | 0.0267 |
| 70 | 120.0 | 0.0080 | -0.0021 | -0.1163 | -0.0361 | -0.1357 | -0.0265 | -0.1006 | 0.0266 |
| 71 | 125.0 | 0.0079 | -0.0020 | -0.1166 | -0.0364 | -0.1370 | -0.0268 | -0.1013 | 0.0269 |
| 72 | 130.0 | 0.0080 | -0.0020 | -0.1168 | -0.0364 | -0.1385 | -0.0269 | -0.1011 | 0.0274 |
| 73 | 135.0 | 0.0080 | -0.0019 | -0.1159 | -0.0363 | -0.1399 | -0.0271 | -0.1004 | 0.0280 |
| 74 | 140.0 | 0.0080 | -0.0019 | -0.1150 | -0.0360 | -0.1410 | -0.0272 | -0.0993 | 0.0288 |
| 75 | 145.0 | 0.0079 | -0.0017 | -0.1137 | -0.0358 | -0.1422 | -0.0273 | -0.0979 | 0.0297 |
| 76 | 150.0 | 0.0079 | -0.0016 | -0.1123 | -0.0353 | -0.1439 | -0.0274 | -0.0963 | 0.0306 |
| 77 | 155.0 | 0.0078 | -0.0015 | -0.1108 | -0.0350 | -0.1453 | -0.0275 | -0.0947 | 0.0315 |
| 78 | 160.0 | 0.0078 | -0.0014 | -0.1092 | -0.0346 | -0.1465 | -0.0276 | -0.0929 | 0.0325 |
| 79 | 165.0 | 0.0105 | -0.0029 | -0.1145 | -0.0338 | -0.1455 | -0.0292 | -0.0996 | 0.0330 |
| 80 | 170.0 | 0.0105 | -0.0037 | -0.1189 | -0.0344 | -0.1461 | -0.0298 | -0.1027 | 0.0328 |
| 81 | 175.0 | 0.0103 | -0.0037 | -0.1190 | -0.0344 | -0.1465 | -0.0301 | -0.1037 | 0.0327 |
| 82 | 180.0 | 0.0103 | -0.0039 | -0.1191 | -0.0342 | -0.1467 | -0.0302 | -0.1033 | 0.0329 |
| 83 | 185.0 | 0.0101 | -0.0038 | -0.1174 | -0.0338 | -0.1467 | -0.0302 | -0.1020 | 0.0332 |
| 84 | 190.0 | 0.0100 | -0.0038 | -0.1157 | -0.0332 | -0.1472 | -0.0301 | -0.1000 | 0.0337 |
| 85 | 195.0 | 0.0097 | -0.0036 | -0.1132 | -0.0326 | -0.1475 | -0.0300 | -0.0977 | 0.0344 |
| 86 | 200.0 | 0.0096 | -0.0035 | -0.1107 | -0.0318 | -0.1474 | -0.0299 | -0.0951 | 0.0351 |
| 87 | 210.0 | 0.0091 | -0.0032 | -0.1052 | -0.0304 | -0.1476 | -0.0296 | -0.0895 | 0.0366 |
| 88 | 220.0 | 0.0088 | -0.0030 | -0.0996 | -0.0288 | -0.1484 | -0.0294 | -0.0838 | 0.0381 |
| 89 | 230.0 | 0.0082 | -0.0028 | -0.0940 | -0.0274 | -0.1490 | -0.0291 | -0.0782 | 0.0397 |
| 90 | 240.0 | 0.0080 | -0.0026 | -0.0887 | -0.0258 | -0.1489 | -0.0289 | -0.0728 | 0.0412 |
| 91 | 250.0 | 0.0075 | -0.0023 | -0.0835 | -0.0244 | -0.1492 | -0.0287 | -0.0676 | 0.0427 |
| 92 | 260.0 | 0.0073 | -0.0022 | -0.0787 | -0.0229 | -0.1500 | -0.0285 | -0.0627 | 0.0440 |
| 93 | 270.0 | 0.0068 | -0.0020 | -0.0740 | -0.0217 | -0.1505 | -0.0283 | -0.0580 | 0.0454 |
| 94 | 280.0 | 0.0065 | -0.0019 | -0.0697 | -0.0204 | -0.1505 | -0.0282 | -0.0535 | 0.0467 |
| 95 | 290.0 | 0.0061 | -0.0017 | -0.0655 | -0.0192 | -0.1507 | -0.0280 | -0.0493 | 0.0479 |
| 96 | 300.0 | 0.0059 | -0.0016 | -0.0616 | -0.0180 | -0.1514 | -0.0279 | -0.0452 | 0.0490 |
| 97 | 320.0 | 0.0052 | -0.0014 | -0.0544 | -0.0160 | -0.1524 | -0.0276 | -0.0380 | 0.0511 |
| 98 | 340.0 | 0.0047 | -0.0012 | -0.0480 | -0.0141 | -0.1524 | -0.0275 | -0.0316 | 0.0530 |
| 99 | 360.0 | 0.0041 | -0.0010 | -0.0423 | -0.0125 | -0.1523 | -0.0273 | -0.0258 | 0.0548 |
| 100 | 380.0 | 0.0038 | -0.0009 | -0.0372 | -0.0109 | -0.1529 | -0.0272 | -0.0207 | 0.0562 |
| 101 | 400.0 | 0.0033 | -0.0008 | -0.0328 | -0.0097 | -0.1540 | -0.0270 | -0.0161 | 0.0575 |
| 102 | 420.0 | 0.0031 | -0.0007 | -0.0288 | -0.0084 | -0.1546 | -0.0269 | -0.0121 | 0.0586 |
| 103 | 440.0 | 0.0027 | -0.0006 | -0.0253 | -0.0074 | -0.1545 | -0.0268 | -0.0087 | 0.0597 |
| 104 | 460.0 | 0.0026 | -0.0005 | -0.0223 | -0.0065 | -0.1542 | -0.0268 | -0.0055 | 0.0607 |
| 105 | 480.0 | 0.0022 | -0.0005 | -0.0196 | -0.0057 | -0.1545 | -0.0267 | -0.0028 | 0.0615 |
| 106 | 500.0 | 0.0021 | -0.0004 | -0.0172 | -0.0050 | -0.1554 | -0.0266 | -0.0004 | 0.0621 |

表 4. 3 (1) 評価断面3の応力テンソル成分1

F I N A S 解と簡易計算値との比較 (コールドショック)

断面3の応力成分1

| ステップ | 時間(S) | F I N A S 解 | | | | 簡易計算値 | | | |
|------|-------|-------------|--------|---------|---------|---------|---------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.0076 | 0.0029 | -0.0145 | 0.0000 | 0.0020 | 0.0028 | -0.0182 | -0.0006 |
| 3 | 1.0 | 0.0040 | 0.0101 | -0.0441 | 0.0014 | 0.0011 | 0.0090 | -0.0465 | 0.0021 |
| 4 | 1.5 | 0.0066 | 0.0186 | -0.0726 | 0.0054 | 0.0033 | 0.0155 | -0.0749 | 0.0061 |
| 5 | 2.0 | 0.0060 | 0.0267 | -0.0991 | 0.0089 | 0.0037 | 0.0208 | -0.1016 | 0.0102 |
| 6 | 2.5 | 0.0086 | 0.0340 | -0.1235 | 0.0129 | 0.0063 | 0.0258 | -0.1259 | 0.0145 |
| 7 | 3.0 | 0.0089 | 0.0408 | -0.1457 | 0.0167 | 0.0137 | 0.0296 | -0.1482 | 0.0193 |
| 8 | 3.5 | 0.0113 | 0.0469 | -0.1659 | 0.0205 | 0.0210 | 0.0321 | -0.1686 | 0.0241 |
| 9 | 4.0 | 0.0124 | 0.0525 | -0.1845 | 0.0242 | 0.0242 | 0.0350 | -0.1876 | 0.0285 |
| 10 | 4.5 | 0.0145 | 0.0576 | -0.2014 | 0.0278 | 0.0272 | 0.0371 | -0.2049 | 0.0331 |
| 11 | 5.0 | 0.0159 | 0.0622 | -0.2170 | 0.0312 | 0.0333 | 0.0392 | -0.2208 | 0.0375 |
| 12 | 6.0 | 0.0149 | 0.0659 | -0.2255 | 0.0370 | 0.0441 | 0.0382 | -0.2282 | 0.0446 |
| 13 | 7.0 | 0.0199 | 0.0640 | -0.2183 | 0.0396 | 0.0503 | 0.0334 | -0.2250 | 0.0475 |
| 14 | 8.0 | 0.0198 | 0.0629 | -0.2165 | 0.0408 | 0.0520 | 0.0285 | -0.2226 | 0.0495 |
| 15 | 9.0 | 0.0220 | 0.0624 | -0.2147 | 0.0424 | 0.0502 | 0.0224 | -0.2215 | 0.0507 |
| 16 | 10.0 | 0.0219 | 0.0618 | -0.2143 | 0.0431 | 0.0485 | 0.0150 | -0.2210 | 0.0517 |
| 17 | 11.0 | 0.0235 | 0.0615 | -0.2142 | 0.0441 | 0.0490 | 0.0080 | -0.2207 | 0.0525 |
| 18 | 12.0 | 0.0231 | 0.0614 | -0.2144 | 0.0446 | 0.0494 | 0.0013 | -0.2207 | 0.0531 |
| 19 | 13.0 | 0.0241 | 0.0612 | -0.2146 | 0.0451 | 0.0496 | -0.0057 | -0.2207 | 0.0535 |
| 20 | 14.0 | 0.0240 | 0.0614 | -0.2148 | 0.0453 | 0.0499 | -0.0122 | -0.2205 | 0.0535 |
| 21 | 15.0 | 0.0242 | 0.0613 | -0.2149 | 0.0455 | 0.0503 | -0.0176 | -0.2202 | 0.0534 |
| 22 | 16.0 | 0.0225 | 0.0600 | -0.2090 | 0.0452 | 0.0456 | -0.0246 | -0.2121 | 0.0527 |
| 23 | 17.0 | 0.0234 | 0.0573 | -0.1995 | 0.0442 | 0.0407 | -0.0321 | -0.2034 | 0.0513 |
| 24 | 18.0 | 0.0220 | 0.0547 | -0.1923 | 0.0428 | 0.0353 | -0.0387 | -0.1957 | 0.0498 |
| 25 | 19.0 | 0.0220 | 0.0527 | -0.1859 | 0.0416 | 0.0303 | -0.0446 | -0.1890 | 0.0480 |
| 26 | 20.0 | 0.0206 | 0.0507 | -0.1803 | 0.0402 | 0.0238 | -0.0511 | -0.1836 | 0.0463 |
| 27 | 21.0 | 0.0203 | 0.0491 | -0.1752 | 0.0390 | 0.0135 | -0.0577 | -0.1790 | 0.0445 |
| 28 | 22.0 | 0.0191 | 0.0478 | -0.1706 | 0.0377 | 0.0084 | -0.0640 | -0.1746 | 0.0432 |
| 29 | 23.0 | 0.0186 | 0.0465 | -0.1664 | 0.0365 | 0.0022 | -0.0703 | -0.1707 | 0.0419 |
| 30 | 24.0 | 0.0171 | 0.0456 | -0.1623 | 0.0352 | -0.0101 | -0.0763 | -0.1672 | 0.0405 |
| 31 | 25.0 | 0.0166 | 0.0445 | -0.1585 | 0.0341 | -0.0216 | -0.0819 | -0.1637 | 0.0391 |
| 32 | 26.0 | 0.0150 | 0.0432 | -0.1530 | 0.0329 | -0.0245 | -0.0879 | -0.1575 | 0.0381 |
| 33 | 27.0 | 0.0146 | 0.0414 | -0.1465 | 0.0315 | -0.0294 | -0.0936 | -0.1514 | 0.0367 |
| 34 | 28.0 | 0.0133 | 0.0397 | -0.1409 | 0.0300 | -0.0400 | -0.0986 | -0.1459 | 0.0350 |
| 35 | 29.0 | 0.0126 | 0.0382 | -0.1357 | 0.0287 | -0.0476 | -0.1032 | -0.1408 | 0.0333 |
| 36 | 30.0 | 0.0111 | 0.0368 | -0.1311 | 0.0272 | -0.0500 | -0.1076 | -0.1360 | 0.0319 |
| 37 | 31.0 | 0.0105 | 0.0354 | -0.1267 | 0.0260 | -0.0554 | -0.1119 | -0.1317 | 0.0304 |
| 38 | 32.0 | 0.0095 | 0.0342 | -0.1226 | 0.0248 | -0.0656 | -0.1162 | -0.1281 | 0.0287 |
| 39 | 33.0 | 0.0087 | 0.0331 | -0.1188 | 0.0236 | -0.0724 | -0.1206 | -0.1248 | 0.0273 |
| 40 | 34.0 | 0.0074 | 0.0322 | -0.1151 | 0.0224 | -0.0732 | -0.1249 | -0.1217 | 0.0265 |
| 41 | 35.0 | 0.0066 | 0.0313 | -0.1116 | 0.0214 | -0.0757 | -0.1291 | -0.1187 | 0.0258 |
| 42 | 37.0 | 0.0039 | 0.0287 | -0.1007 | 0.0189 | -0.0947 | -0.1371 | -0.1099 | 0.0237 |
| 43 | 39.0 | 0.0022 | 0.0255 | -0.0895 | 0.0162 | -0.0970 | -0.1461 | -0.0999 | 0.0217 |
| 44 | 41.0 | -0.0001 | 0.0235 | -0.0813 | 0.0137 | -0.1122 | -0.1543 | -0.0915 | 0.0187 |
| 45 | 43.0 | -0.0015 | 0.0217 | -0.0737 | 0.0116 | -0.1243 | -0.1625 | -0.0846 | 0.0166 |
| 46 | 45.0 | -0.0035 | 0.0199 | -0.0673 | 0.0095 | -0.1267 | -0.1702 | -0.0784 | 0.0155 |
| 47 | 47.5 | -0.0058 | 0.0168 | -0.0544 | 0.0068 | -0.0924 | -0.1814 | -0.0638 | 0.0166 |
| 48 | 50.0 | -0.0079 | 0.0131 | -0.0421 | 0.0036 | -0.1313 | -0.1900 | -0.0537 | 0.0117 |
| 49 | 52.5 | -0.0099 | 0.0109 | -0.0338 | 0.0012 | -0.1271 | -0.1988 | -0.0444 | 0.0105 |
| 50 | 55.0 | -0.0119 | 0.0087 | -0.0260 | -0.0011 | -0.1082 | -0.2068 | -0.0362 | 0.0105 |
| 51 | 57.5 | -0.0137 | 0.0071 | -0.0198 | -0.0031 | -0.1118 | -0.2147 | -0.0297 | 0.0092 |
| 52 | 60.0 | -0.0152 | 0.0059 | -0.0141 | -0.0049 | -0.1352 | -0.2220 | -0.0246 | 0.0067 |
| 53 | 62.5 | -0.0165 | 0.0047 | -0.0092 | -0.0064 | -0.1431 | -0.2289 | -0.0199 | 0.0055 |
| 54 | 65.0 | -0.0179 | 0.0036 | -0.0047 | -0.0077 | -0.1323 | -0.2356 | -0.0152 | 0.0057 |

| | | | | | | | | | |
|-----|-------|---------|---------|---------|---------|---------|---------|---------|---------|
| 55 | 67.5 | -0.0189 | 0.0027 | -0.0008 | -0.0089 | -0.1231 | -0.2422 | -0.0109 | 0.0059 |
| 56 | 70.0 | -0.0202 | 0.0018 | 0.0028 | -0.0100 | -0.1364 | -0.2487 | -0.0076 | 0.0047 |
| 57 | 73.0 | -0.0227 | -0.0028 | 0.0201 | -0.0125 | -0.1523 | -0.2606 | 0.0125 | 0.0015 |
| 58 | 76.0 | -0.0237 | -0.0078 | 0.0361 | -0.0161 | -0.1367 | -0.2690 | 0.0268 | 0.0000 |
| 59 | 79.0 | -0.0261 | -0.0099 | 0.0439 | -0.0186 | -0.1422 | -0.2760 | 0.0365 | -0.0024 |
| 60 | 82.0 | -0.0271 | -0.0119 | 0.0520 | -0.0207 | -0.1661 | -0.2821 | 0.0432 | -0.0055 |
| 61 | 85.0 | -0.0290 | -0.0131 | 0.0569 | -0.0224 | -0.1555 | -0.2873 | 0.0491 | -0.0057 |
| 62 | 88.0 | -0.0294 | -0.0143 | 0.0618 | -0.0237 | -0.1458 | -0.2920 | 0.0537 | -0.0056 |
| 63 | 91.0 | -0.0306 | -0.0151 | 0.0650 | -0.0248 | -0.1672 | -0.2963 | 0.0568 | -0.0074 |
| 64 | 94.0 | -0.0309 | -0.0158 | 0.0680 | -0.0255 | -0.1693 | -0.3003 | 0.0596 | -0.0078 |
| 65 | 97.0 | -0.0317 | -0.0164 | 0.0701 | -0.0262 | -0.1502 | -0.3041 | 0.0623 | -0.0066 |
| 66 | 100.0 | -0.0319 | -0.0168 | 0.0720 | -0.0266 | -0.1631 | -0.3080 | 0.0637 | -0.0074 |
| 67 | 105.0 | -0.0335 | -0.0201 | 0.0847 | -0.0286 | -0.1766 | -0.3168 | 0.0778 | -0.0102 |
| 68 | 110.0 | -0.0340 | -0.0227 | 0.0929 | -0.0307 | -0.1621 | -0.3221 | 0.0853 | -0.0103 |
| 69 | 115.0 | -0.0353 | -0.0232 | 0.0951 | -0.0315 | -0.1549 | -0.3265 | 0.0893 | -0.0102 |
| 70 | 120.0 | -0.0350 | -0.0239 | 0.0980 | -0.0321 | -0.1771 | -0.3299 | 0.0908 | -0.0117 |
| 71 | 125.0 | -0.0358 | -0.0238 | 0.0980 | -0.0322 | -0.1837 | -0.3329 | 0.0914 | -0.0118 |
| 72 | 130.0 | -0.0352 | -0.0239 | 0.0987 | -0.0321 | -0.1670 | -0.3357 | 0.0919 | -0.0102 |
| 73 | 135.0 | -0.0353 | -0.0236 | 0.0977 | -0.0319 | -0.1594 | -0.3384 | 0.0916 | -0.0090 |
| 74 | 140.0 | -0.0344 | -0.0235 | 0.0972 | -0.0315 | -0.1777 | -0.3411 | 0.0903 | -0.0095 |
| 75 | 145.0 | -0.0343 | -0.0233 | 0.0958 | -0.0311 | -0.1868 | -0.3436 | 0.0890 | -0.0094 |
| 76 | 150.0 | -0.0335 | -0.0230 | 0.0949 | -0.0306 | -0.1682 | -0.3461 | 0.0883 | -0.0075 |
| 77 | 155.0 | -0.0334 | -0.0227 | 0.0934 | -0.0302 | -0.1612 | -0.3486 | 0.0871 | -0.0063 |
| 78 | 160.0 | -0.0325 | -0.0224 | 0.0922 | -0.0297 | -0.1815 | -0.3510 | 0.0852 | -0.0069 |
| 79 | 165.0 | -0.0332 | -0.0248 | 0.1011 | -0.0306 | -0.1929 | -0.3556 | 0.0951 | -0.0090 |
| 80 | 170.0 | -0.0328 | -0.0267 | 0.1065 | -0.0318 | -0.1775 | -0.3579 | 0.0992 | -0.0087 |
| 81 | 175.0 | -0.0336 | -0.0265 | 0.1062 | -0.0320 | -0.1690 | -0.3585 | 0.1006 | -0.0082 |
| 82 | 180.0 | -0.0327 | -0.0265 | 0.1070 | -0.0320 | -0.1900 | -0.3587 | 0.0997 | -0.0093 |
| 83 | 185.0 | -0.0330 | -0.0264 | 0.1051 | -0.0316 | -0.1983 | -0.3584 | 0.0983 | -0.0094 |
| 84 | 190.0 | -0.0319 | -0.0259 | 0.1040 | -0.0310 | -0.1749 | -0.3581 | 0.0972 | -0.0072 |
| 85 | 195.0 | -0.0316 | -0.0252 | 0.1015 | -0.0304 | -0.1635 | -0.3577 | 0.0955 | -0.0056 |
| 86 | 200.0 | -0.0305 | -0.0248 | 0.0996 | -0.0296 | -0.1833 | -0.3572 | 0.0927 | -0.0062 |
| 87 | 210.0 | -0.0292 | -0.0235 | 0.0944 | -0.0281 | -0.1940 | -0.3560 | 0.0875 | -0.0054 |
| 88 | 220.0 | -0.0272 | -0.0223 | 0.0897 | -0.0265 | -0.1619 | -0.3548 | 0.0833 | -0.0017 |
| 89 | 230.0 | -0.0261 | -0.0211 | 0.0845 | -0.0250 | -0.1514 | -0.3535 | 0.0785 | 0.0004 |
| 90 | 240.0 | -0.0242 | -0.0200 | 0.0800 | -0.0235 | -0.1837 | -0.3523 | 0.0728 | -0.0003 |
| 91 | 250.0 | -0.0235 | -0.0188 | 0.0752 | -0.0222 | -0.1893 | -0.3512 | 0.0680 | 0.0006 |
| 92 | 260.0 | -0.0217 | -0.0178 | 0.0710 | -0.0208 | -0.1563 | -0.3501 | 0.0643 | 0.0041 |
| 93 | 270.0 | -0.0207 | -0.0167 | 0.0666 | -0.0196 | -0.1483 | -0.3491 | 0.0603 | 0.0059 |
| 94 | 280.0 | -0.0193 | -0.0156 | 0.0629 | -0.0184 | -0.1760 | -0.3481 | 0.0555 | 0.0051 |
| 95 | 290.0 | -0.0186 | -0.0148 | 0.0590 | -0.0174 | -0.1844 | -0.3472 | 0.0515 | 0.0056 |
| 96 | 300.0 | -0.0171 | -0.0139 | 0.0556 | -0.0162 | -0.1543 | -0.3463 | 0.0486 | 0.0087 |
| 97 | 320.0 | -0.0155 | -0.0123 | 0.0490 | -0.0144 | -0.1253 | -0.3447 | 0.0428 | 0.0124 |
| 98 | 340.0 | -0.0132 | -0.0109 | 0.0434 | -0.0126 | -0.1613 | -0.3433 | 0.0360 | 0.0116 |
| 99 | 360.0 | -0.0122 | -0.0098 | 0.0382 | -0.0112 | -0.2006 | -0.3420 | 0.0297 | 0.0104 |
| 100 | 380.0 | -0.0106 | -0.0085 | 0.0337 | -0.0098 | -0.1876 | -0.3409 | 0.0254 | 0.0125 |
| 101 | 400.0 | -0.0099 | -0.0076 | 0.0296 | -0.0087 | -0.1344 | -0.3399 | 0.0227 | 0.0172 |
| 102 | 420.0 | -0.0084 | -0.0068 | 0.0261 | -0.0076 | -0.1178 | -0.3391 | 0.0195 | 0.0193 |
| 103 | 440.0 | -0.0077 | -0.0060 | 0.0229 | -0.0067 | -0.1480 | -0.3383 | 0.0155 | 0.0181 |
| 104 | 460.0 | -0.0067 | -0.0054 | 0.0201 | -0.0059 | -0.1913 | -0.3376 | 0.0115 | 0.0159 |
| 105 | 480.0 | -0.0064 | -0.0048 | 0.0176 | -0.0052 | -0.1829 | -0.3370 | 0.0093 | 0.0171 |
| 106 | 500.0 | -0.0058 | -0.0043 | 0.0155 | -0.0046 | -0.1324 | -0.3365 | 0.0083 | 0.0211 |

表4. 3(2) 評価断面3の応力テンソル成分2

FINAS解と簡易計算値との比較 (コールドショック)

断面3の応力成分2

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|---------|---------|---------|--------|---------|---------|--------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.6263 | -0.2430 | -0.0050 | 0.3521 | 0.7259 | -0.2909 | -0.0066 | 0.4361 |
| 3 | 1.0 | 1.4566 | -0.7785 | -0.0145 | 1.0202 | 1.5057 | -0.8188 | -0.0152 | 1.0725 |
| 4 | 1.5 | 2.1605 | -1.3477 | -0.0215 | 1.6544 | 2.2424 | -1.3766 | -0.0222 | 1.7071 |
| 5 | 2.0 | 2.8466 | -1.8860 | -0.0267 | 2.2513 | 2.9100 | -1.9169 | -0.0275 | 2.3019 |
| 6 | 2.5 | 3.4383 | -2.3969 | -0.0305 | 2.7973 | 3.5158 | -2.4267 | -0.0312 | 2.8495 |
| 7 | 3.0 | 3.9940 | -2.8735 | -0.0334 | 3.2994 | 4.0706 | -2.9035 | -0.0340 | 3.3523 |
| 8 | 3.5 | 4.4809 | -3.3176 | -0.0354 | 3.7582 | 4.5749 | -3.3478 | -0.0359 | 3.8137 |
| 9 | 4.0 | 4.9363 | -3.7325 | -0.0368 | 4.1807 | 5.0274 | -3.7612 | -0.0373 | 4.2374 |
| 10 | 4.5 | 5.3410 | -4.1191 | -0.0376 | 4.5689 | 5.4403 | -4.1464 | -0.0382 | 4.6278 |
| 11 | 5.0 | 5.7206 | -4.4814 | -0.0379 | 4.9283 | 5.8226 | -4.5073 | -0.0387 | 4.9885 |
| 12 | 6.0 | 5.7022 | -4.7968 | -0.0316 | 5.1195 | 5.7782 | -4.8043 | -0.0320 | 5.1508 |
| 13 | 7.0 | 5.5098 | -4.7705 | -0.0225 | 4.9861 | 5.6488 | -4.8360 | -0.0248 | 5.0970 |
| 14 | 8.0 | 5.4500 | -4.7962 | -0.0180 | 4.9676 | 5.5604 | -4.8542 | -0.0199 | 5.0596 |
| 15 | 9.0 | 5.3845 | -4.8220 | -0.0140 | 4.9436 | 5.5076 | -4.8796 | -0.0166 | 5.0449 |
| 16 | 10.0 | 5.3780 | -4.8493 | -0.0111 | 4.9493 | 5.4832 | -4.9086 | -0.0138 | 5.0460 |
| 17 | 11.0 | 5.3631 | -4.8809 | -0.0089 | 4.9566 | 5.4794 | -4.9363 | -0.0115 | 5.0547 |
| 18 | 12.0 | 5.3725 | -4.9052 | -0.0073 | 4.9700 | 5.4827 | -4.9613 | -0.0097 | 5.0665 |
| 19 | 13.0 | 5.3707 | -4.9274 | -0.0061 | 4.9801 | 5.4889 | -4.9810 | -0.0083 | 5.0777 |
| 20 | 14.0 | 5.3784 | -4.9414 | -0.0054 | 4.9887 | 5.4948 | -4.9948 | -0.0072 | 5.0858 |
| 21 | 15.0 | 5.3749 | -4.9502 | -0.0050 | 4.9920 | 5.4984 | -5.0017 | -0.0063 | 5.0896 |
| 22 | 16.0 | 5.1709 | -4.8494 | -0.0030 | 4.8560 | 5.2564 | -4.8637 | -0.0031 | 4.9114 |
| 23 | 17.0 | 4.9322 | -4.6629 | -0.0007 | 4.6427 | 5.0369 | -4.6914 | -0.0009 | 4.7202 |
| 24 | 18.0 | 4.7588 | -4.5064 | -0.0001 | 4.4810 | 4.8518 | -4.5311 | 0.0003 | 4.5521 |
| 25 | 19.0 | 4.5931 | -4.3614 | 0.0000 | 4.3304 | 4.6949 | -4.3847 | 0.0009 | 4.4043 |
| 26 | 20.0 | 4.4622 | -4.2276 | -0.0004 | 4.2002 | 4.5568 | -4.2502 | 0.0007 | 4.2722 |
| 27 | 21.0 | 4.3346 | -4.1042 | -0.0011 | 4.0796 | 4.4281 | -4.1256 | -0.0002 | 4.1526 |
| 28 | 22.0 | 4.2269 | -3.9868 | -0.0020 | 3.9694 | 4.3191 | -4.0092 | -0.0012 | 4.0429 |
| 29 | 23.0 | 4.1197 | -3.8762 | -0.0032 | 3.8652 | 4.2176 | -3.8989 | -0.0026 | 3.9402 |
| 30 | 24.0 | 4.0252 | -3.7700 | -0.0044 | 3.7675 | 4.1131 | -3.7930 | -0.0042 | 3.8430 |
| 31 | 25.0 | 3.9309 | -3.6685 | -0.0057 | 3.6740 | 4.0138 | -3.6914 | -0.0058 | 3.7505 |
| 32 | 26.0 | 3.7774 | -3.5367 | -0.0065 | 3.5399 | 3.8518 | -3.5471 | -0.0063 | 3.6033 |
| 33 | 27.0 | 3.6152 | -3.3817 | -0.0071 | 3.3850 | 3.6979 | -3.3967 | -0.0071 | 3.4566 |
| 34 | 28.0 | 3.4817 | -3.2423 | -0.0083 | 3.2521 | 3.5504 | -3.2557 | -0.0084 | 3.3219 |
| 35 | 29.0 | 3.3530 | -3.1115 | -0.0096 | 3.1272 | 3.4195 | -3.1246 | -0.0098 | 3.1985 |
| 36 | 30.0 | 3.2416 | -2.9889 | -0.0110 | 3.0134 | 3.3065 | -3.0029 | -0.0113 | 3.0845 |
| 37 | 31.0 | 3.1334 | -2.8736 | -0.0125 | 2.9062 | 3.1972 | -2.8880 | -0.0131 | 2.9778 |
| 38 | 32.0 | 3.0367 | -2.7641 | -0.0141 | 2.8061 | 3.0874 | -2.7785 | -0.0151 | 2.8771 |
| 39 | 33.0 | 2.9419 | -2.6604 | -0.0156 | 2.7112 | 2.9882 | -2.6736 | -0.0170 | 2.7819 |
| 40 | 34.0 | 2.8550 | -2.5613 | -0.0172 | 2.6212 | 2.9028 | -2.5730 | -0.0188 | 2.6922 |
| 41 | 35.0 | 2.7701 | -2.4668 | -0.0187 | 2.5354 | 2.8186 | -2.4763 | -0.0204 | 2.6069 |
| 42 | 37.0 | 2.4789 | -2.2064 | -0.0205 | 2.2735 | 2.5079 | -2.2418 | -0.0225 | 2.3689 |
| 43 | 39.0 | 2.2159 | -1.9331 | -0.0226 | 2.0101 | 2.2556 | -1.9794 | -0.0240 | 2.1239 |
| 44 | 41.0 | 2.0193 | -1.7188 | -0.0256 | 1.8135 | 2.0276 | -1.7520 | -0.0263 | 1.9167 |
| 45 | 43.0 | 1.8373 | -1.5191 | -0.0283 | 1.6289 | 1.8356 | -1.5520 | -0.0289 | 1.7378 |
| 46 | 45.0 | 1.6861 | -1.3453 | -0.0312 | 1.4726 | 1.6779 | -1.3706 | -0.0313 | 1.5790 |
| 47 | 47.5 | 1.3426 | -1.0412 | -0.0331 | 1.1646 | 1.3854 | -1.0411 | -0.0312 | 1.2568 |
| 48 | 50.0 | 1.0625 | -0.7397 | -0.0356 | 0.8779 | 1.0608 | -0.7537 | -0.0340 | 0.9897 |
| 49 | 52.5 | 0.8583 | -0.5188 | -0.0390 | 0.6762 | 0.8557 | -0.5150 | -0.0364 | 0.7754 |
| 50 | 55.0 | 0.6784 | -0.3148 | -0.0419 | 0.4888 | 0.7068 | -0.3095 | -0.0385 | 0.5959 |
| 51 | 57.5 | 0.5294 | -0.1465 | -0.0449 | 0.3376 | 0.5497 | -0.1310 | -0.0410 | 0.4398 |
| 52 | 60.0 | 0.3955 | 0.0060 | -0.0475 | 0.1987 | 0.3838 | 0.0256 | -0.0438 | 0.3018 |
| 53 | 62.5 | 0.2802 | 0.1374 | -0.0500 | 0.0808 | 0.2576 | 0.1637 | -0.0461 | 0.1816 |
| 54 | 65.0 | 0.1758 | 0.2563 | -0.0522 | -0.0273 | 0.1708 | 0.2868 | -0.0478 | 0.0764 |

| | | | | | | | | | |
|-----|-------|---------|--------|---------|---------|---------|--------|---------|---------|
| 55 | 67.5 | 0.0834 | 0.3619 | -0.0543 | -0.1222 | 0.0912 | 0.3990 | -0.0493 | -0.0190 |
| 56 | 70.0 | -0.0013 | 0.4580 | -0.0562 | -0.2096 | -0.0114 | 0.5008 | -0.0512 | -0.1072 |
| 57 | 73.0 | -0.4825 | 0.8215 | -0.0551 | -0.6096 | -0.5443 | 0.9333 | -0.0492 | -0.5663 |
| 58 | 76.0 | -0.8384 | 1.1955 | -0.0561 | -0.9751 | -0.8418 | 1.2602 | -0.0499 | -0.8783 |
| 59 | 79.0 | -1.0340 | 1.4052 | -0.0592 | -1.1635 | -1.0697 | 1.5066 | -0.0518 | -1.1038 |
| 60 | 82.0 | -1.2166 | 1.6095 | -0.0611 | -1.3554 | -1.2699 | 1.6999 | -0.0544 | -1.2784 |
| 61 | 85.0 | -1.3345 | 1.7473 | -0.0637 | -1.4749 | -1.3837 | 1.8531 | -0.0561 | -1.4127 |
| 62 | 88.0 | -1.4460 | 1.8700 | -0.0653 | -1.5904 | -1.4718 | 1.9745 | -0.0577 | -1.5181 |
| 63 | 91.0 | -1.5184 | 1.9581 | -0.0670 | -1.6664 | -1.5827 | 2.0709 | -0.0595 | -1.6034 |
| 64 | 94.0 | -1.5887 | 2.0328 | -0.0682 | -1.7372 | -1.6508 | 2.1483 | -0.0606 | -1.6698 |
| 65 | 97.0 | -1.6331 | 2.0889 | -0.0693 | -1.7852 | -1.6753 | 2.2099 | -0.0610 | -1.7203 |
| 66 | 100.0 | -1.6776 | 2.1346 | -0.0701 | -1.8289 | -1.7332 | 2.2591 | -0.0619 | -1.7623 |
| 67 | 105.0 | -2.0137 | 2.4017 | -0.0690 | -2.1174 | -2.1036 | 2.5628 | -0.0602 | -2.0817 |
| 68 | 110.0 | -2.1868 | 2.6021 | -0.0701 | -2.3044 | -2.2419 | 2.7351 | -0.0606 | -2.2388 |
| 69 | 115.0 | -2.2447 | 2.6684 | -0.0716 | -2.3591 | -2.3152 | 2.8340 | -0.0613 | -2.3252 |
| 70 | 120.0 | -2.3042 | 2.7350 | -0.0718 | -2.4243 | -2.3888 | 2.8854 | -0.0622 | -2.3705 |
| 71 | 125.0 | -2.3043 | 2.7386 | -0.0723 | -2.4230 | -2.4139 | 2.9061 | -0.0623 | -2.3870 |
| 72 | 130.0 | -2.3127 | 2.7439 | -0.0718 | -2.4322 | -2.3889 | 2.9060 | -0.0616 | -2.3827 |
| 73 | 135.0 | -2.2871 | 2.7199 | -0.0716 | -2.4067 | -2.3639 | 2.8918 | -0.0607 | -2.3665 |
| 74 | 140.0 | -2.2728 | 2.6985 | -0.0708 | -2.3912 | -2.3664 | 2.8679 | -0.0604 | -2.3441 |
| 75 | 145.0 | -2.2365 | 2.6629 | -0.0703 | -2.3559 | -2.3508 | 2.8376 | -0.0598 | -2.3155 |
| 76 | 150.0 | -2.2125 | 2.6298 | -0.0694 | -2.3292 | -2.2925 | 2.8030 | -0.0585 | -2.2809 |
| 77 | 155.0 | -2.1724 | 2.5899 | -0.0687 | -2.2906 | -2.2481 | 2.7657 | -0.0574 | -2.2449 |
| 78 | 160.0 | -2.1439 | 2.5520 | -0.0678 | -2.2589 | -2.2406 | 2.7271 | -0.0569 | -2.2098 |
| 79 | 165.0 | -2.3957 | 2.7234 | -0.0649 | -2.4606 | -2.5060 | 2.9341 | -0.0545 | -2.4353 |
| 80 | 170.0 | -2.5024 | 2.8474 | -0.0643 | -2.5787 | -2.5682 | 3.0215 | -0.0536 | -2.5178 |
| 81 | 175.0 | -2.5037 | 2.8492 | -0.0645 | -2.5750 | -2.5815 | 3.0507 | -0.0529 | -2.5431 |
| 82 | 180.0 | -2.5164 | 2.8613 | -0.0635 | -2.5909 | -2.6043 | 3.0431 | -0.0528 | -2.5371 |
| 83 | 185.0 | -2.4734 | 2.8161 | -0.0629 | -2.5455 | -2.5899 | 3.0118 | -0.0519 | -2.5084 |
| 84 | 190.0 | -2.4444 | 2.7785 | -0.0615 | -2.5158 | -2.5171 | 2.9645 | -0.0501 | -2.4630 |
| 85 | 195.0 | -2.3835 | 2.7147 | -0.0604 | -2.4541 | -2.4522 | 2.9074 | -0.0484 | -2.4097 |
| 86 | 200.0 | -2.3378 | 2.6568 | -0.0588 | -2.4055 | -2.4259 | 2.8443 | -0.0474 | -2.3540 |
| 87 | 210.0 | -2.2114 | 2.5191 | -0.0560 | -2.2778 | -2.3246 | 2.7094 | -0.0447 | -2.2330 |
| 88 | 220.0 | -2.0994 | 2.3856 | -0.0529 | -2.1604 | -2.1598 | 2.5703 | -0.0410 | -2.1049 |
| 89 | 230.0 | -1.9732 | 2.2481 | -0.0501 | -2.0333 | -2.0274 | 2.4340 | -0.0379 | -1.9811 |
| 90 | 240.0 | -1.8669 | 2.1207 | -0.0471 | -1.9213 | -1.9594 | 2.3029 | -0.0358 | -1.8654 |
| 91 | 250.0 | -1.7510 | 1.9947 | -0.0446 | -1.8046 | -1.8588 | 2.1772 | -0.0332 | -1.7524 |
| 92 | 260.0 | -1.6545 | 1.8786 | -0.0419 | -1.7024 | -1.7088 | 2.0568 | -0.0299 | -1.6411 |
| 93 | 270.0 | -1.5493 | 1.7653 | -0.0395 | -1.5975 | -1.5996 | 1.9429 | -0.0273 | -1.5377 |
| 94 | 280.0 | -1.4633 | 1.6607 | -0.0371 | -1.5055 | -1.5453 | 1.8353 | -0.0255 | -1.4427 |
| 95 | 290.0 | -1.3692 | 1.5597 | -0.0350 | -1.4119 | -1.4693 | 1.7334 | -0.0235 | -1.3514 |
| 96 | 300.0 | -1.2925 | 1.4661 | -0.0328 | -1.3296 | -1.3439 | 1.6368 | -0.0207 | -1.2617 |
| 97 | 320.0 | -1.1348 | 1.2926 | -0.0291 | -1.1705 | -1.1534 | 1.4628 | -0.0163 | -1.1022 |
| 98 | 340.0 | -1.0057 | 1.1396 | -0.0256 | -1.0343 | -1.0709 | 1.3088 | -0.0137 | -0.9661 |
| 99 | 360.0 | -0.8806 | 1.0028 | -0.0226 | -0.9087 | -1.0058 | 1.1698 | -0.0115 | -0.8436 |
| 100 | 380.0 | -0.7807 | 0.8831 | -0.0199 | -0.8024 | -0.8836 | 1.0491 | -0.0086 | -0.7335 |
| 101 | 400.0 | -0.6820 | 0.7765 | -0.0176 | -0.7038 | -0.7151 | 0.9397 | -0.0051 | -0.6304 |
| 102 | 420.0 | -0.6051 | 0.6829 | -0.0155 | -0.6211 | -0.6097 | 0.8444 | -0.0026 | -0.5430 |
| 103 | 440.0 | -0.5269 | 0.5998 | -0.0137 | -0.5440 | -0.5302 | 0.7612 | -0.0014 | -0.4702 |
| 104 | 460.0 | -0.4682 | 0.5269 | -0.0120 | -0.4800 | -0.5765 | 0.6869 | -0.0007 | -0.4065 |
| 105 | 480.0 | -0.4067 | 0.4625 | -0.0106 | -0.4197 | -0.5091 | 0.6223 | 0.0009 | -0.3474 |
| 106 | 500.0 | -0.3621 | 0.4059 | -0.0093 | -0.3705 | -0.3881 | 0.5637 | 0.0032 | -0.2904 |

表4. 3(3) 評価断面3の応力テンソル成分3

F I N A S解と簡易計算値との比較 (コールドショック)

断面3の応力成分3

| ステップ | 時間(S) | F I N A S解 | | | | 簡易計算値 | | | |
|------|-------|------------|---------|---------|--------|--------|---------|---------|--------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.6102 | -0.2201 | -0.0299 | 0.3318 | 0.7138 | -0.2693 | -0.0364 | 0.4176 |
| 3 | 1.0 | 1.3801 | -0.6857 | -0.0927 | 0.9394 | 1.4263 | -0.7248 | -0.0985 | 0.9900 |
| 4 | 1.5 | 1.9733 | -1.1440 | -0.1585 | 1.4720 | 2.0493 | -1.1719 | -0.1651 | 1.5207 |
| 5 | 2.0 | 2.5210 | -1.5450 | -0.2203 | 1.9401 | 2.5797 | -1.5768 | -0.2269 | 1.9883 |
| 6 | 2.5 | 2.9667 | -1.9024 | -0.2728 | 2.3461 | 3.0403 | -1.9352 | -0.2794 | 2.3970 |
| 7 | 3.0 | 3.3763 | -2.2144 | -0.3149 | 2.7024 | 3.4491 | -2.2498 | -0.3221 | 2.7549 |
| 8 | 3.5 | 3.7210 | -2.4863 | -0.3468 | 3.0134 | 3.8108 | -2.5247 | -0.3547 | 3.0695 |
| 9 | 4.0 | 4.0396 | -2.7246 | -0.3697 | 3.2884 | 4.1264 | -2.7646 | -0.3785 | 3.3468 |
| 10 | 4.5 | 4.3137 | -2.9321 | -0.3846 | 3.5308 | 4.4084 | -2.9738 | -0.3943 | 3.5923 |
| 11 | 5.0 | 4.5688 | -3.1150 | -0.3931 | 3.7468 | 4.6666 | -3.1584 | -0.4035 | 3.8110 |
| 12 | 6.0 | 4.3566 | -3.1213 | -0.3545 | 3.7014 | 4.4343 | -3.1538 | -0.3620 | 3.7429 |
| 13 | 7.0 | 4.0702 | -2.8761 | -0.2748 | 3.4175 | 4.2189 | -2.9733 | -0.2887 | 3.5456 |
| 14 | 8.0 | 3.9741 | -2.7432 | -0.2077 | 3.3051 | 4.0854 | -2.8338 | -0.2240 | 3.4105 |
| 15 | 9.0 | 3.8766 | -2.6459 | -0.1564 | 3.2074 | 4.0000 | -2.7395 | -0.1751 | 3.3223 |
| 16 | 10.0 | 3.8411 | -2.5804 | -0.1216 | 3.1543 | 3.9476 | -2.6786 | -0.1407 | 3.2666 |
| 17 | 11.0 | 3.8015 | -2.5429 | -0.0977 | 3.1171 | 3.9191 | -2.6398 | -0.1174 | 3.2313 |
| 18 | 12.0 | 3.7890 | -2.5165 | -0.0825 | 3.0955 | 3.9017 | -2.6169 | -0.1023 | 3.2097 |
| 19 | 13.0 | 3.7703 | -2.5027 | -0.0725 | 3.0805 | 3.8919 | -2.6044 | -0.0928 | 3.1971 |
| 20 | 14.0 | 3.7657 | -2.4923 | -0.0664 | 3.0714 | 3.8872 | -2.5980 | -0.0869 | 3.1897 |
| 21 | 15.0 | 3.7550 | -2.4861 | -0.0624 | 3.0641 | 3.8852 | -2.5940 | -0.0830 | 3.1849 |
| 22 | 16.0 | 3.5601 | -2.3912 | -0.0475 | 2.9352 | 3.6538 | -2.4666 | -0.0642 | 3.0159 |
| 23 | 17.0 | 3.3585 | -2.2400 | -0.0250 | 2.7553 | 3.4771 | -2.3347 | -0.0427 | 2.8626 |
| 24 | 18.0 | 3.2381 | -2.1362 | -0.0089 | 2.6431 | 3.3439 | -2.2297 | -0.0269 | 2.7442 |
| 25 | 19.0 | 3.1254 | -2.0520 | 0.0015 | 2.5464 | 3.2404 | -2.1467 | -0.0170 | 2.6509 |
| 26 | 20.0 | 3.0475 | -1.9846 | 0.0068 | 2.4724 | 3.1560 | -2.0808 | -0.0121 | 2.5760 |
| 27 | 21.0 | 2.9730 | -1.9299 | 0.0094 | 2.4095 | 3.0806 | -2.0275 | -0.0103 | 2.5148 |
| 28 | 22.0 | 2.9180 | -1.8822 | 0.0102 | 2.3572 | 3.0246 | -1.9822 | -0.0097 | 2.4633 |
| 29 | 23.0 | 2.8639 | -1.8407 | 0.0104 | 2.3111 | 2.9768 | -1.9425 | -0.0097 | 2.4190 |
| 30 | 24.0 | 2.8224 | -1.8022 | 0.0105 | 2.2706 | 2.9263 | -1.9069 | -0.0101 | 2.3801 |
| 31 | 25.0 | 2.7812 | -1.7665 | 0.0111 | 2.2336 | 2.8812 | -1.8743 | -0.0100 | 2.3454 |
| 32 | 26.0 | 2.6845 | -1.7028 | 0.0162 | 2.1589 | 2.7775 | -1.8018 | -0.0035 | 2.2592 |
| 33 | 27.0 | 2.5870 | -1.6213 | 0.0249 | 2.0693 | 2.6917 | -1.7287 | 0.0049 | 2.1806 |
| 34 | 28.0 | 2.5217 | -1.5570 | 0.0323 | 2.0045 | 2.6145 | -1.6650 | 0.0126 | 2.1154 |
| 35 | 29.0 | 2.4599 | -1.5002 | 0.0385 | 1.9465 | 2.5535 | -1.6092 | 0.0196 | 2.0604 |
| 36 | 30.0 | 2.4137 | -1.4498 | 0.0437 | 1.8978 | 2.5087 | -1.5597 | 0.0260 | 2.0129 |
| 37 | 31.0 | 2.3692 | -1.4044 | 0.0485 | 1.8542 | 2.4657 | -1.5142 | 0.0316 | 1.9705 |
| 38 | 32.0 | 2.3347 | -1.3622 | 0.0532 | 1.8156 | 2.4200 | -1.4714 | 0.0366 | 1.9320 |
| 39 | 33.0 | 2.3008 | -1.3227 | 0.0582 | 1.7801 | 2.3830 | -1.4309 | 0.0414 | 1.8970 |
| 40 | 34.0 | 2.2736 | -1.2849 | 0.0636 | 1.7477 | 2.3578 | -1.3929 | 0.0462 | 1.8656 |
| 41 | 35.0 | 2.2471 | -1.2487 | 0.0694 | 1.7174 | 2.3321 | -1.3572 | 0.0508 | 1.8369 |
| 42 | 37.0 | 2.0825 | -1.1117 | 0.0917 | 1.5744 | 2.1388 | -1.2478 | 0.0659 | 1.7143 |
| 43 | 39.0 | 1.9586 | -0.9706 | 0.1166 | 1.4395 | 2.0212 | -1.1251 | 0.0852 | 1.5987 |
| 44 | 41.0 | 1.8926 | -0.8813 | 0.1338 | 1.3646 | 1.9210 | -1.0307 | 0.0999 | 1.5148 |
| 45 | 43.0 | 1.8298 | -0.7957 | 0.1497 | 1.2910 | 1.8475 | -0.9531 | 0.1125 | 1.4497 |
| 46 | 45.0 | 1.7923 | -0.7252 | 0.1656 | 1.2380 | 1.8015 | -0.8836 | 0.1253 | 1.3966 |
| 47 | 47.5 | 1.6002 | -0.5561 | 0.1985 | 1.0663 | 1.6571 | -0.7032 | 0.1554 | 1.2143 |
| 48 | 50.0 | 1.4827 | -0.3987 | 0.2311 | 0.9249 | 1.4886 | -0.5692 | 0.1796 | 1.0934 |
| 49 | 52.5 | 1.4220 | -0.3073 | 0.2526 | 0.8534 | 1.4259 | -0.4709 | 0.1988 | 1.0128 |
| 50 | 55.0 | 1.3701 | -0.2158 | 0.2738 | 0.7803 | 1.4067 | -0.3884 | 0.2174 | 0.9527 |
| 51 | 57.5 | 1.3406 | -0.1439 | 0.2953 | 0.7321 | 1.3687 | -0.3168 | 0.2360 | 0.9036 |
| 52 | 60.0 | 1.3147 | -0.0727 | 0.3177 | 0.6835 | 1.3118 | -0.2520 | 0.2547 | 0.8605 |
| 53 | 62.5 | 1.2997 | -0.0108 | 0.3405 | 0.6465 | 1.2858 | -0.1926 | 0.2745 | 0.8250 |
| 54 | 65.0 | 1.2871 | 0.0487 | 0.3635 | 0.6107 | 1.2914 | -0.1381 | 0.2948 | 0.7960 |

| | | | | | | | | | |
|-----|-------|---------|--------|--------|---------|---------|---------|--------|---------|
| 55 | 67.5 | 1.2802 | 0.1027 | 0.3862 | 0.5812 | 1.2981 | -0.0874 | 0.3149 | 0.7704 |
| 56 | 70.0 | 1.2747 | 0.1539 | 0.4086 | 0.5532 | 1.2756 | -0.0401 | 0.3344 | 0.7459 |
| 57 | 73.0 | 0.9319 | 0.4134 | 0.4621 | 0.2681 | 0.8979 | 0.2659 | 0.3936 | 0.4188 |
| 58 | 76.0 | 0.7494 | 0.6333 | 0.5055 | 0.0571 | 0.7617 | 0.4354 | 0.4253 | 0.2571 |
| 59 | 79.0 | 0.6869 | 0.7090 | 0.5196 | -0.0038 | 0.6696 | 0.5418 | 0.4431 | 0.1621 |
| 60 | 82.0 | 0.6160 | 0.8046 | 0.5364 | -0.0911 | 0.5861 | 0.6211 | 0.4585 | 0.0967 |
| 61 | 85.0 | 0.5984 | 0.8586 | 0.5528 | -0.1229 | 0.5729 | 0.6861 | 0.4758 | 0.0519 |
| 62 | 88.0 | 0.5680 | 0.9202 | 0.5713 | -0.1705 | 0.5707 | 0.7404 | 0.4939 | 0.0191 |
| 63 | 91.0 | 0.5671 | 0.9625 | 0.5892 | -0.1906 | 0.5326 | 0.7865 | 0.5115 | -0.0078 |
| 64 | 94.0 | 0.5554 | 1.0052 | 0.6074 | -0.2181 | 0.5266 | 0.8260 | 0.5292 | -0.0269 |
| 65 | 97.0 | 0.5615 | 1.0382 | 0.6242 | -0.2309 | 0.5545 | 0.8599 | 0.5465 | -0.0396 |
| 66 | 100.0 | 0.5590 | 1.0684 | 0.6404 | -0.2471 | 0.5399 | 0.8889 | 0.5616 | -0.0514 |
| 67 | 105.0 | 0.3278 | 1.2631 | 0.6841 | -0.4517 | 0.2851 | 1.1035 | 0.6071 | -0.2750 |
| 68 | 110.0 | 0.2614 | 1.3679 | 0.7070 | -0.5430 | 0.2405 | 1.1861 | 0.6252 | -0.3456 |
| 69 | 115.0 | 0.2570 | 1.3854 | 0.7130 | -0.5486 | 0.2316 | 1.2324 | 0.6394 | -0.3766 |
| 70 | 120.0 | 0.2378 | 1.4318 | 0.7290 | -0.5850 | 0.1983 | 1.2610 | 0.6524 | -0.3922 |
| 71 | 125.0 | 0.2576 | 1.4364 | 0.7392 | -0.5745 | 0.1956 | 1.2786 | 0.6644 | -0.3967 |
| 72 | 130.0 | 0.2542 | 1.4542 | 0.7495 | -0.5873 | 0.2291 | 1.2872 | 0.6745 | -0.3927 |
| 73 | 135.0 | 0.2769 | 1.4495 | 0.7561 | -0.5722 | 0.2521 | 1.2887 | 0.6820 | -0.3851 |
| 74 | 140.0 | 0.2787 | 1.4516 | 0.7614 | -0.5738 | 0.2401 | 1.2854 | 0.6869 | -0.3775 |
| 75 | 145.0 | 0.2993 | 1.4412 | 0.7641 | -0.5579 | 0.2409 | 1.2784 | 0.6902 | -0.3673 |
| 76 | 150.0 | 0.3022 | 1.4348 | 0.7656 | -0.5539 | 0.2805 | 1.2683 | 0.6924 | -0.3535 |
| 77 | 155.0 | 0.3197 | 1.4211 | 0.7653 | -0.5386 | 0.3030 | 1.2561 | 0.6928 | -0.3402 |
| 78 | 160.0 | 0.3227 | 1.4096 | 0.7642 | -0.5316 | 0.2860 | 1.2423 | 0.6912 | -0.3289 |
| 79 | 165.0 | 0.0929 | 1.5487 | 0.7811 | -0.7082 | 0.0677 | 1.3950 | 0.7125 | -0.5075 |
| 80 | 170.0 | 0.0224 | 1.6071 | 0.7797 | -0.7786 | 0.0259 | 1.4274 | 0.7052 | -0.5546 |
| 81 | 175.0 | 0.0140 | 1.5829 | 0.7634 | -0.7658 | 0.0125 | 1.4320 | 0.6970 | -0.5685 |
| 82 | 180.0 | -0.0118 | 1.5935 | 0.7591 | -0.7875 | -0.0263 | 1.4248 | 0.6895 | -0.5704 |
| 83 | 185.0 | 0.0032 | 1.5650 | 0.7508 | -0.7633 | -0.0405 | 1.4095 | 0.6824 | -0.5631 |
| 84 | 190.0 | -0.0062 | 1.5537 | 0.7441 | -0.7646 | -0.0060 | 1.3882 | 0.6749 | -0.5483 |
| 85 | 195.0 | 0.0119 | 1.5215 | 0.7350 | -0.7384 | 0.0143 | 1.3622 | 0.6662 | -0.5312 |
| 86 | 200.0 | 0.0082 | 1.4987 | 0.7257 | -0.7301 | -0.0079 | 1.3342 | 0.6563 | -0.5153 |
| 87 | 210.0 | 0.0320 | 1.4334 | 0.7034 | -0.6859 | -0.0101 | 1.2733 | 0.6349 | -0.4790 |
| 88 | 220.0 | 0.0347 | 1.3720 | 0.6788 | -0.6551 | 0.0467 | 1.2082 | 0.6116 | -0.4379 |
| 89 | 230.0 | 0.0535 | 1.3029 | 0.6520 | -0.6120 | 0.0708 | 1.1426 | 0.5863 | -0.3995 |
| 90 | 240.0 | 0.0526 | 1.2401 | 0.6248 | -0.5819 | 0.0325 | 1.0782 | 0.5592 | -0.3664 |
| 91 | 250.0 | 0.0662 | 1.1738 | 0.5969 | -0.5428 | 0.0296 | 1.0144 | 0.5321 | -0.3324 |
| 92 | 260.0 | 0.0628 | 1.1139 | 0.5696 | -0.5150 | 0.0792 | 0.9516 | 0.5054 | -0.2966 |
| 93 | 270.0 | 0.0732 | 1.0524 | 0.5423 | -0.4803 | 0.0923 | 0.8913 | 0.4785 | -0.2647 |
| 94 | 280.0 | 0.0680 | 0.9963 | 0.5159 | -0.4550 | 0.0541 | 0.8336 | 0.4514 | -0.2377 |
| 95 | 290.0 | 0.0757 | 0.9401 | 0.4899 | -0.4242 | 0.0422 | 0.7781 | 0.4254 | -0.2107 |
| 96 | 300.0 | 0.0697 | 0.8885 | 0.4651 | -0.4014 | 0.0839 | 0.7246 | 0.4009 | -0.1816 |
| 97 | 320.0 | 0.0750 | 0.7900 | 0.4177 | -0.3512 | 0.1218 | 0.6269 | 0.3546 | -0.1316 |
| 98 | 340.0 | 0.0665 | 0.7025 | 0.3743 | -0.3120 | 0.0670 | 0.5394 | 0.3108 | -0.0928 |
| 99 | 360.0 | 0.0690 | 0.6224 | 0.3343 | -0.2722 | 0.0068 | 0.4593 | 0.2699 | -0.0584 |
| 100 | 380.0 | 0.0591 | 0.5520 | 0.2983 | -0.2419 | 0.0198 | 0.3886 | 0.2345 | -0.0244 |
| 101 | 400.0 | 0.0604 | 0.4881 | 0.2654 | -0.2105 | 0.0894 | 0.3235 | 0.2028 | 0.0100 |
| 102 | 420.0 | 0.0504 | 0.4317 | 0.2361 | -0.1871 | 0.1075 | 0.2665 | 0.1739 | 0.0374 |
| 103 | 440.0 | 0.0515 | 0.3809 | 0.2094 | -0.1624 | 0.0598 | 0.2165 | 0.1471 | 0.0573 |
| 104 | 460.0 | 0.0417 | 0.3362 | 0.1858 | -0.1446 | -0.0062 | 0.1716 | 0.1224 | 0.0737 |
| 105 | 480.0 | 0.0428 | 0.2961 | 0.1645 | -0.1250 | 0.0010 | 0.1320 | 0.1017 | 0.0920 |
| 106 | 500.0 | 0.0338 | 0.2610 | 0.1457 | -0.1116 | 0.0677 | 0.0955 | 0.0837 | 0.1124 |

表4. 3(4) 評価断面3の応力テンソル成分4

F I N A S解と簡易計算値との比較 (コールドショック)

断面3の応力成分4

| ステップ | 時間(S) | F I N A S解 | | | | 簡易計算値 | | | |
|------|-------|------------|---------|---------|---------|---------|---------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.0040 | 0.0058 | 0.0079 | -0.0074 | -0.0045 | 0.0070 | 0.0090 | -0.0089 |
| 3 | 1.0 | -0.0089 | 0.0186 | 0.0264 | -0.0238 | -0.0092 | 0.0193 | 0.0277 | -0.0255 |
| 4 | 1.5 | -0.0129 | 0.0323 | 0.0480 | -0.0416 | -0.0135 | 0.0326 | 0.0493 | -0.0434 |
| 5 | 2.0 | -0.0165 | 0.0453 | 0.0696 | -0.0585 | -0.0172 | 0.0456 | 0.0709 | -0.0610 |
| 6 | 2.5 | -0.0195 | 0.0576 | 0.0900 | -0.0740 | -0.0204 | 0.0580 | 0.0914 | -0.0774 |
| 7 | 3.0 | -0.0223 | 0.0691 | 0.1088 | -0.0883 | -0.0233 | 0.0695 | 0.1104 | -0.0926 |
| 8 | 3.5 | -0.0247 | 0.0797 | 0.1260 | -0.1013 | -0.0260 | 0.0798 | 0.1278 | -0.1065 |
| 9 | 4.0 | -0.0271 | 0.0896 | 0.1417 | -0.1132 | -0.0282 | 0.0891 | 0.1437 | -0.1190 |
| 10 | 4.5 | -0.0291 | 0.0938 | 0.1561 | -0.1241 | -0.0303 | 0.0977 | 0.1581 | -0.1305 |
| 11 | 5.0 | -0.0311 | 0.1074 | 0.1692 | -0.1342 | -0.0324 | 0.1055 | 0.1714 | -0.1411 |
| 12 | 6.0 | -0.0303 | 0.1149 | 0.1806 | -0.1415 | -0.0316 | 0.1113 | 0.1822 | -0.1485 |
| 13 | 7.0 | -0.0292 | 0.1142 | 0.1777 | -0.1382 | -0.0308 | 0.1106 | 0.1809 | -0.1470 |
| 14 | 8.0 | -0.0290 | 0.1146 | 0.1749 | -0.1367 | -0.0305 | 0.1091 | 0.1787 | -0.1453 |
| 15 | 9.0 | -0.0289 | 0.1151 | 0.1735 | -0.1361 | -0.0306 | 0.1089 | 0.1774 | -0.1445 |
| 16 | 10.0 | -0.0289 | 0.1157 | 0.1731 | -0.1360 | -0.0307 | 0.1092 | 0.1774 | -0.1450 |
| 17 | 11.0 | -0.0289 | 0.1165 | 0.1733 | -0.1362 | -0.0309 | 0.1101 | 0.1781 | -0.1464 |
| 18 | 12.0 | -0.0289 | 0.1171 | 0.1738 | -0.1365 | -0.0311 | 0.1111 | 0.1791 | -0.1481 |
| 19 | 13.0 | -0.0289 | 0.1176 | 0.1744 | -0.1369 | -0.0311 | 0.1123 | 0.1801 | -0.1497 |
| 20 | 14.0 | -0.0289 | 0.1180 | 0.1748 | -0.1372 | -0.0310 | 0.1136 | 0.1810 | -0.1511 |
| 21 | 15.0 | -0.0289 | 0.1183 | 0.1751 | -0.1374 | -0.0308 | 0.1147 | 0.1815 | -0.1520 |
| 22 | 16.0 | -0.0276 | 0.1160 | 0.1715 | -0.1343 | -0.0291 | 0.1126 | 0.1771 | -0.1485 |
| 23 | 17.0 | -0.0264 | 0.1117 | 0.1644 | -0.1286 | -0.0277 | 0.1098 | 0.1705 | -0.1438 |
| 24 | 18.0 | -0.0255 | 0.1080 | 0.1578 | -0.1238 | -0.0267 | 0.1070 | 0.1641 | -0.1399 |
| 25 | 19.0 | -0.0248 | 0.1046 | 0.1519 | -0.1197 | -0.0258 | 0.1044 | 0.1585 | -0.1367 |
| 26 | 20.0 | -0.0242 | 0.1014 | 0.1466 | -0.1160 | -0.0251 | 0.1021 | 0.1535 | -0.1343 |
| 27 | 21.0 | -0.0236 | 0.0986 | 0.1417 | -0.1126 | -0.0244 | 0.1000 | 0.1489 | -0.1323 |
| 28 | 22.0 | -0.0232 | 0.0958 | 0.1370 | -0.1095 | -0.0237 | 0.0980 | 0.1446 | -0.1305 |
| 29 | 23.0 | -0.0228 | 0.0933 | 0.1325 | -0.1066 | -0.0232 | 0.0962 | 0.1405 | -0.1287 |
| 30 | 24.0 | -0.0224 | 0.0908 | 0.1281 | -0.1038 | -0.0226 | 0.0944 | 0.1364 | -0.1271 |
| 31 | 25.0 | -0.0221 | 0.0883 | 0.1238 | -0.1011 | -0.0221 | 0.0925 | 0.1322 | -0.1253 |
| 32 | 26.0 | -0.0214 | 0.0852 | 0.1183 | -0.0974 | -0.0211 | 0.0894 | 0.1266 | -0.1219 |
| 33 | 27.0 | -0.0207 | 0.0815 | 0.1118 | -0.0931 | -0.0203 | 0.0859 | 0.1202 | -0.1181 |
| 34 | 28.0 | -0.0203 | 0.0782 | 0.1055 | -0.0892 | -0.0196 | 0.0823 | 0.1141 | -0.1144 |
| 35 | 29.0 | -0.0199 | 0.0751 | 0.0997 | -0.0856 | -0.0190 | 0.0789 | 0.1083 | -0.1111 |
| 36 | 30.0 | -0.0195 | 0.0722 | 0.0941 | -0.0823 | -0.0186 | 0.0759 | 0.1028 | -0.1083 |
| 37 | 31.0 | -0.0192 | 0.0695 | 0.0888 | -0.0792 | -0.0183 | 0.0732 | 0.0978 | -0.1059 |
| 38 | 32.0 | -0.0190 | 0.0668 | 0.0837 | -0.0763 | -0.0180 | 0.0707 | 0.0930 | -0.1039 |
| 39 | 33.0 | -0.0187 | 0.0644 | 0.0788 | -0.0735 | -0.0176 | 0.0687 | 0.0884 | -0.1023 |
| 40 | 34.0 | -0.0185 | 0.0620 | 0.0740 | -0.0708 | -0.0174 | 0.0667 | 0.0840 | -0.1007 |
| 41 | 35.0 | -0.0183 | 0.0598 | 0.0693 | -0.0682 | -0.0171 | 0.0648 | 0.0796 | -0.0990 |
| 42 | 37.0 | -0.0173 | 0.0537 | 0.0573 | -0.0609 | -0.0154 | 0.0591 | 0.0694 | -0.0936 |
| 43 | 39.0 | -0.0165 | 0.0472 | 0.0444 | -0.0531 | -0.0142 | 0.0521 | 0.0574 | -0.0869 |
| 44 | 41.0 | -0.0161 | 0.0421 | 0.0337 | -0.0472 | -0.0130 | 0.0459 | 0.0469 | -0.0812 |
| 45 | 43.0 | -0.0157 | 0.0373 | 0.0239 | -0.0418 | -0.0121 | 0.0411 | 0.0374 | -0.0765 |
| 46 | 45.0 | -0.0155 | 0.0332 | 0.0148 | -0.0371 | -0.0114 | 0.0367 | 0.0286 | -0.0724 |
| 47 | 47.5 | -0.0144 | 0.0259 | 0.0004 | -0.0284 | -0.0098 | 0.0289 | 0.0141 | -0.0640 |
| 48 | 50.0 | -0.0136 | 0.0187 | -0.0144 | -0.0198 | -0.0080 | 0.0220 | 0.0005 | -0.0558 |
| 49 | 52.5 | -0.0133 | 0.0134 | -0.0258 | -0.0138 | -0.0071 | 0.0165 | -0.0111 | -0.0495 |
| 50 | 55.0 | -0.0130 | 0.0085 | -0.0363 | -0.0082 | -0.0065 | 0.0117 | -0.0213 | -0.0444 |
| 51 | 57.5 | -0.0129 | 0.0044 | -0.0457 | -0.0036 | -0.0059 | 0.0076 | -0.0305 | -0.0398 |
| 52 | 60.0 | -0.0129 | 0.0007 | -0.0544 | 0.0006 | -0.0052 | 0.0039 | -0.0389 | -0.0359 |
| 53 | 62.5 | -0.0129 | -0.0024 | -0.0623 | 0.0043 | -0.0048 | 0.0005 | -0.0466 | -0.0325 |
| 54 | 65.0 | -0.0130 | -0.0054 | -0.0697 | 0.0077 | -0.0046 | -0.0024 | -0.0537 | -0.0296 |

| | | | | | | | | | |
|-----|-------|---------|---------|---------|--------|---------|---------|---------|---------|
| 55 | 67.5 | -0.0131 | -0.0080 | -0.0764 | 0.0107 | -0.0045 | -0.0052 | -0.0602 | -0.0269 |
| 56 | 70.0 | -0.0132 | -0.0103 | -0.0827 | 0.0134 | -0.0042 | -0.0077 | -0.0664 | -0.0246 |
| 57 | 73.0 | -0.0111 | -0.0191 | -0.0993 | 0.0243 | -0.0015 | -0.0179 | -0.0854 | -0.0122 |
| 58 | 76.0 | -0.0100 | -0.0281 | -0.1166 | 0.0352 | -0.0004 | -0.0254 | -0.1001 | -0.0034 |
| 59 | 79.0 | -0.0096 | -0.0331 | -0.1267 | 0.0407 | 0.0006 | -0.0309 | -0.1113 | 0.0029 |
| 60 | 82.0 | -0.0091 | -0.0380 | -0.1363 | 0.0463 | 0.0014 | -0.0353 | -0.1207 | 0.0079 |
| 61 | 85.0 | -0.0090 | -0.0414 | -0.1439 | 0.0500 | 0.0017 | -0.0388 | -0.1285 | 0.0116 |
| 62 | 88.0 | -0.0089 | -0.0443 | -0.1506 | 0.0534 | 0.0017 | -0.0420 | -0.1352 | 0.0147 |
| 63 | 91.0 | -0.0090 | -0.0465 | -0.1562 | 0.0560 | 0.0020 | -0.0445 | -0.1409 | 0.0173 |
| 64 | 94.0 | -0.0091 | -0.0484 | -0.1610 | 0.0581 | 0.0020 | -0.0466 | -0.1457 | 0.0193 |
| 65 | 97.0 | -0.0092 | -0.0499 | -0.1650 | 0.0598 | 0.0019 | -0.0482 | -0.1497 | 0.0209 |
| 66 | 100.0 | -0.0093 | -0.0510 | -0.1683 | 0.0611 | 0.0020 | -0.0494 | -0.1531 | 0.0219 |
| 67 | 105.0 | -0.0079 | -0.0575 | -0.1807 | 0.0692 | 0.0037 | -0.0563 | -0.1668 | 0.0311 |
| 68 | 110.0 | -0.0075 | -0.0624 | -0.1902 | 0.0749 | 0.0043 | -0.0602 | -0.1748 | 0.0356 |
| 69 | 115.0 | -0.0075 | -0.0641 | -0.1937 | 0.0764 | 0.0045 | -0.0625 | -0.1798 | 0.0382 |
| 70 | 120.0 | -0.0074 | -0.0658 | -0.1975 | 0.0785 | 0.0047 | -0.0639 | -0.1830 | 0.0395 |
| 71 | 125.0 | -0.0076 | -0.0660 | -0.1987 | 0.0786 | 0.0047 | -0.0646 | -0.1847 | 0.0400 |
| 72 | 130.0 | -0.0077 | -0.0662 | -0.1994 | 0.0789 | 0.0045 | -0.0647 | -0.1852 | 0.0398 |
| 73 | 135.0 | -0.0079 | -0.0657 | -0.1990 | 0.0783 | 0.0044 | -0.0645 | -0.1850 | 0.0394 |
| 74 | 140.0 | -0.0080 | -0.0652 | -0.1982 | 0.0778 | 0.0045 | -0.0639 | -0.1842 | 0.0385 |
| 75 | 145.0 | -0.0081 | -0.0644 | -0.1968 | 0.0769 | 0.0044 | -0.0632 | -0.1829 | 0.0375 |
| 76 | 150.0 | -0.0082 | -0.0637 | -0.1953 | 0.0760 | 0.0042 | -0.0623 | -0.1812 | 0.0363 |
| 77 | 155.0 | -0.0083 | -0.0628 | -0.1934 | 0.0750 | 0.0041 | -0.0614 | -0.1793 | 0.0350 |
| 78 | 160.0 | -0.0083 | -0.0619 | -0.1915 | 0.0740 | 0.0043 | -0.0605 | -0.1773 | 0.0336 |
| 79 | 165.0 | -0.0067 | -0.0660 | -0.1972 | 0.0793 | 0.0059 | -0.0654 | -0.1850 | 0.0400 |
| 80 | 170.0 | -0.0061 | -0.0689 | -0.2011 | 0.0827 | 0.0064 | -0.0670 | -0.1870 | 0.0421 |
| 81 | 175.0 | -0.0059 | -0.0690 | -0.1998 | 0.0823 | 0.0068 | -0.0677 | -0.1871 | 0.0428 |
| 82 | 180.0 | -0.0057 | -0.0693 | -0.1993 | 0.0827 | 0.0071 | -0.0678 | -0.1859 | 0.0427 |
| 83 | 185.0 | -0.0057 | -0.0682 | -0.1967 | 0.0813 | 0.0073 | -0.0673 | -0.1837 | 0.0420 |
| 84 | 190.0 | -0.0056 | -0.0673 | -0.1940 | 0.0803 | 0.0072 | -0.0662 | -0.1807 | 0.0407 |
| 85 | 195.0 | -0.0056 | -0.0659 | -0.1903 | 0.0785 | 0.0072 | -0.0649 | -0.1772 | 0.0393 |
| 86 | 200.0 | -0.0055 | -0.0645 | -0.1866 | 0.0770 | 0.0074 | -0.0634 | -0.1734 | 0.0377 |
| 87 | 210.0 | -0.0055 | -0.0612 | -0.1783 | 0.0731 | 0.0074 | -0.0602 | -0.1653 | 0.0341 |
| 88 | 220.0 | -0.0054 | -0.0580 | -0.1698 | 0.0693 | 0.0072 | -0.0569 | -0.1566 | 0.0302 |
| 89 | 230.0 | -0.0053 | -0.0547 | -0.1611 | 0.0655 | 0.0072 | -0.0536 | -0.1480 | 0.0264 |
| 90 | 240.0 | -0.0051 | -0.0517 | -0.1527 | 0.0618 | 0.0076 | -0.0505 | -0.1397 | 0.0227 |
| 91 | 250.0 | -0.0050 | -0.0486 | -0.1445 | 0.0582 | 0.0078 | -0.0474 | -0.1315 | 0.0191 |
| 92 | 260.0 | -0.0048 | -0.0459 | -0.1366 | 0.0549 | 0.0077 | -0.0445 | -0.1234 | 0.0157 |
| 93 | 270.0 | -0.0046 | -0.0431 | -0.1290 | 0.0516 | 0.0078 | -0.0418 | -0.1157 | 0.0124 |
| 94 | 280.0 | -0.0044 | -0.0406 | -0.1218 | 0.0486 | 0.0082 | -0.0392 | -0.1085 | 0.0093 |
| 95 | 290.0 | -0.0042 | -0.0382 | -0.1149 | 0.0457 | 0.0085 | -0.0367 | -0.1015 | 0.0064 |
| 96 | 300.0 | -0.0040 | -0.0359 | -0.1084 | 0.0430 | 0.0084 | -0.0344 | -0.0948 | 0.0036 |
| 97 | 320.0 | -0.0037 | -0.0317 | -0.0962 | 0.0380 | 0.0086 | -0.0302 | -0.0826 | -0.0014 |
| 98 | 340.0 | -0.0033 | -0.0280 | -0.0853 | 0.0335 | 0.0092 | -0.0264 | -0.0717 | -0.0059 |
| 99 | 360.0 | -0.0030 | -0.0247 | -0.0755 | 0.0295 | 0.0098 | -0.0230 | -0.0619 | -0.0099 |
| 100 | 380.0 | -0.0027 | -0.0218 | -0.0668 | 0.0261 | 0.0100 | -0.0201 | -0.0532 | -0.0135 |
| 101 | 400.0 | -0.0024 | -0.0192 | -0.0590 | 0.0229 | 0.0099 | -0.0174 | -0.0451 | -0.0167 |
| 102 | 420.0 | -0.0021 | -0.0169 | -0.0521 | 0.0202 | 0.0101 | -0.0151 | -0.0382 | -0.0194 |
| 103 | 440.0 | -0.0019 | -0.0149 | -0.0460 | 0.0178 | 0.0105 | -0.0130 | -0.0321 | -0.0219 |
| 104 | 460.0 | -0.0017 | -0.0131 | -0.0406 | 0.0156 | 0.0110 | -0.0112 | -0.0267 | -0.0241 |
| 105 | 480.0 | -0.0015 | -0.0115 | -0.0357 | 0.0138 | 0.0112 | -0.0096 | -0.0219 | -0.0260 |
| 106 | 500.0 | -0.0013 | -0.0101 | -0.0315 | 0.0120 | 0.0110 | -0.0082 | -0.0174 | -0.0277 |

表4. 4(1) 評価断面4の応力テンソル成分1

FINAS解と簡易計算値との比較 (コールドショック)

断面4の応力成分1

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|--------|---------|--------|--------|--------|---------|--------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.0501 | 0.0014 | 0.0008 | 0.0054 | 0.0382 | 0.0015 | 0.0003 | 0.0042 |
| 3 | 1.0 | 0.0638 | 0.0049 | -0.0002 | 0.0129 | 0.0627 | 0.0049 | -0.0004 | 0.0128 |
| 4 | 1.5 | 0.0843 | 0.0106 | -0.0024 | 0.0241 | 0.0880 | 0.0116 | -0.0024 | 0.0238 |
| 5 | 2.0 | 0.1000 | 0.0182 | -0.0071 | 0.0357 | 0.1100 | 0.0206 | -0.0062 | 0.0357 |
| 6 | 2.5 | 0.1158 | 0.0275 | -0.0137 | 0.0481 | 0.1316 | 0.0308 | -0.0120 | 0.0482 |
| 7 | 3.0 | 0.1317 | 0.0380 | -0.0222 | 0.0606 | 0.1537 | 0.0417 | -0.0201 | 0.0613 |
| 8 | 3.5 | 0.1460 | 0.0492 | -0.0326 | 0.0731 | 0.1745 | 0.0533 | -0.0296 | 0.0740 |
| 9 | 4.0 | 0.1620 | 0.0611 | -0.0444 | 0.0857 | 0.1961 | 0.0655 | -0.0405 | 0.0869 |
| 10 | 4.5 | 0.1754 | 0.0734 | -0.0576 | 0.0980 | 0.2177 | 0.0780 | -0.0528 | 0.0999 |
| 11 | 5.0 | 0.1912 | 0.0858 | -0.0719 | 0.1104 | 0.2386 | 0.0907 | -0.0664 | 0.1127 |
| 12 | 6.0 | 0.1796 | 0.1087 | -0.1034 | 0.1275 | 0.2500 | 0.1135 | -0.0962 | 0.1326 |
| 13 | 7.0 | 0.1998 | 0.1279 | -0.1347 | 0.1399 | 0.2641 | 0.1313 | -0.1273 | 0.1466 |
| 14 | 8.0 | 0.2052 | 0.1438 | -0.1650 | 0.1487 | 0.2781 | 0.1464 | -0.1575 | 0.1590 |
| 15 | 9.0 | 0.2206 | 0.1578 | -0.1934 | 0.1578 | 0.2931 | 0.1616 | -0.1870 | 0.1700 |
| 16 | 10.0 | 0.2288 | 0.1708 | -0.2212 | 0.1654 | 0.3073 | 0.1748 | -0.2161 | 0.1802 |
| 17 | 11.0 | 0.2422 | 0.1834 | -0.2482 | 0.1733 | 0.3221 | 0.1870 | -0.2439 | 0.1903 |
| 18 | 12.0 | 0.2511 | 0.1960 | -0.2751 | 0.1803 | 0.3382 | 0.1988 | -0.2707 | 0.2001 |
| 19 | 13.0 | 0.2636 | 0.2082 | -0.3018 | 0.1876 | 0.3555 | 0.2110 | -0.2968 | 0.2092 |
| 20 | 14.0 | 0.2728 | 0.2204 | -0.3285 | 0.1943 | 0.3722 | 0.2232 | -0.3223 | 0.2179 |
| 21 | 15.0 | 0.2846 | 0.2324 | -0.3550 | 0.2011 | 0.3877 | 0.2362 | -0.3477 | 0.2262 |
| 22 | 16.0 | 0.2825 | 0.2436 | -0.3816 | 0.2055 | 0.3929 | 0.2493 | -0.3739 | 0.2319 |
| 23 | 17.0 | 0.2912 | 0.2535 | -0.4072 | 0.2087 | 0.4008 | 0.2601 | -0.4000 | 0.2362 |
| 24 | 18.0 | 0.2943 | 0.2622 | -0.4318 | 0.2109 | 0.4085 | 0.2686 | -0.4249 | 0.2398 |
| 25 | 19.0 | 0.3016 | 0.2704 | -0.4552 | 0.2133 | 0.4157 | 0.2763 | -0.4493 | 0.2429 |
| 26 | 20.0 | 0.3060 | 0.2781 | -0.4780 | 0.2153 | 0.4224 | 0.2839 | -0.4730 | 0.2455 |
| 27 | 21.0 | 0.3129 | 0.2856 | -0.5001 | 0.2175 | 0.4283 | 0.2913 | -0.4958 | 0.2479 |
| 28 | 22.0 | 0.3180 | 0.2931 | -0.5218 | 0.2196 | 0.4341 | 0.2986 | -0.5179 | 0.2503 |
| 29 | 23.0 | 0.3245 | 0.3007 | -0.5431 | 0.2218 | 0.4402 | 0.3063 | -0.5398 | 0.2528 |
| 30 | 24.0 | 0.3296 | 0.3083 | -0.5641 | 0.2240 | 0.4466 | 0.3133 | -0.5613 | 0.2557 |
| 31 | 25.0 | 0.3359 | 0.3157 | -0.5849 | 0.2263 | 0.4532 | 0.3203 | -0.5826 | 0.2589 |
| 32 | 26.0 | 0.3375 | 0.3227 | -0.6054 | 0.2278 | 0.4565 | 0.3271 | -0.6037 | 0.2613 |
| 33 | 27.0 | 0.3429 | 0.3297 | -0.6254 | 0.2289 | 0.4606 | 0.3338 | -0.6245 | 0.2629 |
| 34 | 28.0 | 0.3466 | 0.3358 | -0.6448 | 0.2300 | 0.4649 | 0.3405 | -0.6448 | 0.2641 |
| 35 | 29.0 | 0.3514 | 0.3419 | -0.6637 | 0.2310 | 0.4694 | 0.3473 | -0.6647 | 0.2650 |
| 36 | 30.0 | 0.3551 | 0.3480 | -0.6823 | 0.2320 | 0.4742 | 0.3542 | -0.6840 | 0.2658 |
| 37 | 31.0 | 0.3599 | 0.3541 | -0.7004 | 0.2331 | 0.4792 | 0.3609 | -0.7028 | 0.2665 |
| 38 | 32.0 | 0.3636 | 0.3599 | -0.7183 | 0.2343 | 0.4842 | 0.3675 | -0.7211 | 0.2676 |
| 39 | 33.0 | 0.3685 | 0.3661 | -0.7359 | 0.2355 | 0.4892 | 0.3742 | -0.7392 | 0.2690 |
| 40 | 34.0 | 0.3724 | 0.3722 | -0.7533 | 0.2368 | 0.4941 | 0.3807 | -0.7571 | 0.2705 |
| 41 | 35.0 | 0.3769 | 0.3785 | -0.7705 | 0.2380 | 0.4991 | 0.3869 | -0.7749 | 0.2721 |
| 42 | 37.0 | 0.3798 | 0.3894 | -0.8039 | 0.2390 | 0.4977 | 0.3978 | -0.8096 | 0.2742 |
| 43 | 39.0 | 0.3871 | 0.3993 | -0.8352 | 0.2392 | 0.4987 | 0.4068 | -0.8426 | 0.2738 |
| 44 | 41.0 | 0.3919 | 0.4083 | -0.8646 | 0.2396 | 0.5004 | 0.4162 | -0.8730 | 0.2733 |
| 45 | 43.0 | 0.3987 | 0.4173 | -0.8928 | 0.2403 | 0.5014 | 0.4248 | -0.9017 | 0.2730 |
| 46 | 45.0 | 0.4040 | 0.4263 | -0.9200 | 0.2413 | 0.5041 | 0.4328 | -0.9291 | 0.2734 |
| 47 | 47.5 | 0.4053 | 0.4360 | -0.9521 | 0.2406 | 0.5095 | 0.4412 | -0.9618 | 0.2716 |
| 48 | 50.0 | 0.4105 | 0.4437 | -0.9811 | 0.2390 | 0.5056 | 0.4484 | -0.9923 | 0.2684 |
| 49 | 52.5 | 0.4140 | 0.4509 | -1.0074 | 0.2380 | 0.5059 | 0.4556 | -1.0210 | 0.2648 |
| 50 | 55.0 | 0.4190 | 0.4580 | -1.0321 | 0.2376 | 0.5048 | 0.4613 | -1.0480 | 0.2624 |
| 51 | 57.5 | 0.4231 | 0.4652 | -1.0556 | 0.2373 | 0.5018 | 0.4652 | -1.0740 | 0.2601 |
| 52 | 60.0 | 0.4278 | 0.4721 | -1.0780 | 0.2374 | 0.5023 | 0.4691 | -1.0987 | 0.2585 |
| 53 | 62.5 | 0.4320 | 0.4789 | -1.0994 | 0.2377 | 0.5051 | 0.4736 | -1.1221 | 0.2572 |
| 54 | 65.0 | 0.4368 | 0.4856 | -1.1199 | 0.2382 | 0.5064 | 0.4779 | -1.1442 | 0.2560 |

| | | | | | | | | | |
|-----|-------|--------|--------|---------|--------|---------|---------|---------|--------|
| 55 | 67.5 | 0.4412 | 0.4919 | -1.1397 | 0.2390 | 0.5066 | 0.4821 | -1.1655 | 0.2547 |
| 56 | 70.0 | 0.4457 | 0.4984 | -1.1588 | 0.2398 | 0.5056 | 0.4866 | -1.1863 | 0.2535 |
| 57 | 73.0 | 0.4354 | 0.5023 | -1.1788 | 0.2353 | 0.4898 | 0.4862 | -1.2085 | 0.2464 |
| 58 | 76.0 | 0.4360 | 0.5021 | -1.1922 | 0.2285 | 0.4811 | 0.4824 | -1.2235 | 0.2385 |
| 59 | 79.0 | 0.4305 | 0.5011 | -1.2012 | 0.2232 | 0.4746 | 0.4794 | -1.2341 | 0.2318 |
| 60 | 82.0 | 0.4300 | 0.5005 | -1.2081 | 0.2187 | 0.4667 | 0.4775 | -1.2424 | 0.2264 |
| 61 | 85.0 | 0.4260 | 0.4997 | -1.2134 | 0.2148 | 0.4594 | 0.4757 | -1.2492 | 0.2213 |
| 62 | 88.0 | 0.4254 | 0.4989 | -1.2173 | 0.2116 | 0.4510 | 0.4736 | -1.2544 | 0.2162 |
| 63 | 91.0 | 0.4225 | 0.4984 | -1.2203 | 0.2085 | 0.4391 | 0.4704 | -1.2586 | 0.2115 |
| 64 | 94.0 | 0.4218 | 0.4978 | -1.2222 | 0.2061 | 0.4288 | 0.4681 | -1.2622 | 0.2073 |
| 65 | 97.0 | 0.4196 | 0.4970 | -1.2237 | 0.2037 | 0.4194 | 0.4667 | -1.2654 | 0.2038 |
| 66 | 100.0 | 0.4188 | 0.4961 | -1.2244 | 0.2018 | 0.4069 | 0.4638 | -1.2683 | 0.2009 |
| 67 | 105.0 | 0.4050 | 0.4909 | -1.2216 | 0.1938 | 0.3766 | 0.4541 | -1.2694 | 0.1904 |
| 68 | 110.0 | 0.3991 | 0.4823 | -1.2115 | 0.1852 | 0.3506 | 0.4401 | -1.2634 | 0.1806 |
| 69 | 115.0 | 0.3886 | 0.4747 | -1.1983 | 0.1786 | 0.3284 | 0.4262 | -1.2548 | 0.1729 |
| 70 | 120.0 | 0.3831 | 0.4669 | -1.1839 | 0.1729 | 0.3072 | 0.4115 | -1.2433 | 0.1685 |
| 71 | 125.0 | 0.3744 | 0.4593 | -1.1685 | 0.1679 | 0.2876 | 0.3980 | -1.2305 | 0.1648 |
| 72 | 130.0 | 0.3690 | 0.4519 | -1.1525 | 0.1635 | 0.2691 | 0.3859 | -1.2174 | 0.1603 |
| 73 | 135.0 | 0.3611 | 0.4446 | -1.1363 | 0.1594 | 0.2489 | 0.3751 | -1.2040 | 0.1561 |
| 74 | 140.0 | 0.3563 | 0.4376 | -1.1198 | 0.1559 | 0.2260 | 0.3659 | -1.1906 | 0.1525 |
| 75 | 145.0 | 0.3493 | 0.4307 | -1.1034 | 0.1523 | 0.2050 | 0.3566 | -1.1773 | 0.1496 |
| 76 | 150.0 | 0.3442 | 0.4239 | -1.0872 | 0.1493 | 0.1876 | 0.3463 | -1.1643 | 0.1472 |
| 77 | 155.0 | 0.3380 | 0.4173 | -1.0712 | 0.1462 | 0.1712 | 0.3363 | -1.1511 | 0.1448 |
| 78 | 160.0 | 0.3335 | 0.4108 | -1.0553 | 0.1435 | 0.1545 | 0.3277 | -1.1377 | 0.1420 |
| 79 | 165.0 | 0.3168 | 0.4007 | -1.0368 | 0.1358 | 0.1317 | 0.3138 | -1.1206 | 0.1325 |
| 80 | 170.0 | 0.3079 | 0.3875 | -1.0123 | 0.1271 | 0.1192 | 0.2981 | -1.0973 | 0.1229 |
| 81 | 175.0 | 0.2945 | 0.3754 | -0.9860 | 0.1203 | 0.1049 | 0.2839 | -1.0724 | 0.1136 |
| 82 | 180.0 | 0.2863 | 0.3634 | -0.9593 | 0.1143 | 0.0843 | 0.2718 | -1.0471 | 0.1042 |
| 83 | 185.0 | 0.2749 | 0.3518 | -0.9323 | 0.1088 | 0.0684 | 0.2594 | -1.0221 | 0.0969 |
| 84 | 190.0 | 0.2671 | 0.3407 | -0.9055 | 0.1040 | 0.0609 | 0.2458 | -0.9979 | 0.0924 |
| 85 | 195.0 | 0.2564 | 0.3298 | -0.8789 | 0.0993 | 0.0551 | 0.2330 | -0.9736 | 0.0889 |
| 86 | 200.0 | 0.2491 | 0.3193 | -0.8527 | 0.0951 | 0.0482 | 0.2218 | -0.9489 | 0.0857 |
| 87 | 210.0 | 0.2316 | 0.2994 | -0.8019 | 0.0872 | 0.0367 | 0.1996 | -0.9017 | 0.0801 |
| 88 | 220.0 | 0.2174 | 0.2805 | -0.7532 | 0.0804 | 0.0274 | 0.1772 | -0.8572 | 0.0753 |
| 89 | 230.0 | 0.2020 | 0.2625 | -0.7071 | 0.0740 | 0.0172 | 0.1555 | -0.8148 | 0.0698 |
| 90 | 240.0 | 0.1897 | 0.2458 | -0.6634 | 0.0685 | 0.0032 | 0.1344 | -0.7743 | 0.0632 |
| 91 | 250.0 | 0.1764 | 0.2302 | -0.6223 | 0.0631 | -0.0028 | 0.1155 | -0.7365 | 0.0586 |
| 92 | 260.0 | 0.1657 | 0.2153 | -0.5836 | 0.0585 | 0.0022 | 0.1002 | -0.7006 | 0.0563 |
| 93 | 270.0 | 0.1542 | 0.2016 | -0.5472 | 0.0540 | 0.0042 | 0.0876 | -0.6660 | 0.0550 |
| 94 | 280.0 | 0.1447 | 0.1884 | -0.5130 | 0.0502 | 0.0014 | 0.0768 | -0.6322 | 0.0549 |
| 95 | 290.0 | 0.1342 | 0.1762 | -0.4810 | 0.0463 | -0.0014 | 0.0668 | -0.6000 | 0.0537 |
| 96 | 300.0 | 0.1260 | 0.1650 | -0.4508 | 0.0430 | -0.0033 | 0.0567 | -0.5696 | 0.0510 |
| 97 | 320.0 | 0.1095 | 0.1445 | -0.3959 | 0.0367 | -0.0076 | 0.0393 | -0.5147 | 0.0454 |
| 98 | 340.0 | 0.0962 | 0.1267 | -0.3475 | 0.0316 | -0.0181 | 0.0245 | -0.4662 | 0.0403 |
| 99 | 360.0 | 0.0837 | 0.1112 | -0.3050 | 0.0270 | -0.0291 | 0.0105 | -0.4226 | 0.0358 |
| 100 | 380.0 | 0.0738 | 0.0976 | -0.2675 | 0.0233 | -0.0327 | -0.0039 | -0.3856 | 0.0355 |
| 101 | 400.0 | 0.0641 | 0.0856 | -0.2347 | 0.0199 | -0.0295 | -0.0181 | -0.3526 | 0.0386 |
| 102 | 420.0 | 0.0566 | 0.0753 | -0.2057 | 0.0171 | -0.0281 | -0.0302 | -0.3232 | 0.0409 |
| 103 | 440.0 | 0.0491 | 0.0660 | -0.1804 | 0.0147 | -0.0304 | -0.0407 | -0.2967 | 0.0406 |
| 104 | 460.0 | 0.0434 | 0.0580 | -0.1581 | 0.0126 | -0.0339 | -0.0502 | -0.2726 | 0.0388 |
| 105 | 480.0 | 0.0374 | 0.0508 | -0.1386 | 0.0108 | -0.0378 | -0.0593 | -0.2518 | 0.0353 |
| 106 | 500.0 | 0.0334 | 0.0446 | -0.1214 | 0.0094 | -0.0413 | -0.0684 | -0.2333 | 0.0308 |

表4. 4 (2) 評価断面4の応力テンソル成分2

F I N A S解と簡易計算値との比較 (コールドショック)

断面4の応力成分2

| ステップ | 時間(S) | F I N A S解 | | | | 簡易計算値 | | | |
|------|-------|------------|----------|--------|---------|---------|----------|--------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.8215 | -0.1543 | 0.0066 | 0.2915 | 0.9409 | -0.1656 | 0.0074 | 0.3268 |
| 3 | 1.0 | 2.1215 | -0.5551 | 0.0199 | 0.9822 | 2.1853 | -0.5655 | 0.0206 | 1.0134 |
| 4 | 1.5 | 3.4542 | -1.1282 | 0.0360 | 1.8778 | 3.5511 | -1.1429 | 0.0371 | 1.9116 |
| 5 | 2.0 | 4.8945 | -1.8360 | 0.0539 | 2.9141 | 4.9764 | -1.8520 | 0.0553 | 2.9454 |
| 6 | 2.5 | 6.3358 | -2.6397 | 0.0727 | 4.0375 | 6.4368 | -2.6555 | 0.0747 | 4.0681 |
| 7 | 3.0 | 7.8196 | -3.5121 | 0.0922 | 5.2209 | 7.9170 | -3.5260 | 0.0947 | 5.2493 |
| 8 | 3.5 | 9.2922 | -4.4329 | 0.1119 | 6.4415 | 9.4054 | -4.4449 | 0.1151 | 6.4686 |
| 9 | 4.0 | 10.7821 | -5.3891 | 0.1318 | 7.6875 | 10.8950 | -5.3996 | 0.1356 | 7.7125 |
| 10 | 4.5 | 12.2545 | -6.3704 | 0.1517 | 8.9479 | 12.3820 | -6.3800 | 0.1561 | 8.9715 |
| 11 | 5.0 | 13.7321 | -7.3709 | 0.1716 | 10.2173 | 13.8620 | -7.3795 | 0.1767 | 10.2390 |
| 12 | 6.0 | 15.6532 | -9.1464 | 0.2017 | 12.3100 | 15.7550 | -9.1419 | 0.2076 | 12.3050 |
| 13 | 7.0 | 17.0609 | -10.5754 | 0.2231 | 13.8660 | 17.2490 | -10.5710 | 0.2302 | 13.8880 |
| 14 | 8.0 | 18.4477 | -11.8250 | 0.2421 | 15.2408 | 18.6120 | -11.8200 | 0.2496 | 15.2660 |
| 15 | 9.0 | 19.7179 | -12.9779 | 0.2597 | 16.5089 | 19.9060 | -12.9800 | 0.2675 | 16.5440 |
| 16 | 10.0 | 20.9803 | -14.0874 | 0.2768 | 17.7299 | 21.1570 | -14.0930 | 0.2844 | 17.7690 |
| 17 | 11.0 | 22.1931 | -15.1694 | 0.2934 | 18.9178 | 22.3790 | -15.1800 | 0.3012 | 18.9610 |
| 18 | 12.0 | 23.4021 | -16.2351 | 0.3097 | 20.0875 | 23.5830 | -16.2490 | 0.3179 | 20.1330 |
| 19 | 13.0 | 24.5838 | -17.2892 | 0.3258 | 21.2417 | 24.7750 | -17.3060 | 0.3347 | 21.2890 |
| 20 | 14.0 | 25.7611 | -18.3349 | 0.3417 | 22.3853 | 25.9550 | -18.3540 | 0.3514 | 22.4340 |
| 21 | 15.0 | 26.9200 | -19.3734 | 0.3575 | 23.5187 | 27.1240 | -19.3920 | 0.3679 | 23.5690 |
| 22 | 16.0 | 27.7773 | -20.3272 | 0.3705 | 24.5081 | 27.9410 | -20.3370 | 0.3807 | 24.5350 |
| 23 | 17.0 | 28.4767 | -21.1619 | 0.3807 | 25.3291 | 28.6700 | -21.1680 | 0.3912 | 25.3620 |
| 24 | 18.0 | 29.1816 | -21.9321 | 0.3904 | 26.0934 | 29.3660 | -21.9360 | 0.4009 | 26.1260 |
| 25 | 19.0 | 29.8521 | -22.6655 | 0.3998 | 26.8244 | 30.0480 | -22.6700 | 0.4102 | 26.8590 |
| 26 | 20.0 | 30.5312 | -23.3802 | 0.4091 | 27.5416 | 30.7220 | -23.3840 | 0.4192 | 27.5770 |
| 27 | 21.0 | 31.1968 | -24.0813 | 0.4183 | 28.2491 | 31.3910 | -24.0850 | 0.4282 | 28.2850 |
| 28 | 22.0 | 31.8705 | -24.7736 | 0.4275 | 28.9519 | 32.0590 | -24.7770 | 0.4372 | 28.9880 |
| 29 | 23.0 | 32.5371 | -25.4583 | 0.4368 | 29.6506 | 32.7290 | -25.4620 | 0.4462 | 29.6880 |
| 30 | 24.0 | 33.2097 | -26.1372 | 0.4460 | 30.3467 | 33.3970 | -26.1410 | 0.4550 | 30.3840 |
| 31 | 25.0 | 33.8773 | -26.8113 | 0.4553 | 31.0400 | 34.0660 | -26.8140 | 0.4639 | 31.0770 |
| 32 | 26.0 | 34.4504 | -27.4546 | 0.4636 | 31.6858 | 34.6220 | -27.4530 | 0.4717 | 31.7130 |
| 33 | 27.0 | 34.9715 | -28.0550 | 0.4711 | 32.2755 | 35.1530 | -28.0520 | 0.4788 | 32.3040 |
| 34 | 28.0 | 35.4990 | -28.6322 | 0.4785 | 32.8464 | 35.6760 | -28.6270 | 0.4856 | 32.8730 |
| 35 | 29.0 | 36.0143 | -29.1944 | 0.4857 | 33.4061 | 36.1960 | -29.1890 | 0.4925 | 33.4320 |
| 36 | 30.0 | 36.5360 | -29.7479 | 0.4929 | 33.9606 | 36.7160 | -29.7420 | 0.4993 | 33.9850 |
| 37 | 31.0 | 37.0529 | -30.2948 | 0.5002 | 34.5114 | 37.2350 | -30.2890 | 0.5063 | 34.5350 |
| 38 | 32.0 | 37.5744 | -30.8366 | 0.5074 | 35.0599 | 37.7540 | -30.8310 | 0.5134 | 35.0820 |
| 39 | 33.0 | 38.0934 | -31.3733 | 0.5147 | 35.6060 | 38.2740 | -31.3690 | 0.5205 | 35.6280 |
| 40 | 34.0 | 38.6152 | -31.9057 | 0.5219 | 36.1503 | 38.7930 | -31.9030 | 0.5276 | 36.1710 |
| 41 | 35.0 | 39.1342 | -32.4343 | 0.5291 | 36.6924 | 39.3130 | -32.4320 | 0.5348 | 36.7120 |
| 42 | 37.0 | 39.9460 | -33.3972 | 0.5412 | 37.6396 | 40.1370 | -33.4080 | 0.5473 | 37.6890 |
| 43 | 39.0 | 40.6684 | -34.2469 | 0.5516 | 38.4571 | 40.8780 | -34.2700 | 0.5579 | 38.5260 |
| 44 | 41.0 | 41.4156 | -35.0600 | 0.5620 | 39.2620 | 41.6110 | -35.0860 | 0.5687 | 39.3300 |
| 45 | 43.0 | 42.1478 | -35.8543 | 0.5724 | 40.0544 | 42.3460 | -35.8810 | 0.5792 | 40.1230 |
| 46 | 45.0 | 42.8944 | -36.6335 | 0.5829 | 40.8420 | 43.0840 | -36.6600 | 0.5894 | 40.9080 |
| 47 | 47.5 | 43.5180 | -37.4699 | 0.5926 | 41.6344 | 43.6950 | -37.4950 | 0.5979 | 41.6870 |
| 48 | 50.0 | 44.0502 | -38.1590 | 0.6002 | 42.2661 | 44.2380 | -38.1970 | 0.6048 | 42.3390 |
| 49 | 52.5 | 44.6128 | -38.8128 | 0.6083 | 42.8965 | 44.7880 | -38.8580 | 0.6117 | 42.9660 |
| 50 | 55.0 | 45.1685 | -39.4470 | 0.6163 | 43.5144 | 45.3470 | -39.4970 | 0.6182 | 43.5850 |
| 51 | 57.5 | 45.7365 | -40.0626 | 0.6244 | 44.1275 | 45.9060 | -40.1170 | 0.6250 | 44.1960 |
| 52 | 60.0 | 46.2990 | -40.6618 | 0.6325 | 44.7305 | 46.4680 | -40.7200 | 0.6325 | 44.7980 |
| 53 | 62.5 | 46.8625 | -41.2461 | 0.6405 | 45.3252 | 47.0340 | -41.3070 | 0.6404 | 45.3920 |
| 54 | 65.0 | 47.4195 | -41.8154 | 0.6484 | 45.9093 | 47.5970 | -41.8790 | 0.6484 | 45.9760 |

| | | | | | | | | | |
|-----|-------|---------|----------|--------|---------|---------|----------|---------|---------|
| 55 | 67.5 | 47.9715 | -42.3716 | 0.6562 | 46.4835 | 48.1500 | -42.4380 | 0.6561 | 46.5490 |
| 56 | 70.0 | 48.5154 | -42.9139 | 0.6639 | 47.0466 | 48.6930 | -42.9840 | 0.6629 | 47.1100 |
| 57 | 73.0 | 48.4231 | -43.2375 | 0.6647 | 47.2433 | 48.5080 | -43.2580 | 0.6604 | 47.2170 |
| 58 | 76.0 | 48.1087 | -43.2313 | 0.6606 | 47.0743 | 48.2490 | -43.2900 | 0.6556 | 47.1070 |
| 59 | 79.0 | 47.9053 | -43.2009 | 0.6581 | 46.9550 | 48.0180 | -43.2690 | 0.6513 | 46.9800 |
| 60 | 82.0 | 47.6841 | -43.1556 | 0.6556 | 46.8247 | 47.8180 | -43.2240 | 0.6475 | 46.8550 |
| 61 | 85.0 | 47.5221 | -43.0964 | 0.6536 | 46.7103 | 47.6460 | -43.1680 | 0.6439 | 46.7360 |
| 62 | 88.0 | 47.3508 | -43.0286 | 0.6516 | 46.5936 | 47.4900 | -43.1030 | 0.6410 | 46.6220 |
| 63 | 91.0 | 47.2126 | -42.9541 | 0.6499 | 46.4838 | 47.3410 | -43.0330 | 0.6387 | 46.5090 |
| 64 | 94.0 | 47.0663 | -42.8726 | 0.6483 | 46.3719 | 47.2050 | -42.9560 | 0.6367 | 46.3990 |
| 65 | 97.0 | 46.9402 | -42.7875 | 0.6467 | 46.2628 | 47.0780 | -42.8710 | 0.6345 | 46.2900 |
| 66 | 100.0 | 46.8065 | -42.6974 | 0.6451 | 46.1517 | 46.9470 | -42.7840 | 0.6321 | 46.1800 |
| 67 | 105.0 | 45.9541 | -42.2168 | 0.6347 | 45.5109 | 46.0370 | -42.2750 | 0.6189 | 45.4890 |
| 68 | 110.0 | 44.9860 | -41.4825 | 0.6215 | 44.6223 | 45.1230 | -41.6010 | 0.6047 | 44.6760 |
| 69 | 115.0 | 44.1695 | -40.8023 | 0.6106 | 43.8567 | 44.2740 | -40.9200 | 0.5913 | 43.8880 |
| 70 | 120.0 | 43.3461 | -40.1133 | 0.5996 | 43.0801 | 43.4720 | -40.2450 | 0.5792 | 43.1270 |
| 71 | 125.0 | 42.5972 | -39.4373 | 0.5894 | 42.3449 | 42.7100 | -39.5780 | 0.5679 | 42.3880 |
| 72 | 130.0 | 41.8447 | -38.7733 | 0.5792 | 41.6189 | 41.9800 | -38.9240 | 0.5569 | 41.6700 |
| 73 | 135.0 | 41.1436 | -38.1223 | 0.5695 | 40.9199 | 41.2700 | -38.2800 | 0.5461 | 40.9710 |
| 74 | 140.0 | 40.4424 | -37.4867 | 0.5601 | 40.2344 | 40.5780 | -37.6470 | 0.5357 | 40.2890 |
| 75 | 145.0 | 39.7825 | -36.8667 | 0.5510 | 39.5720 | 39.9060 | -37.0290 | 0.5254 | 39.6250 |
| 76 | 150.0 | 39.1255 | -36.2633 | 0.5420 | 38.9253 | 39.2580 | -36.4280 | 0.5151 | 38.9810 |
| 77 | 155.0 | 38.5046 | -35.6770 | 0.5334 | 38.3005 | 38.6260 | -35.8440 | 0.5053 | 38.3550 |
| 78 | 160.0 | 37.8897 | -35.1077 | 0.5250 | 37.6922 | 38.0080 | -35.2750 | 0.4962 | 37.7480 |
| 79 | 165.0 | 36.6573 | -34.2318 | 0.5091 | 36.6479 | 36.6750 | -34.3040 | 0.4774 | 36.5810 |
| 80 | 170.0 | 35.3197 | -33.1257 | 0.4906 | 35.3746 | 35.3950 | -33.2520 | 0.4590 | 35.3770 |
| 81 | 175.0 | 34.1504 | -32.0945 | 0.4747 | 34.2430 | 34.1860 | -32.2140 | 0.4418 | 34.2180 |
| 82 | 180.0 | 32.9862 | -31.0727 | 0.4588 | 33.1171 | 33.0300 | -31.1990 | 0.4256 | 33.1020 |
| 83 | 185.0 | 31.9121 | -30.0799 | 0.4439 | 32.0482 | 31.9250 | -30.2100 | 0.4099 | 32.0250 |
| 84 | 190.0 | 30.8458 | -29.1129 | 0.4294 | 31.0027 | 30.8660 | -29.2470 | 0.3944 | 30.9830 |
| 85 | 195.0 | 29.8437 | -28.1721 | 0.4155 | 29.9969 | 29.8420 | -28.3070 | 0.3794 | 29.9730 |
| 86 | 200.0 | 28.8517 | -27.2579 | 0.4019 | 29.0165 | 28.8500 | -27.3900 | 0.3652 | 28.9930 |
| 87 | 210.0 | 26.9940 | -25.5091 | 0.3762 | 27.1515 | 26.9710 | -25.6420 | 0.3379 | 27.1290 |
| 88 | 220.0 | 25.2352 | -23.8649 | 0.3519 | 25.3974 | 25.2100 | -23.9950 | 0.3117 | 25.3730 |
| 89 | 230.0 | 23.6066 | -22.3232 | 0.3293 | 23.7567 | 23.5560 | -22.4570 | 0.2860 | 23.7300 |
| 90 | 240.0 | 22.0659 | -20.8780 | 0.3081 | 22.2173 | 21.9950 | -21.0220 | 0.2611 | 22.1910 |
| 91 | 250.0 | 20.6411 | -19.5262 | 0.2882 | 20.7797 | 20.5400 | -19.6780 | 0.2379 | 20.7520 |
| 92 | 260.0 | 19.2937 | -18.2616 | 0.2695 | 19.4325 | 19.1840 | -18.4110 | 0.2168 | 19.4010 |
| 93 | 270.0 | 18.0485 | -17.0789 | 0.2521 | 18.1749 | 17.9190 | -17.2220 | 0.1979 | 18.1370 |
| 94 | 280.0 | 16.8706 | -15.9724 | 0.2358 | 16.9968 | 16.7310 | -16.1020 | 0.1808 | 16.9520 |
| 95 | 290.0 | 15.7827 | -14.9386 | 0.2205 | 15.8972 | 15.6210 | -15.0570 | 0.1648 | 15.8450 |
| 96 | 300.0 | 14.7527 | -13.9707 | 0.2062 | 14.8670 | 14.5800 | -14.0800 | 0.1496 | 14.8080 |
| 97 | 320.0 | 12.9059 | -12.2187 | 0.1804 | 13.0033 | 12.7230 | -12.3390 | 0.1233 | 12.9610 |
| 98 | 340.0 | 11.2797 | -10.6859 | 0.1578 | 11.3721 | 11.0870 | -10.8100 | 0.1009 | 11.3400 |
| 99 | 360.0 | 9.8697 | -9.3461 | 0.1381 | 9.9471 | 9.6227 | -9.4420 | 0.0812 | 9.8921 |
| 100 | 380.0 | 8.6252 | -8.1736 | 0.1208 | 8.6992 | 8.3687 | -8.2744 | 0.0645 | 8.6548 |
| 101 | 400.0 | 7.5484 | -7.1489 | 0.1057 | 7.6091 | 7.2491 | -7.2303 | 0.0500 | 7.5500 |
| 102 | 420.0 | 6.5956 | -6.2517 | 0.0925 | 6.6543 | 6.2835 | -6.3285 | 0.0374 | 6.5927 |
| 103 | 440.0 | 5.7731 | -5.4677 | 0.0810 | 5.8205 | 5.4466 | -5.5494 | 0.0260 | 5.7595 |
| 104 | 460.0 | 5.0432 | -4.7814 | 0.0709 | 5.0898 | 4.7056 | -4.8617 | 0.0155 | 5.0185 |
| 105 | 480.0 | 4.4153 | -4.1818 | 0.0620 | 4.4521 | 4.0749 | -4.2814 | 0.0065 | 4.3845 |
| 106 | 500.0 | 3.8562 | -3.6567 | 0.0542 | 3.8931 | 3.5140 | -3.7688 | -0.0016 | 3.8178 |

表4. 4(3) 評価断面4の応力テンソル成分3

FINAS解と簡易計算値との比較 (コールドショック)

断面4の応力成分3

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|---------|----------|----------|---------|---------|----------|----------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.7686 | -0.1202 | -0.0099 | 0.2421 | 0.8837 | -0.1292 | -0.0114 | 0.2728 |
| 3 | 1.0 | 1.9296 | -0.4319 | -0.0369 | 0.8074 | 1.9889 | -0.4407 | -0.0385 | 0.8346 |
| 4 | 1.5 | 3.0588 | -0.8773 | -0.0770 | 1.5249 | 3.1503 | -0.8899 | -0.0789 | 1.5536 |
| 5 | 2.0 | 4.2381 | -1.4260 | -0.1309 | 2.3372 | 4.3149 | -1.4396 | -0.1324 | 2.3635 |
| 6 | 2.5 | 5.3690 | -2.0440 | -0.1971 | 3.1982 | 5.4651 | -2.0566 | -0.1982 | 3.2232 |
| 7 | 3.0 | 6.4974 | -2.7079 | -0.2752 | 4.0846 | 6.5911 | -2.7174 | -0.2759 | 4.1075 |
| 8 | 3.5 | 7.5748 | -3.4000 | -0.3643 | 4.9782 | 7.6857 | -3.4067 | -0.3641 | 4.9995 |
| 9 | 4.0 | 8.6339 | -4.1102 | -0.4633 | 5.8701 | 8.7467 | -4.1134 | -0.4621 | 5.8892 |
| 10 | 4.5 | 9.6433 | -4.8303 | -0.5716 | 6.7528 | 9.7721 | -4.8297 | -0.5693 | 6.7700 |
| 11 | 5.0 | 10.6290 | -5.5560 | -0.6883 | 7.6232 | 10.7630 | -5.5498 | -0.6844 | 7.6377 |
| 12 | 6.0 | 11.5825 | -6.8069 | -0.9270 | 8.9458 | 11.6960 | -6.7810 | -0.9194 | 8.9355 |
| 13 | 7.0 | 12.0761 | -7.7604 | -1.1638 | 9.7887 | 12.2780 | -7.7245 | -1.1542 | 9.8011 |
| 14 | 8.0 | 12.5709 | -8.5567 | -1.4011 | 10.4729 | 12.7560 | -8.5150 | -1.3889 | 10.4900 |
| 15 | 9.0 | 12.9645 | -9.2732 | -1.6382 | 11.0675 | 13.1780 | -9.2316 | -1.6251 | 11.0940 |
| 16 | 10.0 | 13.3561 | -9.9582 | -1.8773 | 11.6237 | 13.5640 | -9.9118 | -1.8637 | 11.6530 |
| 17 | 11.0 | 13.6997 | -10.6245 | -2.1193 | 12.1520 | 13.9220 | -10.5740 | -2.1051 | 12.1860 |
| 18 | 12.0 | 14.0367 | -11.2815 | -2.3656 | 12.6642 | 14.2580 | -11.2260 | -2.3502 | 12.7000 |
| 19 | 13.0 | 14.3419 | -11.9328 | -2.6162 | 13.1616 | 14.5760 | -11.8720 | -2.5997 | 13.1990 |
| 20 | 14.0 | 14.6371 | -12.5808 | -2.8716 | 13.6482 | 14.8750 | -12.5140 | -2.8538 | 13.6860 |
| 21 | 15.0 | 14.9080 | -13.2262 | -3.1316 | 14.1239 | 15.1560 | -13.1540 | -3.1133 | 14.1620 |
| 22 | 16.0 | 14.8987 | -13.8089 | -3.3911 | 14.4795 | 15.1070 | -13.7230 | -3.3724 | 14.4960 |
| 23 | 17.0 | 14.7683 | -14.3024 | -3.6462 | 14.7019 | 15.0060 | -14.2070 | -3.6276 | 14.7220 |
| 24 | 18.0 | 14.6673 | -14.7510 | -3.8983 | 14.8892 | 14.8990 | -14.6490 | -3.8790 | 14.9100 |
| 25 | 19.0 | 14.5509 | -15.1785 | -4.1478 | 15.0612 | 14.7960 | -15.0730 | -4.1282 | 15.0840 |
| 26 | 20.0 | 14.4578 | -15.6001 | -4.3955 | 15.2328 | 14.7010 | -15.4900 | -4.3757 | 15.2560 |
| 27 | 21.0 | 14.3629 | -16.0188 | -4.6419 | 15.4060 | 14.6140 | -15.9050 | -4.6212 | 15.4310 |
| 28 | 22.0 | 14.2856 | -16.4375 | -4.8875 | 15.5837 | 14.5360 | -16.3200 | -4.8660 | 15.6090 |
| 29 | 23.0 | 14.2091 | -16.8564 | -5.1322 | 15.7652 | 14.4650 | -16.7360 | -5.1104 | 15.7920 |
| 30 | 24.0 | 14.1457 | -17.2762 | -5.3763 | 15.9510 | 14.4010 | -17.1510 | -5.3541 | 15.9780 |
| 31 | 25.0 | 14.0835 | -17.6969 | -5.6198 | 16.1399 | 14.3420 | -17.5680 | -5.5970 | 16.1680 |
| 32 | 26.0 | 13.9420 | -18.0979 | -5.8608 | 16.2952 | 14.1870 | -17.9610 | -5.8376 | 16.3160 |
| 33 | 27.0 | 13.7681 | -18.4696 | -6.0983 | 16.4117 | 14.0240 | -18.3260 | -6.0750 | 16.4330 |
| 34 | 28.0 | 13.6156 | -18.8273 | -6.3325 | 16.5216 | 13.8690 | -18.6770 | -6.3094 | 16.5430 |
| 35 | 29.0 | 13.4644 | -19.1778 | -6.5637 | 16.6309 | 13.7260 | -19.0230 | -6.5410 | 16.6520 |
| 36 | 30.0 | 13.3310 | -19.5263 | -6.7922 | 16.7442 | 13.5920 | -19.3660 | -6.7699 | 16.7640 |
| 37 | 31.0 | 13.2025 | -19.8737 | -7.0183 | 16.8615 | 13.4680 | -19.7090 | -6.9963 | 16.8800 |
| 38 | 32.0 | 13.0879 | -20.2210 | -7.2420 | 16.9836 | 13.3520 | -20.0520 | -7.2205 | 17.0010 |
| 39 | 33.0 | 12.9788 | -20.5674 | -7.4634 | 17.1096 | 13.2440 | -20.3940 | -7.4423 | 17.1260 |
| 40 | 34.0 | 12.8808 | -20.9134 | -7.6826 | 17.2398 | 13.1450 | -20.7360 | -7.6615 | 17.2540 |
| 41 | 35.0 | 12.7869 | -21.2589 | -7.8998 | 17.3731 | 13.0530 | -21.0770 | -7.8785 | 17.3860 |
| 42 | 37.0 | 12.4251 | -21.8834 | -8.3216 | 17.5446 | 12.7010 | -21.7050 | -8.3010 | 17.5830 |
| 43 | 39.0 | 12.0435 | -22.4303 | -8.7252 | 17.6406 | 12.3340 | -22.2550 | -8.7069 | 17.6940 |
| 44 | 41.0 | 11.7367 | -22.9612 | -9.1133 | 17.7592 | 12.0140 | -22.7850 | -9.0960 | 17.8110 |
| 45 | 43.0 | 11.4559 | -23.4889 | -9.4881 | 17.8942 | 11.7390 | -23.3070 | -9.4700 | 17.9460 |
| 46 | 45.0 | 11.2239 | -24.0129 | -9.8512 | 18.0476 | 11.5000 | -23.8260 | -9.8321 | 18.0970 |
| 47 | 47.5 | 10.7122 | -24.5705 | -10.2802 | 18.1143 | 10.9780 | -24.3750 | -10.2610 | 18.1490 |
| 48 | 50.0 | 10.2143 | -25.0267 | -10.6786 | 18.0977 | 10.4930 | -24.8350 | -10.6590 | 18.1500 |
| 49 | 52.5 | 9.8182 | -25.4712 | -11.0521 | 18.1279 | 10.0880 | -25.2800 | -11.0340 | 18.1750 |
| 50 | 55.0 | 9.4732 | -25.9129 | -11.4045 | 18.1834 | 9.7465 | -25.7190 | -11.3880 | 18.2280 |
| 51 | 57.5 | 9.1881 | -26.3471 | -11.7388 | 18.2640 | 9.4532 | -26.1530 | -11.7250 | 18.3030 |
| 52 | 60.0 | 8.9401 | -26.7736 | -12.0562 | 18.3606 | 9.2041 | -26.5780 | -12.0450 | 18.3960 |
| 53 | 62.5 | 8.7300 | -27.1917 | -12.3585 | 18.4711 | 8.9955 | -26.9950 | -12.3500 | 18.5020 |
| 54 | 65.0 | 8.5467 | -27.6000 | -12.6470 | 18.5908 | 8.8186 | -27.4020 | -12.6400 | 18.6200 |

| | | | | | | | | | |
|-----|-------|---------|----------|----------|---------|---------|----------|----------|---------|
| 55 | 67.5 | 8.3883 | -27.9997 | -12.9229 | 18.7181 | 8.6625 | -27.7990 | -12.9180 | 18.7430 |
| 56 | 70.0 | 8.2491 | -28.3893 | -13.1873 | 18.8502 | 8.5239 | -28.1860 | -13.1840 | 18.8710 |
| 57 | 73.0 | 7.4914 | -28.6076 | -13.4651 | 18.6532 | 7.6925 | -28.3570 | -13.4620 | 18.5950 |
| 58 | 76.0 | 6.7079 | -28.5899 | -13.6889 | 18.2393 | 6.9622 | -28.3690 | -13.6870 | 18.2340 |
| 59 | 79.0 | 6.1439 | -28.5836 | -13.8744 | 17.9472 | 6.3719 | -28.3670 | -13.8740 | 17.9320 |
| 60 | 82.0 | 5.6416 | -28.5850 | -14.0306 | 17.6960 | 5.8898 | -28.3630 | -14.0330 | 17.6830 |
| 61 | 85.0 | 5.2580 | -28.5830 | -14.1627 | 17.4961 | 5.4949 | -28.3610 | -14.1670 | 17.4770 |
| 62 | 88.0 | 4.9164 | -28.5796 | -14.2728 | 17.3238 | 5.1656 | -28.3570 | -14.2800 | 17.3030 |
| 63 | 91.0 | 4.6485 | -28.5722 | -14.3645 | 17.1804 | 4.8851 | -28.3480 | -14.3730 | 17.1530 |
| 64 | 94.0 | 4.4076 | -28.5589 | -14.4397 | 17.0536 | 4.6507 | -28.3320 | -14.4510 | 17.0240 |
| 65 | 97.0 | 4.2155 | -28.5417 | -14.5010 | 16.9440 | 4.4543 | -28.3100 | -14.5150 | 16.9110 |
| 66 | 100.0 | 4.0403 | -28.5185 | -14.5501 | 16.8448 | 4.2815 | -28.2850 | -14.5650 | 16.8110 |
| 67 | 105.0 | 3.3026 | -28.2286 | -14.5786 | 16.3619 | 3.4973 | -27.9680 | -14.5930 | 16.2850 |
| 68 | 110.0 | 2.6613 | -27.7662 | -14.5393 | 15.7812 | 2.9023 | -27.5520 | -14.5560 | 15.7680 |
| 69 | 115.0 | 2.2624 | -27.3680 | -14.4592 | 15.3736 | 2.4689 | -27.1460 | -14.4800 | 15.3350 |
| 70 | 120.0 | 1.9196 | -26.9623 | -14.3496 | 14.9885 | 2.1460 | -26.7490 | -14.3720 | 14.9620 |
| 71 | 125.0 | 1.6914 | -26.5621 | -14.2173 | 14.6610 | 1.9020 | -26.3540 | -14.2430 | 14.6290 |
| 72 | 130.0 | 1.4873 | -26.1651 | -14.0680 | 14.3530 | 1.7151 | -25.9620 | -14.0980 | 14.3260 |
| 73 | 135.0 | 1.3485 | -25.7708 | -13.9075 | 14.0736 | 1.5654 | -25.5700 | -13.9400 | 14.0450 |
| 74 | 140.0 | 1.2174 | -25.3821 | -13.7390 | 13.8072 | 1.4411 | -25.1770 | -13.7730 | 13.7810 |
| 75 | 145.0 | 1.1279 | -24.9993 | -13.5661 | 13.5590 | 1.3421 | -24.7910 | -13.6020 | 13.5320 |
| 76 | 150.0 | 1.0384 | -24.6237 | -13.3907 | 13.3205 | 1.2660 | -24.4150 | -13.4270 | 13.2980 |
| 77 | 155.0 | 0.9776 | -24.2563 | -13.2149 | 13.0954 | 1.2013 | -24.0470 | -13.2500 | 13.0750 |
| 78 | 160.0 | 0.9140 | -23.8972 | -13.0396 | 12.8782 | 1.1424 | -23.6860 | -13.0740 | 12.8610 |
| 79 | 165.0 | 0.3637 | -23.3052 | -12.8342 | 12.3332 | 0.5257 | -23.0120 | -12.8610 | 12.2180 |
| 80 | 170.0 | -0.1331 | -22.5602 | -12.5853 | 11.6795 | 0.0897 | -22.3100 | -12.6090 | 11.6290 |
| 81 | 175.0 | -0.4141 | -21.8970 | -12.3152 | 11.1935 | -0.2196 | -21.6330 | -12.3350 | 11.1170 |
| 82 | 180.0 | -0.6619 | -21.2420 | -12.0312 | 10.7274 | -0.4487 | -20.9750 | -12.0480 | 10.6610 |
| 83 | 185.0 | -0.8085 | -20.6055 | -11.7371 | 10.3181 | -0.6146 | -20.3360 | -11.7520 | 10.2450 |
| 84 | 190.0 | -0.9442 | -19.9842 | -11.4369 | 9.9286 | -0.7316 | -19.7150 | -11.4500 | 9.8625 |
| 85 | 195.0 | -1.0221 | -19.3759 | -11.1343 | 9.5686 | -0.8186 | -19.1090 | -11.1450 | 9.5041 |
| 86 | 200.0 | -1.1000 | -18.7823 | -10.8313 | 9.2229 | -0.8870 | -18.5170 | -10.8410 | 9.1648 |
| 87 | 210.0 | -1.1787 | -17.6384 | -10.2336 | 8.5834 | -0.9700 | -17.3810 | -10.2420 | 8.5342 |
| 88 | 220.0 | -1.2346 | -16.5544 | -9.6530 | 7.9934 | -1.0034 | -16.3000 | -9.6591 | 7.9534 |
| 89 | 230.0 | -1.2464 | -15.5310 | -9.0960 | 7.4510 | -1.0176 | -15.2800 | -9.0987 | 7.4162 |
| 90 | 240.0 | -1.2577 | -14.5663 | -8.5648 | 6.9458 | -1.0248 | -14.3190 | -8.5634 | 6.9167 |
| 91 | 250.0 | -1.2406 | -13.6597 | -8.0604 | 6.4791 | -1.0150 | -13.4120 | -8.0552 | 6.4547 |
| 92 | 260.0 | -1.2302 | -12.8075 | -7.5827 | 6.0432 | -0.9868 | -12.5510 | -7.5724 | 6.0253 |
| 93 | 270.0 | -1.1986 | -12.0074 | -7.1310 | 5.6398 | -0.9550 | -11.7420 | -7.1162 | 5.6268 |
| 94 | 280.0 | -1.1763 | -11.2560 | -6.7044 | 5.2625 | -0.9238 | -10.9830 | -6.6840 | 5.2559 |
| 95 | 290.0 | -1.1370 | -10.5515 | -6.3019 | 4.9129 | -0.8928 | -10.2720 | -6.2766 | 4.9092 |
| 96 | 300.0 | -1.1080 | -9.8896 | -5.9222 | 4.5857 | -0.8609 | -9.6045 | -5.8917 | 4.5831 |
| 97 | 320.0 | -1.0262 | -8.6858 | -5.2265 | 3.9977 | -0.7952 | -8.4090 | -5.1973 | 4.0041 |
| 98 | 340.0 | -0.9540 | -7.6261 | -4.6092 | 3.4853 | -0.7335 | -7.3554 | -4.5798 | 3.4993 |
| 99 | 360.0 | -0.8695 | -6.6946 | -4.0625 | 3.0406 | -0.6730 | -6.4102 | -4.0216 | 3.0498 |
| 100 | 380.0 | -0.7990 | -5.8749 | -3.5784 | 2.6523 | -0.6156 | -5.6007 | -3.5393 | 2.6698 |
| 101 | 400.0 | -0.7202 | -5.1551 | -3.1505 | 2.3150 | -0.5592 | -4.8763 | -3.1052 | 2.3342 |
| 102 | 420.0 | -0.6572 | -4.5219 | -2.7725 | 2.0200 | -0.5053 | -4.2463 | -2.7253 | 2.0417 |
| 103 | 440.0 | -0.5875 | -3.9664 | -2.4389 | 1.7639 | -0.4548 | -3.6954 | -2.3909 | 1.7829 |
| 104 | 460.0 | -0.5336 | -3.4779 | -2.1445 | 1.5394 | -0.4059 | -3.2023 | -2.0909 | 1.5493 |
| 105 | 480.0 | -0.4738 | -3.0498 | -1.8852 | 1.3447 | -0.3604 | -2.7759 | -1.8321 | 1.3445 |
| 106 | 500.0 | -0.4293 | -2.6733 | -1.6565 | 1.1738 | -0.3170 | -2.3918 | -1.5994 | 1.1578 |

表 4. 4 (4) 評価断面 4 の応力テンソル成分 4

F I N A S 解と簡易計算値との比較 (コールドショック)

断面 4 の応力成分 4

| ステップ | 時間(S) | F I N A S 解 | | | | 簡易計算値 | | | |
|------|-------|-------------|---------|--------|---------|---------|---------|--------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.0672 | -0.0026 | 0.0092 | -0.0223 | -0.0787 | -0.0028 | 0.0098 | -0.0254 |
| 3 | 1.0 | -0.1797 | -0.0092 | 0.0328 | -0.0750 | -0.1851 | -0.0093 | 0.0334 | -0.0780 |
| 4 | 1.5 | -0.2943 | -0.0186 | 0.0672 | -0.1420 | -0.3024 | -0.0191 | 0.0678 | -0.1460 |
| 5 | 2.0 | -0.4185 | -0.0304 | 0.1108 | -0.2188 | -0.4248 | -0.0308 | 0.1113 | -0.2231 |
| 6 | 2.5 | -0.5425 | -0.0436 | 0.1620 | -0.3014 | -0.5501 | -0.0443 | 0.1624 | -0.3065 |
| 7 | 3.0 | -0.6700 | -0.0579 | 0.2196 | -0.3882 | -0.6773 | -0.0586 | 0.2199 | -0.3941 |
| 8 | 3.5 | -0.7966 | -0.0730 | 0.2826 | -0.4775 | -0.8054 | -0.0736 | 0.2828 | -0.4847 |
| 9 | 4.0 | -0.9245 | -0.0888 | 0.3502 | -0.5686 | -0.9336 | -0.0894 | 0.3503 | -0.5771 |
| 10 | 4.5 | -1.0510 | -0.1050 | 0.4218 | -0.6607 | -1.0613 | -0.1055 | 0.4219 | -0.6708 |
| 11 | 5.0 | -1.1777 | -0.1215 | 0.4968 | -0.7535 | -1.1886 | -0.1218 | 0.4967 | -0.7651 |
| 12 | 6.0 | -1.3443 | -0.1509 | 0.6395 | -0.9052 | -1.3528 | -0.1515 | 0.6385 | -0.9175 |
| 13 | 7.0 | -1.4633 | -0.1747 | 0.7676 | -1.0171 | -1.4815 | -0.1755 | 0.7668 | -1.0342 |
| 14 | 8.0 | -1.5820 | -0.1956 | 0.8875 | -1.1169 | -1.5988 | -0.1970 | 0.8865 | -1.1357 |
| 15 | 9.0 | -1.6896 | -0.2152 | 1.0016 | -1.2088 | -1.7098 | -0.2176 | 1.0007 | -1.2299 |
| 16 | 10.0 | -1.7974 | -0.2341 | 1.1119 | -1.2969 | -1.8174 | -0.2378 | 1.1113 | -1.3200 |
| 17 | 11.0 | -1.9005 | -0.2526 | 1.2195 | -1.3821 | -1.9224 | -0.2579 | 1.2193 | -1.4075 |
| 18 | 12.0 | -2.0037 | -0.2708 | 1.3254 | -1.4658 | -2.0254 | -0.2777 | 1.3255 | -1.4934 |
| 19 | 13.0 | -2.1041 | -0.2889 | 1.4301 | -1.5478 | -2.1269 | -0.2970 | 1.4305 | -1.5780 |
| 20 | 14.0 | -2.2045 | -0.3068 | 1.5339 | -1.6290 | -2.2274 | -0.3158 | 1.5347 | -1.6615 |
| 21 | 15.0 | -2.3031 | -0.3246 | 1.6372 | -1.7092 | -2.3269 | -0.3343 | 1.6383 | -1.7441 |
| 22 | 16.0 | -2.3765 | -0.3410 | 1.7354 | -1.7783 | -2.3966 | -0.3509 | 1.7364 | -1.8132 |
| 23 | 17.0 | -2.4351 | -0.3555 | 1.8263 | -1.8346 | -2.4589 | -0.3651 | 1.8275 | -1.8718 |
| 24 | 18.0 | -2.4950 | -0.3690 | 1.9124 | -1.8875 | -2.5185 | -0.3778 | 1.9138 | -1.9258 |
| 25 | 19.0 | -2.5514 | -0.3818 | 1.9951 | -1.9379 | -2.5768 | -0.3899 | 1.9966 | -1.9773 |
| 26 | 20.0 | -2.6090 | -0.3944 | 2.0753 | -1.9871 | -2.6344 | -0.4016 | 2.0769 | -2.0271 |
| 27 | 21.0 | -2.6653 | -0.4066 | 2.1537 | -2.0356 | -2.6914 | -0.4125 | 2.1554 | -2.0765 |
| 28 | 22.0 | -2.7224 | -0.4188 | 2.2307 | -2.0837 | -2.7482 | -0.4232 | 2.2325 | -2.1257 |
| 29 | 23.0 | -2.7787 | -0.4308 | 2.3065 | -2.1315 | -2.8052 | -0.4341 | 2.3087 | -2.1748 |
| 30 | 24.0 | -2.8357 | -0.4427 | 2.3815 | -2.1790 | -2.8621 | -0.4451 | 2.3839 | -2.2236 |
| 31 | 25.0 | -2.8922 | -0.4545 | 2.4558 | -2.2264 | -2.9190 | -0.4561 | 2.4583 | -2.2723 |
| 32 | 26.0 | -2.9408 | -0.4659 | 2.5280 | -2.2703 | -2.9660 | -0.4670 | 2.5305 | -2.3166 |
| 33 | 27.0 | -2.9845 | -0.4765 | 2.5972 | -2.3100 | -3.0106 | -0.4776 | 2.5999 | -2.3573 |
| 34 | 28.0 | -3.0291 | -0.4867 | 2.6646 | -2.3486 | -3.0546 | -0.4881 | 2.6674 | -2.3965 |
| 35 | 29.0 | -3.0725 | -0.4968 | 2.7304 | -2.3863 | -3.0983 | -0.4984 | 2.7331 | -2.4348 |
| 36 | 30.0 | -3.1166 | -0.5066 | 2.7950 | -2.4238 | -3.1419 | -0.5085 | 2.7982 | -2.4727 |
| 37 | 31.0 | -3.1602 | -0.5163 | 2.8587 | -2.4611 | -3.1857 | -0.5183 | 2.8620 | -2.5105 |
| 38 | 32.0 | -3.2043 | -0.5259 | 2.9216 | -2.4982 | -3.2295 | -0.5280 | 2.9251 | -2.5482 |
| 39 | 33.0 | -3.2481 | -0.5354 | 2.9838 | -2.5353 | -3.2734 | -0.5376 | 2.9875 | -2.5859 |
| 40 | 34.0 | -3.2921 | -0.5448 | 3.0455 | -2.5722 | -3.3173 | -0.5470 | 3.0492 | -2.6235 |
| 41 | 35.0 | -3.3359 | -0.5541 | 3.1066 | -2.6091 | -3.3611 | -0.5565 | 3.1103 | -2.6609 |
| 42 | 37.0 | -3.4044 | -0.5713 | 3.2221 | -2.6728 | -3.4312 | -0.5744 | 3.2264 | -2.7282 |
| 43 | 39.0 | -3.4648 | -0.5866 | 3.3290 | -2.7273 | -3.4938 | -0.5904 | 3.3339 | -2.7858 |
| 44 | 41.0 | -3.5277 | -0.6013 | 3.4310 | -2.7814 | -3.5561 | -0.6061 | 3.4359 | -2.8409 |
| 45 | 43.0 | -3.5891 | -0.6155 | 3.5295 | -2.8346 | -3.6186 | -0.6211 | 3.5342 | -2.8948 |
| 46 | 45.0 | -3.6520 | -0.6295 | 3.6253 | -2.8878 | -3.6809 | -0.6361 | 3.6299 | -2.9477 |
| 47 | 47.5 | -3.7042 | -0.6447 | 3.7347 | -2.9403 | -3.7317 | -0.6536 | 3.7389 | -2.9981 |
| 48 | 50.0 | -3.7482 | -0.6574 | 3.8315 | -2.9816 | -3.7777 | -0.6686 | 3.8359 | -3.0416 |
| 49 | 52.5 | -3.7952 | -0.6694 | 3.9218 | -3.0234 | -3.8246 | -0.6829 | 3.9263 | -3.0837 |
| 50 | 55.0 | -3.8416 | -0.6810 | 4.0076 | -3.0644 | -3.8718 | -0.6965 | 4.0123 | -3.1257 |
| 51 | 57.5 | -3.8891 | -0.6921 | 4.0899 | -3.1057 | -3.9197 | -0.7088 | 4.0948 | -3.1679 |
| 52 | 60.0 | -3.9362 | -0.7030 | 4.1693 | -3.1464 | -3.9682 | -0.7202 | 4.1742 | -3.2097 |
| 53 | 62.5 | -3.9835 | -0.7136 | 4.2460 | -3.1868 | -4.0168 | -0.7317 | 4.2511 | -3.2511 |
| 54 | 65.0 | -4.0302 | -0.7238 | 4.3203 | -3.2267 | -4.0645 | -0.7428 | 4.3255 | -3.2928 |

| | | | | | | | | | |
|-----|-------|---------|---------|--------|---------|---------|---------|--------|---------|
| 55 | 67.5 | -4.0765 | -0.7339 | 4.3923 | -3.2661 | -4.1113 | -0.7540 | 4.3978 | -3.3336 |
| 56 | 70.0 | -4.1222 | -0.7436 | 4.4622 | -3.3049 | -4.1573 | -0.7657 | 4.4678 | -3.3725 |
| 57 | 73.0 | -4.1135 | -0.7499 | 4.5234 | -3.3160 | -4.1410 | -0.7728 | 4.5265 | -3.3766 |
| 58 | 76.0 | -4.0849 | -0.7507 | 4.5575 | -3.3010 | -4.1190 | -0.7749 | 4.5617 | -3.3667 |
| 59 | 79.0 | -4.0669 | -0.7510 | 4.5811 | -3.2904 | -4.0990 | -0.7758 | 4.5857 | -3.3557 |
| 60 | 82.0 | -4.0470 | -0.7508 | 4.5985 | -3.2789 | -4.0814 | -0.7757 | 4.6034 | -3.3447 |
| 61 | 85.0 | -4.0226 | -0.7503 | 4.6120 | -3.2694 | -4.0661 | -0.7762 | 4.6170 | -3.3345 |
| 62 | 88.0 | -4.0073 | -0.7497 | 4.6222 | -3.2599 | -4.0521 | -0.7769 | 4.6275 | -3.3252 |
| 63 | 91.0 | -4.0051 | -0.7489 | 4.6299 | -3.2514 | -4.0390 | -0.7773 | 4.6353 | -3.3164 |
| 64 | 94.0 | -3.9920 | -0.7478 | 4.6354 | -3.2430 | -4.0270 | -0.7773 | 4.6410 | -3.3083 |
| 65 | 97.0 | -3.9809 | -0.7467 | 4.6390 | -3.2350 | -4.0158 | -0.7764 | 4.6450 | -3.3010 |
| 66 | 100.0 | -3.9691 | -0.7455 | 4.6409 | -3.2270 | -4.0046 | -0.7748 | 4.6472 | -3.2939 |
| 67 | 105.0 | -3.8957 | -0.7379 | 4.6188 | -3.1802 | -3.9268 | -0.7667 | 4.6236 | -3.2444 |
| 68 | 110.0 | -3.8121 | -0.7259 | 4.5706 | -3.1161 | -3.8496 | -0.7551 | 4.5779 | -3.1866 |
| 69 | 115.0 | -3.7423 | -0.7146 | 4.5171 | -3.0616 | -3.7777 | -0.7428 | 4.5252 | -3.1315 |
| 70 | 120.0 | -3.6716 | -0.7030 | 4.4599 | -3.0066 | -3.7090 | -0.7299 | 4.4688 | -3.0795 |
| 71 | 125.0 | -3.6078 | -0.6917 | 4.4010 | -2.9552 | -3.6432 | -0.7182 | 4.4105 | -3.0293 |
| 72 | 130.0 | -3.5433 | -0.6804 | 4.3406 | -2.9045 | -3.5799 | -0.7079 | 4.3509 | -2.9804 |
| 73 | 135.0 | -3.4836 | -0.6693 | 4.2798 | -2.8559 | -3.5185 | -0.6975 | 4.2907 | -2.9328 |
| 74 | 140.0 | -3.4237 | -0.6584 | 4.2187 | -2.8083 | -3.4591 | -0.6862 | 4.2301 | -2.8869 |
| 75 | 145.0 | -3.3677 | -0.6477 | 4.1580 | -2.7625 | -3.4018 | -0.6746 | 4.1699 | -2.8425 |
| 76 | 150.0 | -3.3117 | -0.6373 | 4.0979 | -2.7176 | -3.3467 | -0.6629 | 4.1102 | -2.7995 |
| 77 | 155.0 | -3.2590 | -0.6271 | 4.0386 | -2.6744 | -3.2931 | -0.6519 | 4.0513 | -2.7575 |
| 78 | 160.0 | -3.2067 | -0.6172 | 3.9803 | -2.6322 | -3.2405 | -0.6422 | 3.9933 | -2.7163 |
| 79 | 165.0 | -3.1017 | -0.6023 | 3.9009 | -2.5578 | -3.1263 | -0.6262 | 3.9089 | -2.6335 |
| 80 | 170.0 | -2.9873 | -0.5835 | 3.7998 | -2.4671 | -3.0163 | -0.6090 | 3.8094 | -2.5481 |
| 81 | 175.0 | -2.8880 | -0.5658 | 3.6972 | -2.3871 | -2.9133 | -0.5911 | 3.7067 | -2.4660 |
| 82 | 180.0 | -2.7887 | -0.5482 | 3.5942 | -2.3077 | -2.8160 | -0.5730 | 3.6041 | -2.3870 |
| 83 | 185.0 | -2.6976 | -0.5310 | 3.4921 | -2.2330 | -2.7224 | -0.5549 | 3.5022 | -2.3107 |
| 84 | 190.0 | -2.6069 | -0.5142 | 3.3911 | -2.1599 | -2.6315 | -0.5365 | 3.4015 | -2.2370 |
| 85 | 195.0 | -2.5220 | -0.4978 | 3.2917 | -2.0899 | -2.5439 | -0.5190 | 3.3023 | -2.1653 |
| 86 | 200.0 | -2.4377 | -0.4819 | 3.1938 | -2.0217 | -2.4600 | -0.5028 | 3.2048 | -2.0955 |
| 87 | 210.0 | -2.2804 | -0.4513 | 3.0043 | -1.8921 | -2.3016 | -0.4713 | 3.0163 | -1.9634 |
| 88 | 220.0 | -2.1312 | -0.4225 | 2.8233 | -1.7702 | -2.1535 | -0.4405 | 2.8357 | -1.8392 |
| 89 | 230.0 | -1.9935 | -0.3955 | 2.6516 | -1.6562 | -2.0141 | -0.4125 | 2.6644 | -1.7227 |
| 90 | 240.0 | -1.8631 | -0.3701 | 2.4891 | -1.5492 | -1.8826 | -0.3871 | 2.5023 | -1.6134 |
| 91 | 250.0 | -1.7426 | -0.3463 | 2.3360 | -1.4492 | -1.7584 | -0.3626 | 2.3496 | -1.5105 |
| 92 | 260.0 | -1.6286 | -0.3240 | 2.1916 | -1.3555 | -1.6410 | -0.3386 | 2.2053 | -1.4133 |
| 93 | 270.0 | -1.5234 | -0.3031 | 2.0559 | -1.2680 | -1.5315 | -0.3169 | 2.0696 | -1.3217 |
| 94 | 280.0 | -1.4238 | -0.2836 | 1.9282 | -1.1860 | -1.4291 | -0.2977 | 1.9415 | -1.2351 |
| 95 | 290.0 | -1.3319 | -0.2653 | 1.8082 | -1.1095 | -1.3338 | -0.2803 | 1.8213 | -1.1539 |
| 96 | 300.0 | -1.2448 | -0.2482 | 1.6954 | -1.0377 | -1.2449 | -0.2638 | 1.7082 | -1.0776 |
| 97 | 320.0 | -1.0889 | -0.2173 | 1.4900 | -0.9079 | -1.0863 | -0.2351 | 1.5052 | -0.9419 |
| 98 | 340.0 | -0.9515 | -0.1902 | 1.3089 | -0.7942 | -0.9471 | -0.2109 | 1.3256 | -0.8235 |
| 99 | 360.0 | -0.8325 | -0.1664 | 1.1494 | -0.6948 | -0.8230 | -0.1898 | 1.1639 | -0.7184 |
| 100 | 380.0 | -0.7274 | -0.1457 | 1.0090 | -0.6078 | -0.7185 | -0.1698 | 1.0248 | -0.6288 |
| 101 | 400.0 | -0.6366 | -0.1274 | 0.8856 | -0.5318 | -0.6262 | -0.1504 | 0.9001 | -0.5487 |
| 102 | 420.0 | -0.5562 | -0.1115 | 0.7771 | -0.4652 | -0.5470 | -0.1335 | 0.7916 | -0.4804 |
| 103 | 440.0 | -0.4869 | -0.0975 | 0.6817 | -0.4069 | -0.4785 | -0.1192 | 0.6970 | -0.4224 |
| 104 | 460.0 | -0.4253 | -0.0853 | 0.5979 | -0.3559 | -0.4176 | -0.1069 | 0.6126 | -0.3722 |
| 105 | 480.0 | -0.3724 | -0.0746 | 0.5243 | -0.3115 | -0.3655 | -0.0972 | 0.5401 | -0.3318 |
| 106 | 500.0 | -0.3252 | -0.0652 | 0.4596 | -0.2724 | -0.3190 | -0.0891 | 0.4752 | -0.2975 |

表4. 5 (1) 評価断面5の応力テンソル成分1

FINAS解と簡易計算値との比較 (コールドショック)

断面5の応力成分1

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|---------|---------|--------|---------|---------|---------|--------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.4616 | -0.0019 | 0.0237 | 0.1069 | 0.5518 | -0.0020 | 0.0271 | 0.1234 |
| 3 | 1.0 | 1.1142 | -0.0067 | 0.0702 | 0.3266 | 1.1440 | -0.0069 | 0.0717 | 0.3372 |
| 4 | 1.5 | 1.6869 | -0.0135 | 0.1268 | 0.5887 | 1.7475 | -0.0134 | 0.1294 | 0.6017 |
| 5 | 2.0 | 2.3186 | -0.0223 | 0.1955 | 0.8879 | 2.3516 | -0.0213 | 0.1975 | 0.8970 |
| 6 | 2.5 | 2.9142 | -0.0324 | 0.2713 | 1.2034 | 2.9544 | -0.0298 | 0.2733 | 1.2119 |
| 7 | 3.0 | 3.5277 | -0.0435 | 0.3536 | 1.5326 | 3.5539 | -0.0389 | 0.3555 | 1.5387 |
| 8 | 3.5 | 4.1198 | -0.0557 | 0.4401 | 1.8679 | 4.1480 | -0.0490 | 0.4421 | 1.8732 |
| 9 | 4.0 | 4.7158 | -0.0688 | 0.5299 | 2.2083 | 4.7337 | -0.0604 | 0.5318 | 2.2116 |
| 10 | 4.5 | 5.2963 | -0.0825 | 0.6218 | 2.5504 | 5.3134 | -0.0723 | 0.6238 | 2.5526 |
| 11 | 5.0 | 5.8757 | -0.0971 | 0.7153 | 2.8941 | 5.8846 | -0.0856 | 0.7168 | 2.8948 |
| 12 | 6.0 | 6.4881 | -0.1247 | 0.8713 | 3.4294 | 6.4436 | -0.1119 | 0.8703 | 3.4187 |
| 13 | 7.0 | 6.9417 | -0.1498 | 0.9966 | 3.8222 | 6.9351 | -0.1371 | 0.9964 | 3.8217 |
| 14 | 8.0 | 7.4460 | -0.1740 | 1.1066 | 4.1790 | 7.4067 | -0.1632 | 1.1049 | 4.1770 |
| 15 | 9.0 | 7.8846 | -0.1978 | 1.2027 | 4.5080 | 7.8666 | -0.1881 | 1.2012 | 4.5096 |
| 16 | 10.0 | 8.3583 | -0.2211 | 1.2919 | 4.8300 | 8.3194 | -0.2103 | 1.2895 | 4.8295 |
| 17 | 11.0 | 8.7946 | -0.2440 | 1.3741 | 5.1414 | 8.7676 | -0.2308 | 1.3720 | 5.1417 |
| 18 | 12.0 | 9.2505 | -0.2665 | 1.4523 | 5.4500 | 9.2094 | -0.2511 | 1.4494 | 5.4489 |
| 19 | 13.0 | 9.6825 | -0.2888 | 1.5259 | 5.7526 | 9.6445 | -0.2717 | 1.5224 | 5.7525 |
| 20 | 14.0 | 10.1242 | -0.3110 | 1.5966 | 6.0529 | 10.0740 | -0.2929 | 1.5921 | 6.0527 |
| 21 | 15.0 | 10.5495 | -0.3331 | 1.6639 | 6.3491 | 10.5000 | -0.3157 | 1.6588 | 6.3498 |
| 22 | 16.0 | 10.8238 | -0.3538 | 1.7187 | 6.5978 | 10.7470 | -0.3384 | 1.7113 | 6.5908 |
| 23 | 17.0 | 11.0454 | -0.3730 | 1.7615 | 6.8015 | 10.9830 | -0.3593 | 1.7533 | 6.7972 |
| 24 | 18.0 | 11.2920 | -0.3916 | 1.7979 | 6.9940 | 11.2160 | -0.3776 | 1.7886 | 6.9888 |
| 25 | 19.0 | 11.5155 | -0.4092 | 1.8286 | 7.1774 | 11.4490 | -0.3938 | 1.8190 | 7.1732 |
| 26 | 20.0 | 11.7565 | -0.4266 | 1.8564 | 7.3589 | 11.6810 | -0.4086 | 1.8460 | 7.3534 |
| 27 | 21.0 | 11.9842 | -0.4434 | 1.8813 | 7.5369 | 11.9130 | -0.4227 | 1.8710 | 7.5313 |
| 28 | 22.0 | 12.2229 | -0.4597 | 1.9046 | 7.7143 | 12.1450 | -0.4372 | 1.8942 | 7.7075 |
| 29 | 23.0 | 12.4526 | -0.4758 | 1.9262 | 7.8898 | 12.3740 | -0.4527 | 1.9157 | 7.8826 |
| 30 | 24.0 | 12.6894 | -0.4915 | 1.9467 | 8.0649 | 12.6040 | -0.4689 | 1.9358 | 8.0573 |
| 31 | 25.0 | 12.9196 | -0.5072 | 1.9661 | 8.2385 | 12.8340 | -0.4850 | 1.9549 | 8.2317 |
| 32 | 26.0 | 13.1025 | -0.5222 | 1.9813 | 8.3967 | 13.0050 | -0.4990 | 1.9693 | 8.3876 |
| 33 | 27.0 | 13.2672 | -0.5366 | 1.9927 | 8.5399 | 13.1740 | -0.5115 | 1.9801 | 8.5322 |
| 34 | 28.0 | 13.4421 | -0.5504 | 2.0020 | 8.6794 | 13.3430 | -0.5235 | 1.9885 | 8.6718 |
| 35 | 29.0 | 13.6094 | -0.5640 | 2.0097 | 8.8158 | 13.5130 | -0.5350 | 1.9951 | 8.8086 |
| 36 | 30.0 | 13.7836 | -0.5773 | 2.0165 | 8.9517 | 13.6820 | -0.5461 | 2.0005 | 8.9435 |
| 37 | 31.0 | 13.9529 | -0.5903 | 2.0225 | 9.0862 | 13.8520 | -0.5574 | 2.0052 | 9.0772 |
| 38 | 32.0 | 14.1272 | -0.6031 | 2.0282 | 9.2205 | 14.0220 | -0.5690 | 2.0096 | 9.2104 |
| 39 | 33.0 | 14.2980 | -0.6156 | 2.0335 | 9.3540 | 14.1920 | -0.5807 | 2.0139 | 9.3430 |
| 40 | 34.0 | 14.4718 | -0.6282 | 2.0387 | 9.4871 | 14.3610 | -0.5926 | 2.0184 | 9.4750 |
| 41 | 35.0 | 14.6431 | -0.6403 | 2.0437 | 9.6196 | 14.5300 | -0.6048 | 2.0229 | 9.6065 |
| 42 | 37.0 | 14.8774 | -0.6631 | 2.0444 | 9.8430 | 14.7510 | -0.6292 | 2.0231 | 9.8357 |
| 43 | 39.0 | 15.0924 | -0.6843 | 2.0368 | 10.0343 | 14.9670 | -0.6515 | 2.0158 | 10.0310 |
| 44 | 41.0 | 15.3243 | -0.7044 | 2.0274 | 10.2252 | 15.1870 | -0.6741 | 2.0051 | 10.2200 |
| 45 | 43.0 | 15.5485 | -0.7238 | 2.0177 | 10.4128 | 15.4110 | -0.6947 | 1.9950 | 10.4060 |
| 46 | 45.0 | 15.7839 | -0.7425 | 2.0088 | 10.6003 | 15.6340 | -0.7142 | 1.9856 | 10.5900 |
| 47 | 47.5 | 15.9287 | -0.7634 | 1.9862 | 10.7770 | 15.7670 | -0.7343 | 1.9625 | 10.7600 |
| 48 | 50.0 | 16.0658 | -0.7819 | 1.9551 | 10.9161 | 15.8980 | -0.7569 | 1.9314 | 10.9020 |
| 49 | 52.5 | 16.2169 | -0.7991 | 1.9242 | 11.0578 | 16.0380 | -0.7775 | 1.8999 | 11.0400 |
| 50 | 55.0 | 16.3700 | -0.8152 | 1.8954 | 11.1972 | 16.1810 | -0.7977 | 1.8715 | 11.1780 |
| 51 | 57.5 | 16.5296 | -0.8303 | 1.8693 | 11.3365 | 16.3290 | -0.8149 | 1.8454 | 11.3140 |
| 52 | 60.0 | 16.6890 | -0.8446 | 1.8457 | 11.4741 | 16.4790 | -0.8291 | 1.8218 | 11.4490 |
| 53 | 62.5 | 16.8517 | -0.8584 | 1.8248 | 11.6108 | 16.6330 | -0.8409 | 1.8011 | 11.5830 |
| 54 | 65.0 | 17.0129 | -0.8719 | 1.8061 | 11.7455 | 16.7870 | -0.8511 | 1.7834 | 11.7160 |

| | | | | | | | | | |
|-----|-------|---------|---------|---------|---------|---------|---------|---------|---------|
| 55 | 67.5 | 17.1754 | -0.8850 | 1.7895 | 11.8788 | 16.9430 | -0.8611 | 1.7677 | 11.8470 |
| 56 | 70.0 | 17.3360 | -0.8977 | 1.7748 | 12.0099 | 17.1020 | -0.8721 | 1.7538 | 11.9760 |
| 57 | 73.0 | 17.1871 | -0.9085 | 1.7272 | 12.0263 | 16.9310 | -0.8813 | 1.7033 | 11.9670 |
| 58 | 76.0 | 17.0088 | -0.9140 | 1.6566 | 11.9562 | 16.7700 | -0.8861 | 1.6361 | 11.9130 |
| 59 | 79.0 | 16.8837 | -0.9177 | 1.5882 | 11.9057 | 16.6280 | -0.8886 | 1.5698 | 11.8570 |
| 60 | 82.0 | 16.7528 | -0.9197 | 1.5245 | 11.8520 | 16.4970 | -0.8910 | 1.5073 | 11.8050 |
| 61 | 85.0 | 16.6544 | -0.9205 | 1.4672 | 11.8058 | 16.3800 | -0.8912 | 1.4497 | 11.7550 |
| 62 | 88.0 | 16.5487 | -0.9209 | 1.4147 | 11.7596 | 16.2740 | -0.8900 | 1.3976 | 11.7080 |
| 63 | 91.0 | 16.4669 | -0.9205 | 1.3680 | 11.7180 | 16.1760 | -0.8884 | 1.3516 | 11.6620 |
| 64 | 94.0 | 16.3779 | -0.9199 | 1.3256 | 11.6767 | 16.0870 | -0.8861 | 1.3098 | 11.6180 |
| 65 | 97.0 | 16.3074 | -0.9191 | 1.2878 | 11.6386 | 16.0030 | -0.8843 | 1.2718 | 11.5770 |
| 66 | 100.0 | 16.2299 | -0.9178 | 1.2534 | 11.6003 | 15.9220 | -0.8835 | 1.2376 | 11.5370 |
| 67 | 105.0 | 15.8367 | -0.9110 | 1.1717 | 11.4089 | 15.5000 | -0.8784 | 1.1536 | 11.3280 |
| 68 | 110.0 | 15.4443 | -0.8997 | 1.0786 | 11.1631 | 15.1180 | -0.8688 | 1.0664 | 11.0990 |
| 69 | 115.0 | 15.1171 | -0.8870 | 1.0006 | 10.9545 | 14.7660 | -0.8573 | 0.9892 | 10.8800 |
| 70 | 120.0 | 14.7897 | -0.8735 | 0.9331 | 10.7441 | 14.4390 | -0.8446 | 0.9219 | 10.6710 |
| 71 | 125.0 | 14.5031 | -0.8598 | 0.8757 | 10.5495 | 14.1350 | -0.8303 | 0.8636 | 10.4710 |
| 72 | 130.0 | 14.2142 | -0.8463 | 0.8261 | 10.3583 | 13.8500 | -0.8155 | 0.8133 | 10.2790 |
| 73 | 135.0 | 13.9570 | -0.8326 | 0.7839 | 10.1773 | 13.5790 | -0.8008 | 0.7703 | 10.0940 |
| 74 | 140.0 | 13.6961 | -0.8192 | 0.7467 | 10.0004 | 13.3210 | -0.7859 | 0.7339 | 9.9146 |
| 75 | 145.0 | 13.4613 | -0.8063 | 0.7146 | 9.8318 | 13.0730 | -0.7709 | 0.7023 | 9.7413 |
| 76 | 150.0 | 13.2228 | -0.7935 | 0.6860 | 9.6673 | 12.8370 | -0.7561 | 0.6749 | 9.5749 |
| 77 | 155.0 | 13.0076 | -0.7814 | 0.6612 | 9.5102 | 12.6160 | -0.7414 | 0.6507 | 9.4146 |
| 78 | 160.0 | 12.7882 | -0.7693 | 0.6387 | 9.3569 | 12.4090 | -0.7275 | 0.6291 | 9.2600 |
| 79 | 165.0 | 12.3031 | -0.7528 | 0.5871 | 9.0789 | 11.9080 | -0.7110 | 0.5700 | 8.9500 |
| 80 | 170.0 | 11.8164 | -0.7323 | 0.5186 | 8.7491 | 11.4420 | -0.6923 | 0.5052 | 8.6375 |
| 81 | 175.0 | 11.3971 | -0.7116 | 0.4610 | 8.4594 | 11.0050 | -0.6718 | 0.4467 | 8.3376 |
| 82 | 180.0 | 10.9770 | -0.6903 | 0.4102 | 8.1705 | 10.5880 | -0.6487 | 0.3948 | 8.0490 |
| 83 | 185.0 | 10.6009 | -0.6693 | 0.3670 | 7.9002 | 10.1930 | -0.6252 | 0.3502 | 7.7722 |
| 84 | 190.0 | 10.2223 | -0.6486 | 0.3292 | 7.6356 | 9.8187 | -0.6026 | 0.3128 | 7.5063 |
| 85 | 195.0 | 9.8790 | -0.6284 | 0.2968 | 7.3837 | 9.4602 | -0.5811 | 0.2803 | 7.2512 |
| 86 | 200.0 | 9.5317 | -0.6084 | 0.2680 | 7.1379 | 9.1162 | -0.5608 | 0.2511 | 7.0062 |
| 87 | 210.0 | 8.9020 | -0.5706 | 0.2207 | 6.6745 | 8.4698 | -0.5216 | 0.2025 | 6.5430 |
| 88 | 220.0 | 8.3028 | -0.5348 | 0.1831 | 6.2398 | 7.8717 | -0.4833 | 0.1641 | 6.1088 |
| 89 | 230.0 | 7.7618 | -0.5010 | 0.1534 | 5.8358 | 7.3141 | -0.4502 | 0.1334 | 5.7049 |
| 90 | 240.0 | 7.2434 | -0.4693 | 0.1288 | 5.4567 | 6.7914 | -0.4209 | 0.1085 | 5.3287 |
| 91 | 250.0 | 6.7758 | -0.4392 | 0.1089 | 5.1044 | 6.3024 | -0.3953 | 0.0872 | 4.9770 |
| 92 | 260.0 | 6.3259 | -0.4115 | 0.0919 | 4.7737 | 5.8396 | -0.3739 | 0.0677 | 4.6467 |
| 93 | 270.0 | 5.9204 | -0.3855 | 0.0781 | 4.4662 | 5.4079 | -0.3542 | 0.0507 | 4.3393 |
| 94 | 280.0 | 5.5286 | -0.3609 | 0.0660 | 4.1774 | 5.0067 | -0.3361 | 0.0364 | 4.0531 |
| 95 | 290.0 | 5.1763 | -0.3380 | 0.0562 | 3.9090 | 4.6366 | -0.3152 | 0.0243 | 3.7843 |
| 96 | 300.0 | 4.8345 | -0.3167 | 0.0474 | 3.6567 | 4.2949 | -0.2900 | 0.0141 | 3.5296 |
| 97 | 320.0 | 4.2341 | -0.2780 | 0.0341 | 3.2014 | 3.6952 | -0.2436 | -0.0022 | 3.0756 |
| 98 | 340.0 | 3.6978 | -0.2437 | 0.0240 | 2.8017 | 3.1803 | -0.2023 | -0.0136 | 2.6785 |
| 99 | 360.0 | 3.2410 | -0.2135 | 0.0169 | 2.4533 | 2.7288 | -0.1637 | -0.0219 | 2.3234 |
| 100 | 380.0 | 2.8302 | -0.1871 | 0.0114 | 2.1471 | 2.3376 | -0.1273 | -0.0274 | 2.0181 |
| 101 | 400.0 | 2.4824 | -0.1642 | 0.0076 | 1.8802 | 1.9835 | -0.0921 | -0.0316 | 1.7437 |
| 102 | 420.0 | 2.1667 | -0.1439 | 0.0045 | 1.6454 | 1.6733 | -0.0663 | -0.0349 | 1.5049 |
| 103 | 440.0 | 1.9015 | -0.1261 | 0.0025 | 1.4409 | 1.4008 | -0.0499 | -0.0373 | 1.2956 |
| 104 | 460.0 | 1.6585 | -0.1101 | 0.0009 | 1.2607 | 1.1543 | -0.0393 | -0.0394 | 1.1087 |
| 105 | 480.0 | 1.4567 | -0.0964 | 0.0000 | 1.1041 | 0.9342 | -0.0290 | -0.0408 | 0.9487 |
| 106 | 500.0 | 1.2696 | -0.0846 | -0.0009 | 0.9659 | 0.7302 | -0.0181 | -0.0420 | 0.8054 |

表4. 5(2) 評価断面5の応力テンソル成分2

F I N A S解と簡易計算値との比較 (コールドショック)

断面5の応力成分2

| ステップ | 時間(S) | F I N A S解 | | | | 簡易計算値 | | | |
|------|-------|------------|----------|---------|---------|---------|----------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.4887 | -0.1270 | 0.0067 | 0.1608 | 0.5854 | -0.1370 | 0.0081 | 0.1808 |
| 3 | 1.0 | 1.2386 | -0.4559 | 0.0162 | 0.5359 | 1.2715 | -0.4633 | 0.0170 | 0.5511 |
| 4 | 1.5 | 1.9306 | -0.9303 | 0.0229 | 1.0233 | 1.9882 | -0.9370 | 0.0240 | 1.0391 |
| 5 | 2.0 | 2.6809 | -1.5297 | 0.0273 | 1.5962 | 2.7122 | -1.5335 | 0.0283 | 1.6096 |
| 6 | 2.5 | 3.4030 | -2.2309 | 0.0287 | 2.2271 | 3.4364 | -2.2319 | 0.0300 | 2.2392 |
| 7 | 3.0 | 4.1397 | -3.0177 | 0.0276 | 2.9027 | 4.1578 | -3.0146 | 0.0290 | 2.9126 |
| 8 | 3.5 | 4.8576 | -3.8751 | 0.0239 | 3.6108 | 4.8719 | -3.8684 | 0.0250 | 3.6189 |
| 9 | 4.0 | 5.5763 | -4.7922 | 0.0179 | 4.3444 | 5.5776 | -4.7817 | 0.0186 | 4.3505 |
| 10 | 4.5 | 6.2798 | -5.7592 | 0.0096 | 5.0972 | 6.2752 | -5.7460 | 0.0098 | 5.1015 |
| 11 | 5.0 | 6.9805 | -6.7691 | -0.0005 | 5.8654 | 6.9627 | -6.7546 | -0.0011 | 5.8672 |
| 12 | 6.0 | 7.7806 | -8.6765 | -0.0333 | 7.1856 | 7.6982 | -8.6547 | -0.0357 | 7.1715 |
| 13 | 7.0 | 8.3416 | -10.3750 | -0.0716 | 8.2441 | 8.2976 | -10.3630 | -0.0749 | 8.2425 |
| 14 | 8.0 | 8.9552 | -11.9620 | -0.1084 | 9.2135 | 8.8675 | -11.9570 | -0.1142 | 9.2102 |
| 15 | 9.0 | 9.5004 | -13.4723 | -0.1450 | 10.1231 | 9.4253 | -13.4810 | -0.1523 | 10.1240 |
| 16 | 10.0 | 10.0776 | -14.9409 | -0.1806 | 11.0056 | 9.9751 | -14.9590 | -0.1896 | 11.0070 |
| 17 | 11.0 | 10.6199 | -16.3831 | -0.2162 | 11.8675 | 10.5210 | -16.4100 | -0.2265 | 11.8710 |
| 18 | 12.0 | 11.1783 | -17.8101 | -0.2516 | 12.7188 | 11.0610 | -17.8450 | -0.2635 | 12.7230 |
| 19 | 13.0 | 11.7150 | -19.2267 | -0.2871 | 13.5609 | 11.5950 | -19.2710 | -0.3006 | 13.5670 |
| 20 | 14.0 | 12.2581 | -20.6385 | -0.3228 | 14.3977 | 12.1230 | -20.6910 | -0.3382 | 14.4060 |
| 21 | 15.0 | 12.7865 | -22.0464 | -0.3587 | 15.2297 | 12.6470 | -22.1110 | -0.3760 | 15.2410 |
| 22 | 16.0 | 13.1457 | -23.3877 | -0.3971 | 15.9839 | 12.9670 | -23.4600 | -0.4169 | 15.9860 |
| 23 | 17.0 | 13.4301 | -24.6312 | -0.4357 | 16.6470 | 13.2620 | -24.7150 | -0.4567 | 16.6540 |
| 24 | 18.0 | 13.7393 | -25.8140 | -0.4726 | 17.2748 | 13.5510 | -25.9050 | -0.4948 | 17.2820 |
| 25 | 19.0 | 14.0263 | -26.9522 | -0.5085 | 17.8784 | 13.8400 | -27.0490 | -0.5313 | 17.8870 |
| 26 | 20.0 | 14.3293 | -28.0605 | -0.5432 | 18.4693 | 14.1290 | -28.1610 | -0.5668 | 18.4780 |
| 27 | 21.0 | 14.6207 | -29.1465 | -0.5773 | 19.0504 | 14.4180 | -29.2500 | -0.6014 | 19.0590 |
| 28 | 22.0 | 14.9215 | -30.2155 | -0.6107 | 19.6253 | 14.7070 | -30.3210 | -0.6354 | 19.6350 |
| 29 | 23.0 | 15.2149 | -31.2708 | -0.6436 | 20.1949 | 14.9940 | -31.3800 | -0.6691 | 20.2050 |
| 30 | 24.0 | 15.5141 | -32.3147 | -0.6761 | 20.7608 | 15.2810 | -32.4290 | -0.7024 | 20.7720 |
| 31 | 25.0 | 15.8076 | -33.3493 | -0.7082 | 21.3231 | 15.5680 | -33.4680 | -0.7353 | 21.3350 |
| 32 | 26.0 | 16.0477 | -34.3540 | -0.7408 | 21.8577 | 15.7880 | -34.4730 | -0.7690 | 21.8660 |
| 33 | 27.0 | 16.2626 | -35.3187 | -0.7730 | 22.3602 | 16.0010 | -35.4400 | -0.8019 | 22.3700 |
| 34 | 28.0 | 16.4873 | -36.2562 | -0.8043 | 22.8491 | 16.2140 | -36.3800 | -0.8341 | 22.8590 |
| 35 | 29.0 | 16.7050 | -37.1728 | -0.8350 | 23.3284 | 16.4280 | -37.2980 | -0.8654 | 23.3390 |
| 36 | 30.0 | 16.9291 | -38.0731 | -0.8649 | 23.8015 | 16.6430 | -38.2000 | -0.8961 | 23.8120 |
| 37 | 31.0 | 17.1491 | -38.9603 | -0.8943 | 24.2697 | 16.8590 | -39.0890 | -0.9263 | 24.2800 |
| 38 | 32.0 | 17.3733 | -39.8362 | -0.9232 | 24.7339 | 17.0770 | -39.9680 | -0.9559 | 24.7450 |
| 39 | 33.0 | 17.5944 | -40.7021 | -0.9517 | 25.1947 | 17.2930 | -40.8370 | -0.9849 | 25.2060 |
| 40 | 34.0 | 17.8180 | -41.5592 | -0.9797 | 25.6523 | 17.5090 | -41.6960 | -1.0136 | 25.6630 |
| 41 | 35.0 | 18.0396 | -42.4075 | -1.0074 | 26.1068 | 17.7230 | -42.5470 | -1.0419 | 26.1160 |
| 42 | 37.0 | 18.3577 | -44.0107 | -1.0630 | 26.9349 | 18.0260 | -44.1660 | -1.0989 | 26.9570 |
| 43 | 39.0 | 18.6435 | -45.4915 | -1.1160 | 27.6809 | 18.3100 | -45.6640 | -1.1529 | 27.7130 |
| 44 | 41.0 | 18.9505 | -46.9044 | -1.1657 | 28.4049 | 18.6020 | -47.0850 | -1.2038 | 28.4360 |
| 45 | 43.0 | 19.2483 | -48.2685 | -1.2133 | 29.1096 | 18.8980 | -48.4530 | -1.2522 | 29.1400 |
| 46 | 45.0 | 19.5575 | -49.5948 | -1.2589 | 29.8019 | 19.1950 | -49.7840 | -1.2991 | 29.8310 |
| 47 | 47.5 | 19.7722 | -51.1031 | -1.3151 | 30.5483 | 19.3950 | -51.2930 | -1.3570 | 30.5710 |
| 48 | 50.0 | 19.9641 | -52.4375 | -1.3668 | 31.1869 | 19.5840 | -52.6370 | -1.4099 | 31.2190 |
| 49 | 52.5 | 20.1767 | -53.6821 | -1.4137 | 31.8005 | 19.7800 | -53.8900 | -1.4589 | 31.8310 |
| 50 | 55.0 | 20.3876 | -54.8628 | -1.4576 | 32.3897 | 19.9780 | -55.0820 | -1.5047 | 32.4230 |
| 51 | 57.5 | 20.6067 | -55.9926 | -1.4988 | 32.9626 | 20.1790 | -56.2200 | -1.5474 | 32.9960 |
| 52 | 60.0 | 20.8234 | -57.0768 | -1.5378 | 33.5180 | 20.3830 | -57.3100 | -1.5873 | 33.5510 |
| 53 | 62.5 | 21.0434 | -58.1218 | -1.5748 | 34.0586 | 20.5880 | -58.3590 | -1.6247 | 34.0910 |
| 54 | 65.0 | 21.2602 | -59.1305 | -1.6101 | 34.5841 | 20.7930 | -59.3710 | -1.6599 | 34.6180 |

| | | | | | | | | | |
|-----|-------|---------|----------|---------|---------|---------|----------|---------|---------|
| 55 | 67.5 | 21.4780 | -60.1062 | -1.6439 | 35.0960 | 20.9990 | -60.3500 | -1.6935 | 35.1300 |
| 56 | 70.0 | 21.6925 | -61.0510 | -1.6763 | 35.5942 | 21.2070 | -61.2980 | -1.7257 | 35.6290 |
| 57 | 73.0 | 21.5533 | -61.8730 | -1.7160 | 35.9141 | 21.0260 | -62.0860 | -1.7662 | 35.9050 |
| 58 | 76.0 | 21.3518 | -62.3291 | -1.7473 | 35.9967 | 20.8490 | -62.5570 | -1.7963 | 36.0140 |
| 59 | 79.0 | 21.2227 | -62.6509 | -1.7699 | 36.0615 | 20.6930 | -62.8800 | -1.8191 | 36.0750 |
| 60 | 82.0 | 21.0798 | -62.8882 | -1.7886 | 36.0944 | 20.5520 | -63.1160 | -1.8368 | 36.1120 |
| 61 | 85.0 | 20.9755 | -63.0663 | -1.8031 | 36.1172 | 20.4270 | -63.2920 | -1.8508 | 36.1320 |
| 62 | 88.0 | 20.8611 | -63.1951 | -1.8153 | 36.1233 | 20.3140 | -63.4200 | -1.8619 | 36.1390 |
| 63 | 91.0 | 20.7724 | -63.2861 | -1.8248 | 36.1210 | 20.2070 | -63.5090 | -1.8707 | 36.1340 |
| 64 | 94.0 | 20.6755 | -63.3428 | -1.8326 | 36.1067 | 20.1100 | -63.5700 | -1.8781 | 36.1220 |
| 65 | 97.0 | 20.5974 | -63.3729 | -1.8386 | 36.0853 | 20.0220 | -63.6060 | -1.8842 | 36.1020 |
| 66 | 100.0 | 20.5122 | -63.3779 | -1.8433 | 36.0548 | 19.9370 | -63.6180 | -1.8886 | 36.0740 |
| 67 | 105.0 | 20.0555 | -63.0418 | -1.8488 | 35.7273 | 19.4510 | -63.2640 | -1.8935 | 35.7220 |
| 68 | 110.0 | 19.5822 | -62.3579 | -1.8432 | 35.2097 | 19.0010 | -62.6190 | -1.8861 | 35.2450 |
| 69 | 115.0 | 19.1915 | -61.6054 | -1.8302 | 34.7167 | 18.5840 | -61.8720 | -1.8728 | 34.7460 |
| 70 | 120.0 | 18.7935 | -60.7972 | -1.8142 | 34.2005 | 18.1960 | -61.0710 | -1.8560 | 34.2380 |
| 71 | 125.0 | 18.4441 | -59.9603 | -1.7951 | 33.6917 | 17.8340 | -60.2410 | -1.8365 | 33.7290 |
| 72 | 130.0 | 18.0903 | -59.1050 | -1.7745 | 33.1782 | 17.4910 | -59.3960 | -1.8151 | 33.2220 |
| 73 | 135.0 | 17.7720 | -58.2432 | -1.7525 | 32.6723 | 17.1620 | -58.5420 | -1.7924 | 32.7180 |
| 74 | 140.0 | 17.4497 | -57.3805 | -1.7299 | 32.1693 | 16.8430 | -57.6850 | -1.7686 | 32.2170 |
| 75 | 145.0 | 17.1563 | -56.5250 | -1.7069 | 31.6766 | 16.5370 | -56.8350 | -1.7447 | 31.7250 |
| 76 | 150.0 | 16.8600 | -55.6786 | -1.6839 | 31.1910 | 16.2460 | -55.9990 | -1.7210 | 31.2430 |
| 77 | 155.0 | 16.5887 | -54.8472 | -1.6608 | 30.7176 | 15.9710 | -55.1750 | -1.6973 | 30.7710 |
| 78 | 160.0 | 16.3148 | -54.0308 | -1.6380 | 30.2537 | 15.7100 | -54.3640 | -1.6738 | 30.3100 |
| 79 | 165.0 | 15.7264 | -52.9294 | -1.6157 | 29.5390 | 15.0940 | -53.1980 | -1.6511 | 29.5320 |
| 80 | 170.0 | 15.1215 | -51.5419 | -1.5852 | 28.6609 | 14.5190 | -51.8370 | -1.6196 | 28.6860 |
| 81 | 175.0 | 14.6031 | -50.1378 | -1.5493 | 27.8306 | 13.9780 | -50.4320 | -1.5844 | 27.8440 |
| 82 | 180.0 | 14.0786 | -48.7220 | -1.5124 | 26.9970 | 13.4660 | -49.0190 | -1.5472 | 27.0150 |
| 83 | 185.0 | 13.6074 | -47.3146 | -1.4738 | 26.1881 | 12.9790 | -47.6110 | -1.5090 | 26.2020 |
| 84 | 190.0 | 13.1329 | -45.9206 | -1.4351 | 25.3896 | 12.5120 | -46.2190 | -1.4699 | 25.4030 |
| 85 | 195.0 | 12.6985 | -44.5483 | -1.3960 | 24.6124 | 12.0620 | -44.8440 | -1.4306 | 24.6220 |
| 86 | 200.0 | 12.2616 | -43.1988 | -1.3572 | 23.8496 | 11.6290 | -43.4920 | -1.3914 | 23.8600 |
| 87 | 210.0 | 11.4617 | -40.5882 | -1.2807 | 22.3846 | 10.8140 | -40.8860 | -1.3153 | 22.3970 |
| 88 | 220.0 | 10.7015 | -38.1005 | -1.2069 | 20.9946 | 10.0600 | -38.4010 | -1.2420 | 21.0070 |
| 89 | 230.0 | 10.0094 | -35.7455 | -1.1362 | 19.6846 | 9.3528 | -36.0510 | -1.1731 | 19.6950 |
| 90 | 240.0 | 9.3492 | -33.5221 | -1.0692 | 18.4496 | 8.6876 | -33.8340 | -1.1085 | 18.4590 |
| 91 | 250.0 | 8.7483 | -31.4292 | -1.0055 | 17.2904 | 8.0668 | -31.7500 | -1.0480 | 17.2990 |
| 92 | 260.0 | 8.1737 | -29.4607 | -0.9455 | 16.2005 | 7.4832 | -29.7840 | -0.9913 | 16.2060 |
| 93 | 270.0 | 7.6510 | -27.6123 | -0.8888 | 15.1793 | 6.9376 | -27.9360 | -0.9376 | 15.1820 |
| 94 | 280.0 | 7.1496 | -25.8756 | -0.8354 | 14.2199 | 6.4264 | -26.1930 | -0.8861 | 14.2180 |
| 95 | 290.0 | 6.6943 | -24.2466 | -0.7849 | 13.3216 | 5.9498 | -24.5550 | -0.8371 | 13.3140 |
| 96 | 300.0 | 6.2564 | -22.7174 | -0.7375 | 12.4780 | 5.5058 | -23.0120 | -0.7903 | 12.4620 |
| 97 | 320.0 | 5.4807 | -19.9363 | -0.6505 | 10.9461 | 4.7192 | -20.2490 | -0.7050 | 10.9380 |
| 98 | 340.0 | 4.7912 | -17.4901 | -0.5735 | 9.5993 | 4.0348 | -17.8120 | -0.6275 | 9.5955 |
| 99 | 360.0 | 4.1995 | -15.3407 | -0.5053 | 8.4176 | 3.4280 | -15.6240 | -0.5567 | 8.3908 |
| 100 | 380.0 | 3.6709 | -13.4522 | -0.4450 | 7.3792 | 2.9030 | -13.7420 | -0.4953 | 7.3556 |
| 101 | 400.0 | 3.2188 | -11.7946 | -0.3917 | 6.4687 | 2.4291 | -12.0530 | -0.4398 | 6.4273 |
| 102 | 420.0 | 2.8126 | -10.3388 | -0.3447 | 5.6689 | 2.0230 | -10.5860 | -0.3915 | 5.6218 |
| 103 | 440.0 | 2.4669 | -9.0616 | -0.3032 | 4.9681 | 1.6765 | -9.3089 | -0.3496 | 4.9201 |
| 104 | 460.0 | 2.1541 | -7.9403 | -0.2667 | 4.3525 | 1.3701 | -8.1720 | -0.3126 | 4.2955 |
| 105 | 480.0 | 1.8905 | -6.9577 | -0.2344 | 3.8136 | 1.0974 | -7.1931 | -0.2810 | 3.7587 |
| 106 | 500.0 | 1.6499 | -6.0954 | -0.2060 | 3.3402 | 0.8451 | -6.3133 | -0.2530 | 3.2769 |

表4. 5 (3) 評価断面5の応力テンソル成分3

FINAS解と簡易計算値との比較 (コールドショック)

断面5の応力成分3

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|---------|----------|---------|---------|---------|----------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.7798 | -0.1065 | 0.0058 | 0.2281 | 0.9423 | -0.1145 | 0.0071 | 0.2579 |
| 3 | 1.0 | 2.0407 | -0.3828 | 0.0133 | 0.7565 | 2.1106 | -0.3886 | 0.0139 | 0.7806 |
| 4 | 1.5 | 3.2372 | -0.7822 | 0.0182 | 1.4363 | 3.3468 | -0.7890 | 0.0192 | 1.4634 |
| 5 | 2.0 | 4.5276 | -1.2875 | 0.0218 | 2.2285 | 4.6059 | -1.2935 | 0.0227 | 2.2537 |
| 6 | 2.5 | 5.7813 | -1.8771 | 0.0229 | 3.0914 | 5.8698 | -1.8819 | 0.0237 | 3.1169 |
| 7 | 3.0 | 7.0554 | -2.5350 | 0.0211 | 4.0055 | 7.1300 | -2.5365 | 0.0224 | 4.0299 |
| 8 | 3.5 | 8.3009 | -3.2460 | 0.0160 | 4.9527 | 8.3791 | -3.2437 | 0.0183 | 4.9770 |
| 9 | 4.0 | 9.5430 | -3.9993 | 0.0072 | 5.9232 | 9.6125 | -3.9924 | 0.0106 | 5.9466 |
| 10 | 4.5 | 10.7590 | -4.7858 | -0.0057 | 6.9079 | 10.8290 | -4.7748 | -0.0010 | 6.9310 |
| 11 | 5.0 | 11.9632 | -5.5995 | -0.0229 | 7.9020 | 12.0270 | -5.5831 | -0.0164 | 7.9240 |
| 12 | 6.0 | 13.3711 | -7.1045 | -0.0768 | 9.5491 | 13.3530 | -7.0731 | -0.0672 | 9.5512 |
| 13 | 7.0 | 14.2937 | -8.3985 | -0.1482 | 10.7924 | 14.3690 | -8.3607 | -0.1337 | 10.8150 |
| 14 | 8.0 | 15.2712 | -9.5683 | -0.2326 | 11.8884 | 15.2950 | -9.5218 | -0.2144 | 11.9090 |
| 15 | 9.0 | 16.1125 | -10.6544 | -0.3295 | 12.8854 | 16.1700 | -10.6070 | -0.3083 | 12.9120 |
| 16 | 10.0 | 16.9808 | -11.6965 | -0.4356 | 13.8346 | 17.0100 | -11.6460 | -0.4125 | 13.8600 |
| 17 | 11.0 | 17.7790 | -12.7119 | -0.5500 | 14.7460 | 17.8230 | -12.6600 | -0.5255 | 14.7730 |
| 18 | 12.0 | 18.5870 | -13.7114 | -0.6711 | 15.6357 | 18.6140 | -13.6580 | -0.6458 | 15.6630 |
| 19 | 13.0 | 19.3510 | -14.7000 | -0.7982 | 16.5057 | 19.3830 | -14.6460 | -0.7722 | 16.5340 |
| 20 | 14.0 | 20.1150 | -15.6819 | -0.9304 | 17.3623 | 20.1330 | -15.6280 | -0.9040 | 17.3920 |
| 21 | 15.0 | 20.8483 | -16.6585 | -1.0672 | 18.2060 | 20.8670 | -16.6080 | -1.0406 | 18.2380 |
| 22 | 16.0 | 21.2960 | -17.5768 | -1.2101 | 18.9345 | 21.2550 | -17.5230 | -1.1835 | 18.9490 |
| 23 | 17.0 | 21.5963 | -18.4102 | -1.3564 | 19.5322 | 21.5820 | -18.3580 | -1.3290 | 19.5510 |
| 24 | 18.0 | 21.9295 | -19.1909 | -1.5044 | 20.0813 | 21.8930 | -19.1350 | -1.4758 | 20.0980 |
| 25 | 19.0 | 22.2233 | -19.9344 | -1.6538 | 20.5984 | 22.1980 | -19.8760 | -1.6240 | 20.6170 |
| 26 | 20.0 | 22.5387 | -20.6558 | -1.8035 | 21.1006 | 22.5000 | -20.5960 | -1.7727 | 21.1190 |
| 27 | 21.0 | 22.8359 | -21.3612 | -1.9531 | 21.5913 | 22.8020 | -21.2990 | -1.9211 | 21.6110 |
| 28 | 22.0 | 23.1463 | -22.0549 | -2.1022 | 22.0761 | 23.1020 | -21.9910 | -2.0692 | 22.0960 |
| 29 | 23.0 | 23.4466 | -22.7397 | -2.2505 | 22.5555 | 23.4020 | -22.6740 | -2.2170 | 22.5760 |
| 30 | 24.0 | 23.7555 | -23.4170 | -2.3978 | 23.0316 | 23.7030 | -23.3520 | -2.3637 | 23.0530 |
| 31 | 25.0 | 24.0576 | -24.0877 | -2.5441 | 23.5043 | 24.0050 | -24.0220 | -2.5094 | 23.5270 |
| 32 | 26.0 | 24.2719 | -24.7346 | -2.6899 | 23.9396 | 24.1970 | -24.6650 | -2.6548 | 23.9580 |
| 33 | 27.0 | 24.4402 | -25.3489 | -2.8344 | 24.3319 | 24.3750 | -25.2770 | -2.7989 | 24.3530 |
| 34 | 28.0 | 24.6248 | -25.9412 | -2.9772 | 24.7084 | 24.5530 | -25.8670 | -2.9417 | 24.7300 |
| 35 | 29.0 | 24.7995 | -26.5172 | -3.1181 | 25.0745 | 24.7320 | -26.4410 | -3.0830 | 25.0980 |
| 36 | 30.0 | 24.9856 | -27.0819 | -3.2569 | 25.4359 | 24.9130 | -27.0030 | -3.2224 | 25.4600 |
| 37 | 31.0 | 25.1678 | -27.6376 | -3.3937 | 25.7934 | 25.0970 | -27.5570 | -3.3597 | 25.8180 |
| 38 | 32.0 | 25.3585 | -28.1858 | -3.5282 | 26.1489 | 25.2850 | -28.1050 | -3.4947 | 26.1740 |
| 39 | 33.0 | 25.5474 | -28.7272 | -3.6606 | 26.5023 | 25.4750 | -28.6460 | -3.6270 | 26.5280 |
| 40 | 34.0 | 25.7421 | -29.2629 | -3.7906 | 26.8543 | 25.6650 | -29.1800 | -3.7563 | 26.8810 |
| 41 | 35.0 | 25.9362 | -29.7927 | -3.9187 | 27.2047 | 25.8580 | -29.7080 | -3.8831 | 27.2310 |
| 42 | 37.0 | 26.1216 | -30.7775 | -4.1693 | 27.8007 | 26.0480 | -30.6970 | -4.1315 | 27.8480 |
| 43 | 39.0 | 26.2514 | -31.6654 | -4.4106 | 28.2975 | 26.1940 | -31.5930 | -4.3709 | 28.3610 |
| 44 | 41.0 | 26.4295 | -32.5049 | -4.6411 | 28.7823 | 26.3590 | -32.4370 | -4.6003 | 28.8470 |
| 45 | 43.0 | 26.6043 | -33.3145 | -4.8613 | 29.2578 | 26.5420 | -33.2480 | -4.8185 | 29.3250 |
| 46 | 45.0 | 26.8104 | -34.1018 | -5.0710 | 29.7320 | 26.7390 | -34.0340 | -5.0260 | 29.7980 |
| 47 | 47.5 | 26.7981 | -34.9716 | -5.3209 | 30.1806 | 26.7070 | -34.8980 | -5.2745 | 30.2360 |
| 48 | 50.0 | 26.7515 | -35.7100 | -5.5542 | 30.5092 | 26.6750 | -35.6430 | -5.5048 | 30.5810 |
| 49 | 52.5 | 26.7668 | -36.3922 | -5.7702 | 30.8371 | 26.6770 | -36.3300 | -5.7189 | 30.9080 |
| 50 | 55.0 | 26.7985 | -37.0405 | -5.9697 | 31.1607 | 26.7090 | -36.9840 | -5.9153 | 31.2360 |
| 51 | 57.5 | 26.8669 | -37.6617 | -6.1541 | 31.4873 | 26.7650 | -37.6070 | -6.0972 | 31.5630 |
| 52 | 60.0 | 26.9489 | -38.2580 | -6.3254 | 31.8125 | 26.8440 | -38.2040 | -6.2658 | 31.8890 |
| 53 | 62.5 | 27.0538 | -38.8332 | -6.4849 | 32.1376 | 26.9420 | -38.7770 | -6.4227 | 32.2140 |
| 54 | 65.0 | 27.1680 | -39.3889 | -6.6341 | 32.4600 | 27.0530 | -39.3290 | -6.5691 | 32.5380 |

| | | | | | | | | | |
|-----|-------|---------|----------|---------|---------|---------|----------|---------|---------|
| 55 | 67.5 | 27.2967 | -39.9268 | -6.7743 | 32.7804 | 27.1730 | -39.8630 | -6.7074 | 32.8580 |
| 56 | 70.0 | 27.4312 | -40.4481 | -6.9067 | 33.0969 | 27.3040 | -40.3810 | -6.8381 | 33.1730 |
| 57 | 73.0 | 26.9373 | -40.8257 | -7.0578 | 33.1141 | 26.7340 | -40.7210 | -6.9873 | 33.1250 |
| 58 | 76.0 | 26.3299 | -40.9218 | -7.1905 | 32.8515 | 26.1830 | -40.8250 | -7.1182 | 32.9020 |
| 59 | 79.0 | 25.8856 | -40.9461 | -7.2996 | 32.6244 | 25.7050 | -40.8490 | -7.2244 | 32.6720 |
| 60 | 82.0 | 25.4488 | -40.9377 | -7.3864 | 32.4007 | 25.2870 | -40.8340 | -7.3085 | 32.4550 |
| 61 | 85.0 | 25.1102 | -40.9056 | -7.4536 | 32.2023 | 24.9220 | -40.7930 | -7.3751 | 32.2520 |
| 62 | 88.0 | 24.7803 | -40.8536 | -7.5048 | 32.0132 | 24.6010 | -40.7310 | -7.4259 | 32.0640 |
| 63 | 91.0 | 24.5160 | -40.7885 | -7.5422 | 31.8404 | 24.3170 | -40.6560 | -7.4621 | 31.8860 |
| 64 | 94.0 | 24.2569 | -40.7104 | -7.5688 | 31.6749 | 24.0640 | -40.5710 | -7.4881 | 31.7210 |
| 65 | 97.0 | 24.0439 | -40.6244 | -7.5862 | 31.5204 | 23.8390 | -40.4800 | -7.5057 | 31.5640 |
| 66 | 100.0 | 23.8334 | -40.5302 | -7.5963 | 31.3714 | 23.6370 | -40.3840 | -7.5145 | 31.4160 |
| 67 | 105.0 | 22.9704 | -40.1154 | -7.5988 | 30.7862 | 22.7290 | -39.9440 | -7.5155 | 30.7920 |
| 68 | 110.0 | 22.1045 | -39.4632 | -7.5728 | 30.0203 | 21.9210 | -39.3240 | -7.4856 | 30.0820 |
| 69 | 115.0 | 21.4370 | -38.8132 | -7.5172 | 29.3652 | 21.2200 | -38.6730 | -7.4284 | 29.4140 |
| 70 | 120.0 | 20.7936 | -38.1547 | -7.4407 | 28.7269 | 20.6040 | -38.0160 | -7.3522 | 28.7860 |
| 71 | 125.0 | 20.2624 | -37.4978 | -7.3503 | 28.1367 | 20.0520 | -37.3630 | -7.2633 | 28.1920 |
| 72 | 130.0 | 19.7420 | -36.8494 | -7.2512 | 27.5681 | 19.5480 | -36.7170 | -7.1659 | 27.6270 |
| 73 | 135.0 | 19.2969 | -36.2126 | -7.1470 | 27.0320 | 19.0850 | -36.0810 | -7.0626 | 27.0890 |
| 74 | 140.0 | 18.8550 | -35.5899 | -7.0409 | 26.5155 | 18.6550 | -35.4550 | -6.9556 | 26.5730 |
| 75 | 145.0 | 18.4684 | -34.9845 | -6.9343 | 26.0250 | 18.2540 | -34.8450 | -6.8471 | 26.0790 |
| 76 | 150.0 | 18.0817 | -34.3958 | -6.8289 | 25.5522 | 17.8820 | -34.2520 | -6.7389 | 25.6070 |
| 77 | 155.0 | 17.7388 | -33.8266 | -6.7253 | 25.1018 | 17.5340 | -33.6780 | -6.6327 | 25.1540 |
| 78 | 160.0 | 17.3940 | -33.2749 | -6.6245 | 24.6674 | 17.2090 | -33.1210 | -6.5292 | 24.7190 |
| 79 | 165.0 | 16.5145 | -32.4945 | -6.5242 | 23.8998 | 16.2650 | -32.2720 | -6.4281 | 23.8560 |
| 80 | 170.0 | 15.6075 | -31.5039 | -6.4097 | 22.9529 | 15.4150 | -31.3080 | -6.3094 | 22.9600 |
| 81 | 175.0 | 14.8862 | -30.5376 | -6.2760 | 22.1196 | 14.6570 | -30.3350 | -6.1729 | 22.1080 |
| 82 | 180.0 | 14.1772 | -29.5808 | -6.1289 | 21.3065 | 13.9700 | -29.3710 | -6.0252 | 21.3000 |
| 83 | 185.0 | 13.5759 | -28.6407 | -5.9735 | 20.5455 | 13.3420 | -28.4250 | -5.8691 | 20.5300 |
| 84 | 190.0 | 12.9792 | -27.7215 | -5.8137 | 19.8100 | 12.7610 | -27.4990 | -5.7072 | 19.7950 |
| 85 | 195.0 | 12.4572 | -26.8252 | -5.6519 | 19.1110 | 12.2180 | -26.5950 | -5.5438 | 19.0920 |
| 86 | 200.0 | 11.9357 | -25.9521 | -5.4906 | 18.4355 | 11.7100 | -25.7120 | -5.3816 | 18.4170 |
| 87 | 210.0 | 11.0174 | -24.2834 | -5.1742 | 17.1675 | 10.7800 | -24.0290 | -5.0631 | 17.1500 |
| 88 | 220.0 | 10.1626 | -22.7154 | -4.8708 | 15.9911 | 9.9434 | -22.4430 | -4.7546 | 15.9740 |
| 89 | 230.0 | 9.4094 | -21.2485 | -4.5830 | 14.9039 | 9.1764 | -20.9660 | -4.4629 | 14.8850 |
| 90 | 240.0 | 8.6958 | -19.8763 | -4.3119 | 13.8924 | 8.4645 | -19.5920 | -4.1891 | 13.8760 |
| 91 | 250.0 | 8.0638 | -18.5952 | -4.0569 | 12.9560 | 7.8106 | -18.3130 | -3.9321 | 12.9400 |
| 92 | 260.0 | 7.4602 | -17.3981 | -3.8175 | 12.0835 | 7.2055 | -17.1190 | -3.6902 | 12.0680 |
| 93 | 270.0 | 6.9254 | -16.2806 | -3.5922 | 11.2745 | 6.6491 | -16.0060 | -3.4634 | 11.2600 |
| 94 | 280.0 | 6.4114 | -15.2354 | -3.3806 | 10.5198 | 6.1377 | -14.9650 | -3.2494 | 10.5080 |
| 95 | 290.0 | 5.9568 | -14.2592 | -3.1814 | 9.8193 | 5.6680 | -13.9900 | -3.0476 | 9.8090 |
| 96 | 300.0 | 5.5178 | -13.3458 | -2.9940 | 9.1652 | 5.2355 | -13.0710 | -2.8563 | 9.1543 |
| 97 | 320.0 | 4.7615 | -11.6915 | -2.6508 | 7.9887 | 4.4837 | -11.4330 | -2.5127 | 7.9930 |
| 98 | 340.0 | 4.0965 | -10.2428 | -2.3465 | 6.9647 | 3.8458 | -9.9960 | -2.2082 | 6.9804 |
| 99 | 360.0 | 3.5433 | -8.9748 | -2.0761 | 6.0757 | 3.2918 | -8.7090 | -1.9324 | 6.0787 |
| 100 | 380.0 | 3.0516 | -7.8633 | -1.8361 | 5.3000 | 2.8215 | -7.6031 | -1.6930 | 5.3108 |
| 101 | 400.0 | 2.6453 | -6.8900 | -1.6229 | 4.6260 | 2.4042 | -6.6096 | -1.4766 | 4.6266 |
| 102 | 420.0 | 2.2795 | -6.0363 | -1.4339 | 4.0371 | 2.0511 | -5.7493 | -1.2868 | 4.0358 |
| 103 | 440.0 | 1.9797 | -5.2886 | -1.2661 | 3.5250 | 1.7520 | -5.0024 | -1.1197 | 3.5225 |
| 104 | 460.0 | 1.7058 | -4.6327 | -1.1175 | 3.0770 | 1.4883 | -4.3399 | -0.9699 | 3.0667 |
| 105 | 480.0 | 1.4848 | -4.0584 | -0.9859 | 2.6876 | 1.2528 | -3.7736 | -0.8403 | 2.6776 |
| 106 | 500.0 | 1.2789 | -3.5548 | -0.8694 | 2.3463 | 1.0345 | -3.2669 | -0.7235 | 2.3303 |

表4. 5(4) 評価断面5の応力テンソル成分4

FINAS解と簡易計算値との比較 (コールドショック)

断面5の応力成分4

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|---------|---------|--------|---------|---------|---------|--------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.3323 | -0.0092 | 0.0035 | 0.0968 | 0.3999 | -0.0099 | 0.0033 | 0.1080 |
| 3 | 1.0 | 0.9206 | -0.0330 | 0.0136 | 0.3267 | 0.9547 | -0.0335 | 0.0137 | 0.3367 |
| 4 | 1.5 | 1.5135 | -0.0674 | 0.0302 | 0.6263 | 1.5611 | -0.0681 | 0.0302 | 0.6379 |
| 5 | 2.0 | 2.1510 | -0.1110 | 0.0519 | 0.9742 | 2.1880 | -0.1112 | 0.0519 | 0.9852 |
| 6 | 2.5 | 2.7819 | -0.1619 | 0.0779 | 1.3509 | 2.8226 | -0.1617 | 0.0779 | 1.3620 |
| 7 | 3.0 | 3.4228 | -0.2189 | 0.1076 | 1.7475 | 3.4582 | -0.2182 | 0.1076 | 1.7578 |
| 8 | 3.5 | 4.0550 | -0.2808 | 0.1405 | 2.1561 | 4.0908 | -0.2794 | 0.1405 | 2.1658 |
| 9 | 4.0 | 4.6865 | -0.3468 | 0.1761 | 2.5727 | 4.7186 | -0.3448 | 0.1760 | 2.5816 |
| 10 | 4.5 | 5.3093 | -0.4160 | 0.2141 | 2.9938 | 5.3412 | -0.4138 | 0.2139 | 3.0025 |
| 11 | 5.0 | 5.9281 | -0.4878 | 0.2542 | 3.4176 | 5.9573 | -0.4857 | 0.2539 | 3.4257 |
| 12 | 6.0 | 6.7241 | -0.6220 | 0.3331 | 4.1155 | 6.7180 | -0.6197 | 0.3326 | 4.1141 |
| 13 | 7.0 | 7.2525 | -0.7392 | 0.4059 | 4.6317 | 7.2904 | -0.7366 | 0.4049 | 4.6370 |
| 14 | 8.0 | 7.7999 | -0.8466 | 0.4744 | 5.0839 | 7.8200 | -0.8439 | 0.4734 | 5.0899 |
| 15 | 9.0 | 8.2963 | -0.9471 | 0.5407 | 5.4991 | 8.3321 | -0.9449 | 0.5396 | 5.5082 |
| 16 | 10.0 | 8.8044 | -1.0439 | 0.6056 | 5.8970 | 8.8323 | -1.0418 | 0.6046 | 5.9061 |
| 17 | 11.0 | 9.2897 | -1.1384 | 0.6697 | 6.2813 | 9.3265 | -1.1359 | 0.6689 | 6.2918 |
| 18 | 12.0 | 9.7799 | -1.2314 | 0.7334 | 6.6576 | 9.8137 | -1.2286 | 0.7327 | 6.6684 |
| 19 | 13.0 | 10.2556 | -1.3234 | 0.7968 | 7.0262 | 10.2940 | -1.3208 | 0.7964 | 7.0378 |
| 20 | 14.0 | 10.7324 | -1.4150 | 0.8603 | 7.3896 | 10.7680 | -1.4130 | 0.8601 | 7.4016 |
| 21 | 15.0 | 11.1983 | -1.5060 | 0.9238 | 7.7474 | 11.2360 | -1.5053 | 0.9239 | 7.7603 |
| 22 | 16.0 | 11.5375 | -1.5920 | 0.9855 | 8.0557 | 11.5480 | -1.5921 | 0.9857 | 8.0610 |
| 23 | 17.0 | 11.7954 | -1.6708 | 1.0436 | 8.3059 | 11.8190 | -1.6720 | 1.0439 | 8.3119 |
| 24 | 18.0 | 12.0646 | -1.7450 | 1.0993 | 8.5352 | 12.0790 | -1.7472 | 1.0996 | 8.5402 |
| 25 | 19.0 | 12.3182 | -1.8159 | 1.1532 | 8.7523 | 12.3380 | -1.8188 | 1.1535 | 8.7573 |
| 26 | 20.0 | 12.5796 | -1.8847 | 1.2059 | 8.9640 | 12.5950 | -1.8880 | 1.2062 | 8.9682 |
| 27 | 21.0 | 12.8345 | -1.9520 | 1.2576 | 9.1713 | 12.8520 | -1.9558 | 1.2578 | 9.1753 |
| 28 | 22.0 | 13.0939 | -2.0183 | 1.3086 | 9.3763 | 13.1080 | -2.0226 | 1.3088 | 9.3800 |
| 29 | 23.0 | 13.3491 | -2.0838 | 1.3590 | 9.5791 | 13.3640 | -2.0884 | 1.3593 | 9.5829 |
| 30 | 24.0 | 13.6071 | -2.1486 | 1.4089 | 9.7805 | 13.6180 | -2.1536 | 1.4092 | 9.7839 |
| 31 | 25.0 | 13.8620 | -2.2128 | 1.4584 | 9.9804 | 13.8730 | -2.2182 | 1.4587 | 9.9836 |
| 32 | 26.0 | 14.0765 | -2.2750 | 1.5069 | 10.1642 | 14.0760 | -2.2808 | 1.5072 | 10.1640 |
| 33 | 27.0 | 14.2643 | -2.3343 | 1.5539 | 10.3289 | 14.2670 | -2.3407 | 1.5541 | 10.3290 |
| 34 | 28.0 | 14.4571 | -2.3919 | 1.5996 | 10.4868 | 14.4560 | -2.3984 | 1.5998 | 10.4860 |
| 35 | 29.0 | 14.6450 | -2.4480 | 1.6444 | 10.6409 | 14.6450 | -2.4541 | 1.6447 | 10.6390 |
| 36 | 30.0 | 14.8364 | -2.5030 | 1.6885 | 10.7933 | 14.8340 | -2.5083 | 1.6889 | 10.7910 |
| 37 | 31.0 | 15.0258 | -2.5573 | 1.7320 | 10.9445 | 15.0230 | -2.5615 | 1.7324 | 10.9410 |
| 38 | 32.0 | 15.2173 | -2.6110 | 1.7748 | 11.0948 | 15.2120 | -2.6144 | 1.7754 | 11.0910 |
| 39 | 33.0 | 15.4076 | -2.6641 | 1.8172 | 11.2445 | 15.4010 | -2.6671 | 1.8179 | 11.2400 |
| 40 | 34.0 | 15.5989 | -2.7167 | 1.8592 | 11.3936 | 15.5890 | -2.7195 | 1.8598 | 11.3890 |
| 41 | 35.0 | 15.7893 | -2.7689 | 1.9007 | 11.5422 | 15.7780 | -2.7719 | 1.9012 | 11.5380 |
| 42 | 37.0 | 16.0711 | -2.8667 | 1.9801 | 11.7941 | 16.0680 | -2.8720 | 1.9808 | 11.8010 |
| 43 | 39.0 | 16.3122 | -2.9562 | 2.0543 | 12.0033 | 16.3190 | -2.9632 | 2.0551 | 12.0170 |
| 44 | 41.0 | 16.5716 | -3.0413 | 2.1250 | 12.2094 | 16.5730 | -3.0487 | 2.1260 | 12.2240 |
| 45 | 43.0 | 16.8243 | -3.1237 | 2.1933 | 12.4129 | 16.8290 | -3.1308 | 2.1942 | 12.4280 |
| 46 | 45.0 | 17.0852 | -3.2041 | 2.2595 | 12.6160 | 17.0850 | -3.2109 | 2.2604 | 12.6320 |
| 47 | 47.5 | 17.2771 | -3.2945 | 2.3361 | 12.8081 | 17.2640 | -3.3016 | 2.3370 | 12.8200 |
| 48 | 50.0 | 17.4305 | -3.3732 | 2.4048 | 12.9487 | 17.4270 | -3.3807 | 2.4058 | 12.9700 |
| 49 | 52.5 | 17.6074 | -3.4467 | 2.4688 | 13.0920 | 17.5950 | -3.4551 | 2.4698 | 13.1130 |
| 50 | 55.0 | 17.7810 | -3.5168 | 2.5293 | 13.2342 | 17.7670 | -3.5268 | 2.5303 | 13.2560 |
| 51 | 57.5 | 17.9635 | -3.5842 | 2.5869 | 13.3777 | 17.9410 | -3.5955 | 2.5879 | 13.4000 |
| 52 | 60.0 | 18.1444 | -3.6491 | 2.6421 | 13.5210 | 18.1190 | -3.6612 | 2.6429 | 13.5430 |
| 53 | 62.5 | 18.3288 | -3.7118 | 2.6949 | 13.6644 | 18.2980 | -3.7246 | 2.6957 | 13.6870 |
| 54 | 65.0 | 18.5112 | -3.7726 | 2.7457 | 13.8070 | 18.4760 | -3.7860 | 2.7465 | 13.8290 |

| | | | | | | | | | |
|-----|-------|---------|---------|--------|---------|---------|---------|--------|---------|
| 55 | 67.5 | 18.6945 | -3.8316 | 2.7947 | 13.9489 | 18.6520 | -3.8460 | 2.7955 | 13.9710 |
| 56 | 70.0 | 18.8756 | -3.8888 | 2.8419 | 14.0894 | 18.8290 | -3.9044 | 2.8427 | 14.1110 |
| 57 | 73.0 | 18.7732 | -3.9356 | 2.8868 | 14.1007 | 18.6790 | -3.9509 | 2.8863 | 14.0930 |
| 58 | 76.0 | 18.5788 | -3.9571 | 2.9158 | 13.9925 | 18.5170 | -3.9754 | 2.9156 | 14.0050 |
| 59 | 79.0 | 18.4565 | -3.9709 | 2.9374 | 13.9053 | 18.3730 | -3.9929 | 2.9373 | 13.9160 |
| 60 | 82.0 | 18.3212 | -3.9804 | 2.9543 | 13.8190 | 18.2420 | -4.0045 | 2.9541 | 13.8320 |
| 61 | 85.0 | 18.2198 | -3.9873 | 2.9675 | 13.7426 | 18.1260 | -4.0131 | 2.9674 | 13.7560 |
| 62 | 88.0 | 18.1131 | -3.9915 | 2.9780 | 13.6704 | 18.0220 | -4.0191 | 2.9779 | 13.6850 |
| 63 | 91.0 | 18.0273 | -3.9941 | 2.9860 | 13.6048 | 17.9270 | -4.0226 | 2.9859 | 13.6200 |
| 64 | 94.0 | 17.9384 | -3.9950 | 2.9920 | 13.5426 | 17.8390 | -4.0245 | 2.9919 | 13.5590 |
| 65 | 97.0 | 17.8634 | -3.9945 | 2.9962 | 13.4847 | 17.7560 | -4.0251 | 2.9962 | 13.5020 |
| 66 | 100.0 | 17.7858 | -3.9927 | 2.9991 | 13.4292 | 17.6780 | -4.0254 | 2.9990 | 13.4480 |
| 67 | 105.0 | 17.3932 | -3.9662 | 2.9897 | 13.1906 | 17.2530 | -4.0002 | 2.9884 | 13.1930 |
| 68 | 110.0 | 16.9643 | -3.9168 | 2.9641 | 12.8764 | 16.8470 | -3.9562 | 2.9636 | 12.9050 |
| 69 | 115.0 | 16.6177 | -3.8650 | 2.9335 | 12.6117 | 16.4740 | -3.9072 | 2.9330 | 12.6330 |
| 70 | 120.0 | 16.2641 | -3.8110 | 2.8994 | 12.3510 | 16.1260 | -3.8554 | 2.8990 | 12.3770 |
| 71 | 125.0 | 15.9549 | -3.7558 | 2.8630 | 12.1109 | 15.8000 | -3.8027 | 2.8630 | 12.1360 |
| 72 | 130.0 | 15.6438 | -3.7003 | 2.8252 | 11.8792 | 15.4910 | -3.7500 | 2.8255 | 11.9050 |
| 73 | 135.0 | 15.3630 | -3.6448 | 2.7865 | 11.6605 | 15.1970 | -3.6974 | 2.7872 | 11.6850 |
| 74 | 140.0 | 15.0818 | -3.5896 | 2.7475 | 11.4496 | 14.9180 | -3.6444 | 2.7482 | 11.4740 |
| 75 | 145.0 | 14.8237 | -3.5351 | 2.7084 | 11.2486 | 14.6510 | -3.5918 | 2.7092 | 11.2710 |
| 76 | 150.0 | 14.5665 | -3.4813 | 2.6696 | 11.0547 | 14.3940 | -3.5398 | 2.6703 | 11.0790 |
| 77 | 155.0 | 14.3285 | -3.4287 | 2.6313 | 10.8694 | 14.1470 | -3.4885 | 2.6318 | 10.8930 |
| 78 | 160.0 | 14.0919 | -3.3771 | 2.5936 | 10.6904 | 13.9080 | -3.4379 | 2.5939 | 10.7130 |
| 79 | 165.0 | 13.5917 | -3.3052 | 2.5453 | 10.3664 | 13.3610 | -3.3623 | 2.5426 | 10.3460 |
| 80 | 170.0 | 13.0537 | -3.2136 | 2.4842 | 9.9674 | 12.8500 | -3.2752 | 2.4818 | 9.9704 |
| 81 | 175.0 | 12.6007 | -3.1228 | 2.4209 | 9.6194 | 12.3720 | -3.1867 | 2.4181 | 9.6135 |
| 82 | 180.0 | 12.1411 | -3.0321 | 2.3565 | 9.2769 | 11.9220 | -3.0986 | 2.3535 | 9.2753 |
| 83 | 185.0 | 11.7291 | -2.9425 | 2.2917 | 8.9570 | 11.4930 | -3.0103 | 2.2886 | 8.9528 |
| 84 | 190.0 | 11.3168 | -2.8542 | 2.2272 | 8.6475 | 11.0840 | -2.9214 | 2.2238 | 8.6441 |
| 85 | 195.0 | 10.9376 | -2.7677 | 2.1631 | 8.3529 | 10.6920 | -2.8343 | 2.1595 | 8.3483 |
| 86 | 200.0 | 10.5599 | -2.6827 | 2.1000 | 8.0681 | 10.3150 | -2.7494 | 2.0961 | 8.0646 |
| 87 | 210.0 | 9.8645 | -2.5189 | 1.9770 | 7.5317 | 9.6049 | -2.5865 | 1.9728 | 7.5302 |
| 88 | 220.0 | 9.2081 | -2.3633 | 1.8594 | 7.0324 | 8.9441 | -2.4311 | 1.8543 | 7.0315 |
| 89 | 230.0 | 8.6079 | -2.2163 | 1.7475 | 6.5690 | 8.3333 | -2.2853 | 1.7417 | 6.5689 |
| 90 | 240.0 | 8.0396 | -2.0776 | 1.6417 | 6.1366 | 7.7673 | -2.1487 | 1.6352 | 6.1392 |
| 91 | 250.0 | 7.5193 | -1.9473 | 1.5417 | 5.7347 | 7.2405 | -2.0207 | 1.5348 | 5.7392 |
| 92 | 260.0 | 7.0256 | -1.8248 | 1.4476 | 5.3593 | 6.7475 | -1.9014 | 1.4398 | 5.3657 |
| 93 | 270.0 | 6.5733 | -1.7098 | 1.3589 | 5.0098 | 6.2871 | -1.7899 | 1.3504 | 5.0182 |
| 94 | 280.0 | 6.1432 | -1.6016 | 1.2754 | 4.6831 | 5.8549 | -1.6847 | 1.2659 | 4.6935 |
| 95 | 290.0 | 5.7494 | -1.5007 | 1.1970 | 4.3788 | 5.4526 | -1.5856 | 1.1866 | 4.3905 |
| 96 | 300.0 | 5.3741 | -1.4057 | 1.1232 | 4.0940 | 5.0771 | -1.4916 | 1.1121 | 4.1064 |
| 97 | 320.0 | 4.7052 | -1.2332 | 0.9885 | 3.5797 | 4.4103 | -1.3219 | 0.9784 | 3.5983 |
| 98 | 340.0 | 4.1142 | -1.0815 | 0.8697 | 3.1302 | 3.8284 | -1.1703 | 0.8602 | 3.1508 |
| 99 | 360.0 | 3.6039 | -0.9484 | 0.7648 | 2.7380 | 3.3099 | -1.0335 | 0.7538 | 2.7491 |
| 100 | 380.0 | 3.1513 | -0.8314 | 0.6723 | 2.3947 | 2.8630 | -0.9168 | 0.6620 | 2.4045 |
| 101 | 400.0 | 2.7612 | -0.7288 | 0.5908 | 2.0950 | 2.4603 | -0.8127 | 0.5794 | 2.0957 |
| 102 | 420.0 | 2.4139 | -0.6387 | 0.5191 | 1.8325 | 2.1121 | -0.7222 | 0.5075 | 1.8292 |
| 103 | 440.0 | 2.1157 | -0.5597 | 0.4559 | 1.6033 | 1.8116 | -0.6432 | 0.4447 | 1.5987 |
| 104 | 460.0 | 1.8489 | -0.4904 | 0.4003 | 1.4024 | 1.5457 | -0.5733 | 0.3887 | 1.3947 |
| 105 | 480.0 | 1.6210 | -0.4297 | 0.3514 | 1.2271 | 1.3163 | -0.5155 | 0.3404 | 1.2208 |
| 106 | 500.0 | 1.4160 | -0.3765 | 0.3084 | 1.0732 | 1.1096 | -0.4654 | 0.2969 | 1.0659 |

表4. 6(1) 評価断面6の応力テンソル成分1

FINAS解と簡易計算値との比較 (コールドショック)

断面6の応力成分1

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|---------|---------|---------|--------|--------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.2196 | 0.0002 | -0.0061 | 0.0072 | 0.2539 | 0.0002 | -0.0051 | 0.0107 |
| 3 | 1.0 | 0.3928 | 0.0006 | -0.0311 | 0.0041 | 0.3902 | 0.0006 | -0.0314 | 0.0043 |
| 4 | 1.5 | 0.4586 | 0.0012 | -0.0726 | -0.0124 | 0.4847 | 0.0012 | -0.0724 | -0.0111 |
| 5 | 2.0 | 0.5533 | 0.0020 | -0.1239 | -0.0304 | 0.5559 | 0.0020 | -0.1241 | -0.0304 |
| 6 | 2.5 | 0.5984 | 0.0030 | -0.1841 | -0.0508 | 0.6157 | 0.0030 | -0.1840 | -0.0503 |
| 7 | 3.0 | 0.6607 | 0.0041 | -0.2510 | -0.0701 | 0.6644 | 0.0040 | -0.2508 | -0.0703 |
| 8 | 3.5 | 0.6988 | 0.0053 | -0.3240 | -0.0892 | 0.7086 | 0.0053 | -0.3236 | -0.0892 |
| 9 | 4.0 | 0.7452 | 0.0068 | -0.4019 | -0.1064 | 0.7487 | 0.0066 | -0.4016 | -0.1067 |
| 10 | 4.5 | 0.7795 | 0.0085 | -0.4844 | -0.1221 | 0.7853 | 0.0084 | -0.4842 | -0.1222 |
| 11 | 5.0 | 0.8172 | 0.0101 | -0.5706 | -0.1355 | 0.8187 | 0.0108 | -0.5709 | -0.1355 |
| 12 | 6.0 | 0.6878 | 0.0137 | -0.7374 | -0.1580 | 0.6670 | 0.0165 | -0.7375 | -0.1582 |
| 13 | 7.0 | 0.6576 | 0.0174 | -0.8820 | -0.1534 | 0.6380 | 0.0224 | -0.8816 | -0.1517 |
| 14 | 8.0 | 0.6726 | 0.0213 | -1.0138 | -0.1332 | 0.6334 | 0.0278 | -1.0137 | -0.1326 |
| 15 | 9.0 | 0.6649 | 0.0251 | -1.1383 | -0.1097 | 0.6370 | 0.0336 | -1.1362 | -0.1064 |
| 16 | 10.0 | 0.6904 | 0.0286 | -1.2539 | -0.0800 | 0.6454 | 0.0387 | -1.2503 | -0.0764 |
| 17 | 11.0 | 0.6902 | 0.0322 | -1.3628 | -0.0495 | 0.6559 | 0.0443 | -1.3570 | -0.0441 |
| 18 | 12.0 | 0.7143 | 0.0353 | -1.4649 | -0.0166 | 0.6677 | 0.0510 | -1.4576 | -0.0106 |
| 19 | 13.0 | 0.7183 | 0.0381 | -1.5616 | 0.0160 | 0.6815 | 0.0574 | -1.5530 | 0.0231 |
| 20 | 14.0 | 0.7393 | 0.0403 | -1.6531 | 0.0494 | 0.6960 | 0.0634 | -1.6436 | 0.0571 |
| 21 | 15.0 | 0.7460 | 0.0423 | -1.7405 | 0.0824 | 0.7111 | 0.0690 | -1.7305 | 0.0911 |
| 22 | 16.0 | 0.7066 | 0.0437 | -1.8197 | 0.1150 | 0.6732 | 0.0735 | -1.8090 | 0.1242 |
| 23 | 17.0 | 0.6880 | 0.0445 | -1.8864 | 0.1524 | 0.6636 | 0.0766 | -1.8750 | 0.1632 |
| 24 | 18.0 | 0.6929 | 0.0452 | -1.9444 | 0.1920 | 0.6617 | 0.0792 | -1.9331 | 0.2030 |
| 25 | 19.0 | 0.6839 | 0.0457 | -1.9967 | 0.2296 | 0.6622 | 0.0812 | -1.9852 | 0.2422 |
| 26 | 20.0 | 0.6923 | 0.0457 | -2.0437 | 0.2668 | 0.6644 | 0.0821 | -2.0321 | 0.2806 |
| 27 | 21.0 | 0.6879 | 0.0452 | -2.0867 | 0.3018 | 0.6681 | 0.0819 | -2.0749 | 0.3179 |
| 28 | 22.0 | 0.6960 | 0.0447 | -2.1263 | 0.3357 | 0.6720 | 0.0812 | -2.1147 | 0.3535 |
| 29 | 23.0 | 0.6947 | 0.0437 | -2.1633 | 0.3678 | 0.6757 | 0.0804 | -2.1518 | 0.3872 |
| 30 | 24.0 | 0.7020 | 0.0428 | -2.1981 | 0.3988 | 0.6794 | 0.0797 | -2.1871 | 0.4189 |
| 31 | 25.0 | 0.7028 | 0.0417 | -2.2312 | 0.4283 | 0.6823 | 0.0794 | -2.2206 | 0.4488 |
| 32 | 26.0 | 0.6900 | 0.0405 | -2.2613 | 0.4566 | 0.6668 | 0.0791 | -2.2512 | 0.4771 |
| 33 | 27.0 | 0.6828 | 0.0392 | -2.2872 | 0.4856 | 0.6608 | 0.0786 | -2.2776 | 0.5061 |
| 34 | 28.0 | 0.6850 | 0.0377 | -2.3103 | 0.5144 | 0.6576 | 0.0775 | -2.3013 | 0.5342 |
| 35 | 29.0 | 0.6819 | 0.0360 | -2.3316 | 0.5418 | 0.6559 | 0.0759 | -2.3230 | 0.5614 |
| 36 | 30.0 | 0.6856 | 0.0340 | -2.3512 | 0.5685 | 0.6552 | 0.0741 | -2.3429 | 0.5878 |
| 37 | 31.0 | 0.6844 | 0.0323 | -2.3697 | 0.5940 | 0.6549 | 0.0719 | -2.3616 | 0.6134 |
| 38 | 32.0 | 0.6880 | 0.0307 | -2.3872 | 0.6185 | 0.6545 | 0.0696 | -2.3793 | 0.6384 |
| 39 | 33.0 | 0.6879 | 0.0287 | -2.4040 | 0.6420 | 0.6542 | 0.0674 | -2.3962 | 0.6629 |
| 40 | 34.0 | 0.6912 | 0.0267 | -2.4202 | 0.6648 | 0.6545 | 0.0651 | -2.4125 | 0.6867 |
| 41 | 35.0 | 0.6918 | 0.0251 | -2.4361 | 0.6866 | 0.6551 | 0.0630 | -2.4281 | 0.7099 |
| 42 | 37.0 | 0.6669 | 0.0213 | -2.4614 | 0.7292 | 0.6152 | 0.0592 | -2.4544 | 0.7522 |
| 43 | 39.0 | 0.6641 | 0.0175 | -2.4774 | 0.7731 | 0.6079 | 0.0551 | -2.4698 | 0.7973 |
| 44 | 41.0 | 0.6638 | 0.0139 | -2.4897 | 0.8135 | 0.6053 | 0.0504 | -2.4818 | 0.8394 |
| 45 | 43.0 | 0.6615 | 0.0100 | -2.5001 | 0.8503 | 0.6040 | 0.0459 | -2.4922 | 0.8777 |
| 46 | 45.0 | 0.6641 | 0.0062 | -2.5096 | 0.8845 | 0.6047 | 0.0422 | -2.5016 | 0.9127 |
| 47 | 47.5 | 0.6288 | 0.0015 | -2.5135 | 0.9251 | 0.5767 | 0.0386 | -2.5035 | 0.9544 |
| 48 | 50.0 | 0.6279 | -0.0029 | -2.5062 | 0.9669 | 0.5702 | 0.0357 | -2.4972 | 0.9954 |
| 49 | 52.5 | 0.6202 | -0.0071 | -2.4967 | 1.0026 | 0.5669 | 0.0342 | -2.4873 | 1.0317 |
| 50 | 55.0 | 0.6189 | -0.0116 | -2.4864 | 1.0342 | 0.5637 | 0.0343 | -2.4778 | 1.0627 |
| 51 | 57.5 | 0.6162 | -0.0158 | -2.4773 | 1.0622 | 0.5591 | 0.0342 | -2.4686 | 1.0895 |
| 52 | 60.0 | 0.6158 | -0.0194 | -2.4700 | 1.0872 | 0.5542 | 0.0337 | -2.4613 | 1.1134 |
| 53 | 62.5 | 0.6149 | -0.0227 | -2.4647 | 1.1105 | 0.5493 | 0.0336 | -2.4557 | 1.1351 |
| 54 | 65.0 | 0.6149 | -0.0258 | -2.4613 | 1.1319 | 0.5450 | 0.0343 | -2.4518 | 1.1559 |

| | | | | | | | | | |
|-----|-------|--------|---------|---------|--------|---------|--------|---------|--------|
| 55 | 67.5 | 0.6152 | -0.0287 | -2.4596 | 1.1524 | 0.5404 | 0.0355 | -2.4489 | 1.1760 |
| 56 | 70.0 | 0.6159 | -0.0311 | -2.4595 | 1.1717 | 0.5345 | 0.0368 | -2.4471 | 1.1953 |
| 57 | 73.0 | 0.5394 | -0.0343 | -2.4388 | 1.1982 | 0.4728 | 0.0377 | -2.4201 | 1.2270 |
| 58 | 76.0 | 0.5325 | -0.0377 | -2.3903 | 1.2310 | 0.4467 | 0.0382 | -2.3700 | 1.2574 |
| 59 | 79.0 | 0.5143 | -0.0413 | -2.3366 | 1.2522 | 0.4260 | 0.0389 | -2.3135 | 1.2777 |
| 60 | 82.0 | 0.5031 | -0.0449 | -2.2821 | 1.2656 | 0.4066 | 0.0393 | -2.2576 | 1.2900 |
| 61 | 85.0 | 0.4948 | -0.0481 | -2.2310 | 1.2739 | 0.3919 | 0.0394 | -2.2055 | 1.2967 |
| 62 | 88.0 | 0.4840 | -0.0509 | -2.1847 | 1.2778 | 0.3811 | 0.0392 | -2.1582 | 1.2999 |
| 63 | 91.0 | 0.4801 | -0.0535 | -2.1427 | 1.2803 | 0.3722 | 0.0386 | -2.1155 | 1.3006 |
| 64 | 94.0 | 0.4705 | -0.0555 | -2.1053 | 1.2804 | 0.3661 | 0.0391 | -2.0769 | 1.2996 |
| 65 | 97.0 | 0.4686 | -0.0571 | -2.0715 | 1.2801 | 0.3616 | 0.0398 | -2.0420 | 1.2976 |
| 66 | 100.0 | 0.4602 | -0.0584 | -2.0413 | 1.2783 | 0.3531 | 0.0370 | -2.0114 | 1.2947 |
| 67 | 105.0 | 0.4064 | -0.0603 | -1.9720 | 1.2795 | 0.3042 | 0.0321 | -1.9380 | 1.2961 |
| 68 | 110.0 | 0.3971 | -0.0626 | -1.8838 | 1.2794 | 0.2830 | 0.0293 | -1.8512 | 1.2902 |
| 69 | 115.0 | 0.3790 | -0.0644 | -1.8028 | 1.2657 | 0.2661 | 0.0270 | -1.7700 | 1.2746 |
| 70 | 120.0 | 0.3666 | -0.0653 | -1.7304 | 1.2481 | 0.2513 | 0.0268 | -1.6984 | 1.2535 |
| 71 | 125.0 | 0.3575 | -0.0656 | -1.6680 | 1.2284 | 0.2386 | 0.0274 | -1.6352 | 1.2307 |
| 72 | 130.0 | 0.3455 | -0.0654 | -1.6129 | 1.2077 | 0.2288 | 0.0283 | -1.5787 | 1.2088 |
| 73 | 135.0 | 0.3403 | -0.0650 | -1.5642 | 1.1873 | 0.2220 | 0.0301 | -1.5288 | 1.1871 |
| 74 | 140.0 | 0.3289 | -0.0644 | -1.5208 | 1.1665 | 0.2177 | 0.0321 | -1.4851 | 1.1653 |
| 75 | 145.0 | 0.3257 | -0.0635 | -1.4815 | 1.1467 | 0.2138 | 0.0350 | -1.4461 | 1.1433 |
| 76 | 150.0 | 0.3148 | -0.0623 | -1.4461 | 1.1265 | 0.2084 | 0.0387 | -1.4107 | 1.1208 |
| 77 | 155.0 | 0.3131 | -0.0611 | -1.4136 | 1.1076 | 0.2008 | 0.0421 | -1.3781 | 1.0985 |
| 78 | 160.0 | 0.3036 | -0.0598 | -1.3840 | 1.0886 | 0.1905 | 0.0451 | -1.3478 | 1.0768 |
| 79 | 165.0 | 0.2520 | -0.0590 | -1.3314 | 1.0753 | 0.1545 | 0.0478 | -1.2880 | 1.0656 |
| 80 | 170.0 | 0.2428 | -0.0586 | -1.2554 | 1.0620 | 0.1374 | 0.0502 | -1.2134 | 1.0451 |
| 81 | 175.0 | 0.2257 | -0.0587 | -1.1827 | 1.0363 | 0.1238 | 0.0522 | -1.1411 | 1.0165 |
| 82 | 180.0 | 0.2129 | -0.0585 | -1.1160 | 1.0076 | 0.1103 | 0.0541 | -1.0751 | 0.9844 |
| 83 | 185.0 | 0.2044 | -0.0576 | -1.0569 | 0.9774 | 0.0976 | 0.0574 | -1.0148 | 0.9510 |
| 84 | 190.0 | 0.1912 | -0.0564 | -1.0036 | 0.9468 | 0.0861 | 0.0617 | -0.9592 | 0.9181 |
| 85 | 195.0 | 0.1862 | -0.0550 | -0.9552 | 0.9169 | 0.0758 | 0.0665 | -0.9091 | 0.8859 |
| 86 | 200.0 | 0.1739 | -0.0536 | -0.9111 | 0.8870 | 0.0665 | 0.0715 | -0.8643 | 0.8546 |
| 87 | 210.0 | 0.1637 | -0.0503 | -0.8323 | 0.8306 | 0.0507 | 0.0824 | -0.7845 | 0.7949 |
| 88 | 220.0 | 0.1459 | -0.0471 | -0.7644 | 0.7765 | 0.0371 | 0.0930 | -0.7137 | 0.7389 |
| 89 | 230.0 | 0.1389 | -0.0438 | -0.7043 | 0.7265 | 0.0233 | 0.1024 | -0.6520 | 0.6860 |
| 90 | 240.0 | 0.1236 | -0.0408 | -0.6510 | 0.6789 | 0.0061 | 0.1102 | -0.5984 | 0.6353 |
| 91 | 250.0 | 0.1188 | -0.0379 | -0.6027 | 0.6351 | -0.0118 | 0.1170 | -0.5496 | 0.5876 |
| 92 | 260.0 | 0.1053 | -0.0351 | -0.5593 | 0.5934 | -0.0287 | 0.1230 | -0.5047 | 0.5428 |
| 93 | 270.0 | 0.1022 | -0.0326 | -0.5194 | 0.5552 | -0.0437 | 0.1295 | -0.4643 | 0.4993 |
| 94 | 280.0 | 0.0905 | -0.0301 | -0.4831 | 0.5188 | -0.0576 | 0.1361 | -0.4278 | 0.4562 |
| 95 | 290.0 | 0.0885 | -0.0276 | -0.4495 | 0.4854 | -0.0728 | 0.1411 | -0.3949 | 0.4166 |
| 96 | 300.0 | 0.0775 | -0.0257 | -0.4188 | 0.4537 | -0.0903 | 0.1446 | -0.3646 | 0.3807 |
| 97 | 320.0 | 0.0711 | -0.0220 | -0.3637 | 0.3970 | -0.1199 | 0.1499 | -0.3108 | 0.3172 |
| 98 | 340.0 | 0.0572 | -0.0189 | -0.3167 | 0.3469 | -0.1436 | 0.1540 | -0.2642 | 0.2619 |
| 99 | 360.0 | 0.0540 | -0.0161 | -0.2758 | 0.3037 | -0.1637 | 0.1569 | -0.2233 | 0.2139 |
| 100 | 380.0 | 0.0424 | -0.0137 | -0.2407 | 0.2654 | -0.1798 | 0.1589 | -0.1896 | 0.1759 |
| 101 | 400.0 | 0.0411 | -0.0118 | -0.2099 | 0.2324 | -0.1932 | 0.1603 | -0.1604 | 0.1445 |
| 102 | 420.0 | 0.0315 | -0.0101 | -0.1834 | 0.2030 | -0.1995 | 0.1618 | -0.1354 | 0.1163 |
| 103 | 440.0 | 0.0317 | -0.0089 | -0.1601 | 0.1779 | -0.2001 | 0.1633 | -0.1138 | 0.0900 |
| 104 | 460.0 | 0.0235 | -0.0073 | -0.1400 | 0.1554 | -0.1995 | 0.1642 | -0.0943 | 0.0661 |
| 105 | 480.0 | 0.0244 | -0.0063 | -0.1222 | 0.1362 | -0.2087 | 0.1623 | -0.0772 | 0.0473 |
| 106 | 500.0 | 0.0170 | -0.0053 | -0.1069 | 0.1189 | -0.2245 | 0.1584 | -0.0615 | 0.0318 |

表4. 6(2) 評価断面6の応力テンソル成分2

FINAS解と簡易計算値との比較(コールドショック)

断面6の応力成分2

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|---------|--------|--------|---------|---------|--------|--------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.8227 | 0.0186 | 0.0052 | 0.0480 | 0.9783 | 0.0197 | 0.0063 | 0.0544 |
| 3 | 1.0 | 2.1478 | 0.0675 | 0.0149 | 0.1580 | 2.2121 | 0.0680 | 0.0153 | 0.1619 |
| 4 | 1.5 | 3.4283 | 0.1389 | 0.0248 | 0.3002 | 3.5362 | 0.1394 | 0.0251 | 0.3042 |
| 5 | 2.0 | 4.8274 | 0.2303 | 0.0356 | 0.4707 | 4.9013 | 0.2306 | 0.0354 | 0.4735 |
| 6 | 2.5 | 6.1913 | 0.3393 | 0.0465 | 0.6620 | 6.2853 | 0.3395 | 0.0462 | 0.6646 |
| 7 | 3.0 | 7.5945 | 0.4649 | 0.0577 | 0.8713 | 7.6698 | 0.4652 | 0.0571 | 0.8730 |
| 8 | 3.5 | 8.9684 | 0.6058 | 0.0690 | 1.0949 | 9.0504 | 0.6062 | 0.0682 | 1.0959 |
| 9 | 4.0 | 10.3498 | 0.7609 | 0.0806 | 1.3310 | 10.4230 | 0.7617 | 0.0796 | 1.3314 |
| 10 | 4.5 | 11.7066 | 0.9295 | 0.0925 | 1.5776 | 11.7820 | 0.9319 | 0.0911 | 1.5771 |
| 11 | 5.0 | 13.0565 | 1.1105 | 0.1046 | 1.8333 | 13.1260 | 1.1168 | 0.1032 | 1.8314 |
| 12 | 6.0 | 14.7080 | 1.4737 | 0.1229 | 2.2936 | 14.7020 | 1.4891 | 0.1217 | 2.2857 |
| 13 | 7.0 | 15.8409 | 1.8253 | 0.1382 | 2.6921 | 15.9290 | 1.8508 | 0.1387 | 2.6870 |
| 14 | 8.0 | 17.0023 | 2.1723 | 0.1552 | 3.0717 | 17.0390 | 2.2040 | 0.1559 | 3.0642 |
| 15 | 9.0 | 18.0143 | 2.5105 | 0.1725 | 3.4351 | 18.0850 | 2.5487 | 0.1743 | 3.4279 |
| 16 | 10.0 | 19.0448 | 2.8372 | 0.1909 | 3.7918 | 19.0880 | 2.8778 | 0.1935 | 3.7841 |
| 17 | 11.0 | 19.9933 | 3.1488 | 0.2097 | 4.1422 | 20.0570 | 3.1908 | 0.2127 | 4.1353 |
| 18 | 12.0 | 20.9505 | 3.4441 | 0.2290 | 4.4898 | 20.9960 | 3.4889 | 0.2324 | 4.4831 |
| 19 | 13.0 | 21.8520 | 3.7218 | 0.2486 | 4.8346 | 21.9130 | 3.7695 | 0.2525 | 4.8287 |
| 20 | 14.0 | 22.7556 | 3.9817 | 0.2684 | 5.1782 | 22.8080 | 4.0317 | 0.2728 | 5.1727 |
| 21 | 15.0 | 23.6182 | 4.2247 | 0.2885 | 5.5202 | 23.6820 | 4.2768 | 0.2931 | 5.5154 |
| 22 | 16.0 | 24.1815 | 4.4414 | 0.3067 | 5.8393 | 24.1920 | 4.4960 | 0.3113 | 5.8314 |
| 23 | 17.0 | 24.5778 | 4.6272 | 0.3237 | 6.1315 | 24.6240 | 4.6874 | 0.3293 | 6.1246 |
| 24 | 18.0 | 24.9999 | 4.7876 | 0.3411 | 6.4115 | 25.0250 | 4.8541 | 0.3471 | 6.4037 |
| 25 | 19.0 | 25.3717 | 4.9246 | 0.3583 | 6.6810 | 25.4110 | 4.9962 | 0.3648 | 6.6732 |
| 26 | 20.0 | 25.7640 | 5.0401 | 0.3755 | 6.9440 | 25.7890 | 5.1147 | 0.3823 | 6.9361 |
| 27 | 21.0 | 26.1299 | 5.1357 | 0.3926 | 7.2011 | 26.1630 | 5.2117 | 0.3995 | 7.1938 |
| 28 | 22.0 | 26.5104 | 5.2135 | 0.4097 | 7.4539 | 26.5340 | 5.2902 | 0.4166 | 7.4471 |
| 29 | 23.0 | 26.8745 | 5.2751 | 0.4266 | 7.7029 | 26.9030 | 5.3536 | 0.4338 | 7.6966 |
| 30 | 24.0 | 27.2485 | 5.3230 | 0.4435 | 7.9487 | 27.2700 | 5.4039 | 0.4510 | 7.9425 |
| 31 | 25.0 | 27.6115 | 5.3583 | 0.4603 | 8.1915 | 27.6340 | 5.4430 | 0.4682 | 8.1852 |
| 32 | 26.0 | 27.8819 | 5.3794 | 0.4764 | 8.4245 | 27.8790 | 5.4682 | 0.4846 | 8.4166 |
| 33 | 27.0 | 28.0987 | 5.3858 | 0.4919 | 8.6465 | 28.1020 | 5.4788 | 0.5006 | 8.6383 |
| 34 | 28.0 | 28.3304 | 5.3803 | 0.5075 | 8.8624 | 28.3200 | 5.4775 | 0.5164 | 8.8533 |
| 35 | 29.0 | 28.5475 | 5.3640 | 0.5228 | 9.0729 | 28.5370 | 5.4660 | 0.5319 | 9.0632 |
| 36 | 30.0 | 28.7761 | 5.3386 | 0.5381 | 9.2796 | 28.7550 | 5.4454 | 0.5474 | 9.2693 |
| 37 | 31.0 | 28.9979 | 5.3053 | 0.5533 | 9.4826 | 28.9740 | 5.4162 | 0.5626 | 9.4720 |
| 38 | 32.0 | 29.2281 | 5.2652 | 0.5685 | 9.6827 | 29.1950 | 5.3794 | 0.5776 | 9.6718 |
| 39 | 33.0 | 29.4544 | 5.2185 | 0.5835 | 9.8799 | 29.4180 | 5.3365 | 0.5925 | 9.8689 |
| 40 | 34.0 | 29.6866 | 5.1669 | 0.5985 | 10.0747 | 29.6440 | 5.2888 | 0.6075 | 10.0630 |
| 41 | 35.0 | 29.9164 | 5.1114 | 0.6133 | 10.2671 | 29.8720 | 5.2373 | 0.6226 | 10.2560 |
| 42 | 37.0 | 30.1583 | 4.9786 | 0.6412 | 10.6237 | 30.1260 | 5.1163 | 0.6516 | 10.6160 |
| 43 | 39.0 | 30.3303 | 4.8197 | 0.6680 | 10.9497 | 30.3200 | 4.9671 | 0.6800 | 10.9460 |
| 44 | 41.0 | 30.5450 | 4.6443 | 0.6946 | 11.2612 | 30.5200 | 4.7989 | 0.7076 | 11.2590 |
| 45 | 43.0 | 30.7533 | 4.4564 | 0.7207 | 11.5600 | 30.7340 | 4.6190 | 0.7344 | 11.5580 |
| 46 | 45.0 | 30.9908 | 4.2614 | 0.7464 | 11.8495 | 30.9630 | 4.4328 | 0.7607 | 11.8480 |
| 47 | 47.5 | 30.9979 | 3.9977 | 0.7759 | 12.1692 | 30.9520 | 4.1763 | 0.7912 | 12.1670 |
| 48 | 50.0 | 30.9535 | 3.7121 | 0.8038 | 12.4475 | 30.9330 | 3.8978 | 0.8203 | 12.4480 |
| 49 | 52.5 | 30.9666 | 3.4172 | 0.8313 | 12.7073 | 30.9400 | 3.6074 | 0.8486 | 12.7090 |
| 50 | 55.0 | 30.9963 | 3.1193 | 0.8578 | 12.9515 | 30.9750 | 3.3161 | 0.8757 | 12.9530 |
| 51 | 57.5 | 31.0619 | 2.8257 | 0.8835 | 13.1845 | 31.0310 | 3.0237 | 0.9018 | 13.1850 |
| 52 | 60.0 | 31.1429 | 2.5412 | 0.9085 | 13.4071 | 31.1060 | 2.7420 | 0.9269 | 13.4070 |
| 53 | 62.5 | 31.2469 | 2.2685 | 0.9330 | 13.6210 | 31.1980 | 2.4700 | 0.9511 | 13.6200 |
| 54 | 65.0 | 31.3617 | 2.0081 | 0.9568 | 13.8271 | 31.3060 | 2.2117 | 0.9748 | 13.8250 |

| | | | | | | | | | |
|-----|-------|---------|---------|--------|---------|---------|---------|--------|---------|
| 55 | 67.5 | 31.4915 | 1.7608 | 0.9801 | 14.0262 | 31.4230 | 1.9653 | 0.9982 | 14.0230 |
| 56 | 70.0 | 31.6285 | 1.5262 | 1.0029 | 14.2189 | 31.5470 | 1.7325 | 1.0211 | 14.2150 |
| 57 | 73.0 | 31.0888 | 1.2169 | 1.0242 | 14.3629 | 30.9120 | 1.4214 | 1.0414 | 14.3480 |
| 58 | 76.0 | 30.3991 | 0.8632 | 1.0423 | 14.4234 | 30.2700 | 1.0654 | 1.0599 | 14.4140 |
| 59 | 79.0 | 29.8690 | 0.4921 | 1.0598 | 14.4603 | 29.6950 | 0.6915 | 1.0765 | 14.4500 |
| 60 | 82.0 | 29.3502 | 0.1179 | 1.0749 | 14.4764 | 29.1820 | 0.3182 | 1.0913 | 14.4660 |
| 61 | 85.0 | 28.9322 | -0.2426 | 1.0888 | 14.4819 | 28.7320 | -0.0392 | 1.1045 | 14.4690 |
| 62 | 88.0 | 28.5297 | -0.5816 | 1.1011 | 14.4767 | 28.3370 | -0.3751 | 1.1163 | 14.4640 |
| 63 | 91.0 | 28.1978 | -0.8949 | 1.1125 | 14.4655 | 27.9860 | -0.6858 | 1.1269 | 14.4520 |
| 64 | 94.0 | 27.8761 | -1.1819 | 1.1226 | 14.4478 | 27.6690 | -0.9685 | 1.1365 | 14.4330 |
| 65 | 97.0 | 27.6053 | -1.4430 | 1.1320 | 14.4264 | 27.3810 | -1.2250 | 1.1453 | 14.4100 |
| 66 | 100.0 | 27.3408 | -1.6799 | 1.1405 | 14.4009 | 27.1150 | -1.4630 | 1.1539 | 14.3820 |
| 67 | 105.0 | 26.3483 | -2.0780 | 1.1480 | 14.2702 | 26.0550 | -1.8671 | 1.1616 | 14.2400 |
| 68 | 110.0 | 25.3311 | -2.4853 | 1.1512 | 14.0658 | 25.0770 | -2.2765 | 1.1642 | 14.0390 |
| 69 | 115.0 | 24.5290 | -2.8626 | 1.1520 | 13.8537 | 24.2200 | -2.6515 | 1.1640 | 13.8200 |
| 70 | 120.0 | 23.7635 | -3.1913 | 1.1497 | 13.6308 | 23.4630 | -2.9716 | 1.1618 | 13.5940 |
| 71 | 125.0 | 23.1238 | -3.4639 | 1.1458 | 13.4083 | 22.7840 | -3.2365 | 1.1579 | 13.3660 |
| 72 | 130.0 | 22.5062 | -3.6864 | 1.1398 | 13.1846 | 22.1690 | -3.4516 | 1.1527 | 13.1410 |
| 73 | 135.0 | 21.9740 | -3.8652 | 1.1327 | 12.9650 | 21.6070 | -3.6223 | 1.1461 | 12.9180 |
| 74 | 140.0 | 21.4533 | -4.0072 | 1.1242 | 12.7480 | 21.0930 | -3.7553 | 1.1379 | 12.6980 |
| 75 | 145.0 | 20.9967 | -4.1185 | 1.1149 | 12.5369 | 20.6170 | -3.8564 | 1.1288 | 12.4830 |
| 76 | 150.0 | 20.5459 | -4.2038 | 1.1046 | 12.3302 | 20.1730 | -3.9313 | 1.1194 | 12.2730 |
| 77 | 155.0 | 20.1466 | -4.2678 | 1.0937 | 12.1300 | 19.7550 | -3.9858 | 1.1096 | 12.0690 |
| 78 | 160.0 | 19.7501 | -4.3139 | 1.0821 | 11.9351 | 19.3580 | -4.0239 | 1.0994 | 11.8700 |
| 79 | 165.0 | 18.7750 | -4.3962 | 1.0651 | 11.6635 | 18.2920 | -4.1043 | 1.0835 | 11.5770 |
| 80 | 170.0 | 17.7443 | -4.5278 | 1.0454 | 11.3290 | 17.3190 | -4.2272 | 1.0656 | 11.2460 |
| 81 | 175.0 | 16.9117 | -4.6637 | 1.0249 | 10.9958 | 16.4480 | -4.3498 | 1.0456 | 10.9060 |
| 82 | 180.0 | 16.0988 | -4.7795 | 1.0026 | 10.6589 | 15.6600 | -4.4499 | 1.0238 | 10.5670 |
| 83 | 185.0 | 15.4043 | -4.8621 | 0.9799 | 10.3285 | 14.9380 | -4.5209 | 1.0010 | 10.2310 |
| 84 | 190.0 | 14.7213 | -4.9142 | 0.9564 | 10.0022 | 14.2700 | -4.5656 | 0.9775 | 9.9018 |
| 85 | 195.0 | 14.1212 | -4.9388 | 0.9329 | 9.6843 | 13.6490 | -4.5840 | 0.9538 | 9.5803 |
| 86 | 200.0 | 13.5273 | -4.9407 | 0.9090 | 9.3731 | 13.0680 | -4.5788 | 0.9298 | 9.2677 |
| 87 | 210.0 | 12.4808 | -4.8909 | 0.8615 | 8.7774 | 12.0110 | -4.5158 | 0.8829 | 8.6698 |
| 88 | 220.0 | 11.5149 | -4.7891 | 0.8142 | 8.2154 | 11.0620 | -4.4030 | 0.8371 | 8.1043 |
| 89 | 230.0 | 10.6663 | -4.6528 | 0.7680 | 7.6887 | 10.2010 | -4.2541 | 0.7926 | 7.5737 |
| 90 | 240.0 | 9.8682 | -4.4949 | 0.7230 | 7.1946 | 9.4123 | -4.0805 | 0.7493 | 7.0755 |
| 91 | 250.0 | 9.1624 | -4.3238 | 0.6796 | 6.7329 | 8.6856 | -3.8950 | 0.7070 | 6.6086 |
| 92 | 260.0 | 8.4913 | -4.1456 | 0.6378 | 6.3003 | 8.0139 | -3.7016 | 0.6654 | 6.1699 |
| 93 | 270.0 | 7.8966 | -3.9635 | 0.5981 | 5.8963 | 7.3975 | -3.5051 | 0.6255 | 5.7599 |
| 94 | 280.0 | 7.3270 | -3.7815 | 0.5602 | 5.5178 | 6.8284 | -3.3097 | 0.5873 | 5.3756 |
| 95 | 290.0 | 6.8221 | -3.6012 | 0.5245 | 5.1643 | 6.3014 | -3.1215 | 0.5509 | 5.0169 |
| 96 | 300.0 | 6.3348 | -3.4242 | 0.4905 | 4.8330 | 5.8106 | -2.9427 | 0.5161 | 4.6810 |
| 97 | 320.0 | 5.4939 | -3.0846 | 0.4285 | 4.2332 | 4.9515 | -2.6025 | 0.4535 | 4.0823 |
| 98 | 340.0 | 4.7534 | -2.7673 | 0.3737 | 3.7075 | 4.2161 | -2.2807 | 0.3984 | 3.5571 |
| 99 | 360.0 | 4.1341 | -2.4744 | 0.3256 | 3.2475 | 3.5700 | -1.9765 | 0.3496 | 3.0876 |
| 100 | 380.0 | 3.5814 | -2.2067 | 0.2833 | 2.8441 | 3.0200 | -1.6988 | 0.3074 | 2.6846 |
| 101 | 400.0 | 3.1217 | -1.9641 | 0.2465 | 2.4911 | 2.5302 | -1.4388 | 0.2692 | 2.3238 |
| 102 | 420.0 | 2.7059 | -1.7450 | 0.2143 | 2.1814 | 2.1172 | -1.2072 | 0.2354 | 2.0111 |
| 103 | 440.0 | 2.3630 | -1.5481 | 0.1863 | 1.9106 | 1.7699 | -1.0019 | 0.2051 | 1.7390 |
| 104 | 460.0 | 2.0485 | -1.3714 | 0.1619 | 1.6728 | 1.4674 | -0.8176 | 0.1777 | 1.4974 |
| 105 | 480.0 | 1.7918 | -1.2138 | 0.1407 | 1.4650 | 1.2040 | -0.6654 | 0.1537 | 1.2927 |
| 106 | 500.0 | 1.5525 | -1.0736 | 0.1222 | 1.2825 | 0.9643 | -0.5340 | 0.1317 | 1.1113 |

表 4. 6 (3) 評価断面 6 の応力テンソル成分 3

FINAS解と簡易計算値との比較 (コールドショック)

断面 6 の応力成分 3

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|---------|----------|---------|---------|---------|----------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.8536 | -0.0449 | -0.0068 | 0.0921 | 1.0130 | -0.0483 | -0.0063 | 0.1022 |
| 3 | 1.0 | 2.2544 | -0.1614 | -0.0282 | 0.3173 | 2.3211 | -0.1638 | -0.0282 | 0.3238 |
| 4 | 1.5 | 3.6484 | -0.3311 | -0.0631 | 0.6294 | 3.7599 | -0.3330 | -0.0629 | 0.6358 |
| 5 | 2.0 | 5.2012 | -0.5489 | -0.1088 | 1.0199 | 5.2780 | -0.5497 | -0.1089 | 1.0239 |
| 6 | 2.5 | 6.7544 | -0.8094 | -0.1644 | 1.4762 | 6.8511 | -0.8093 | -0.1645 | 1.4791 |
| 7 | 3.0 | 8.3819 | -1.1094 | -0.2288 | 1.9929 | 8.4602 | -1.1079 | -0.2288 | 1.9943 |
| 8 | 3.5 | 10.0124 | -1.4460 | -0.3011 | 2.5636 | 10.0980 | -1.4429 | -0.3010 | 2.5635 |
| 9 | 4.0 | 11.6814 | -1.8169 | -0.3804 | 3.1844 | 11.7590 | -1.8123 | -0.3806 | 3.1829 |
| 10 | 4.5 | 13.3547 | -2.2198 | -0.4660 | 3.8511 | 13.4360 | -2.2138 | -0.4667 | 3.8488 |
| 11 | 5.0 | 15.0491 | -2.6535 | -0.5573 | 4.5609 | 15.1250 | -2.6452 | -0.5584 | 4.5579 |
| 12 | 6.0 | 17.4143 | -3.5275 | -0.7395 | 5.9458 | 17.4130 | -3.5124 | -0.7411 | 5.9375 |
| 13 | 7.0 | 19.2748 | -4.3866 | -0.9096 | 7.2635 | 19.3700 | -4.3697 | -0.9107 | 7.2636 |
| 14 | 8.0 | 21.1784 | -5.2542 | -1.0687 | 8.5751 | 21.2260 | -5.2342 | -1.0691 | 8.5762 |
| 15 | 9.0 | 22.9439 | -6.1310 | -1.2175 | 9.8802 | 23.0300 | -6.1096 | -1.2162 | 9.8866 |
| 16 | 10.0 | 24.7422 | -7.0185 | -1.3550 | 11.1878 | 24.8040 | -7.0185 | -1.3517 | 11.1970 |
| 17 | 11.0 | 26.4697 | -7.9151 | -1.4816 | 12.4946 | 26.5560 | -7.8925 | -1.4762 | 12.5070 |
| 18 | 12.0 | 28.2180 | -8.8202 | -1.5974 | 13.8028 | 28.2890 | -8.7964 | -1.5909 | 13.8180 |
| 19 | 13.0 | 29.9206 | -9.7326 | -1.7032 | 15.1104 | 30.0090 | -9.7083 | -1.6962 | 15.1280 |
| 20 | 14.0 | 31.6352 | -10.6519 | -1.7998 | 16.4179 | 31.7150 | -10.6270 | -1.7926 | 16.4380 |
| 21 | 15.0 | 33.3174 | -11.5763 | -1.8876 | 17.7242 | 33.4100 | -11.5530 | -1.8807 | 17.7470 |
| 22 | 16.0 | 34.6929 | -12.4826 | -1.9634 | 18.9845 | 34.7330 | -12.4570 | -1.9568 | 18.9845 |
| 23 | 17.0 | 35.8835 | -13.3571 | -2.0238 | 20.1806 | 35.9610 | -13.3320 | -2.0171 | 20.2040 |
| 24 | 18.0 | 37.0850 | -14.2094 | -2.0710 | 21.3365 | 37.1450 | -14.1820 | -2.0643 | 21.3620 |
| 25 | 19.0 | 38.2218 | -15.0415 | -2.1070 | 22.4559 | 38.2990 | -15.0110 | -2.1001 | 22.4840 |
| 26 | 20.0 | 39.3671 | -15.8558 | -2.1328 | 23.5454 | 39.4320 | -15.8240 | -2.1257 | 23.5750 |
| 27 | 21.0 | 40.4740 | -16.6536 | -2.1498 | 24.6069 | 40.5490 | -16.6190 | -2.1425 | 24.6380 |
| 28 | 22.0 | 41.5851 | -17.4360 | -2.1590 | 25.6441 | 41.6510 | -17.3990 | -2.1520 | 25.6770 |
| 29 | 23.0 | 42.6698 | -18.2040 | -2.1614 | 26.6586 | 42.7420 | -18.1650 | -2.1548 | 26.6930 |
| 30 | 24.0 | 43.7558 | -18.9578 | -2.1578 | 27.6531 | 43.8230 | -18.9170 | -2.1519 | 27.6880 |
| 31 | 25.0 | 44.8216 | -19.6989 | -2.1490 | 28.6284 | 44.8930 | -19.6540 | -2.1436 | 28.6640 |
| 32 | 26.0 | 45.7821 | -20.4199 | -2.1342 | 29.5718 | 45.8320 | -20.3710 | -2.1292 | 29.6070 |
| 33 | 27.0 | 46.6731 | -21.1174 | -2.1126 | 30.4785 | 46.7350 | -21.0650 | -2.1079 | 30.5160 |
| 34 | 28.0 | 47.5645 | -21.7953 | -2.0854 | 31.3575 | 47.6190 | -21.7390 | -2.0809 | 31.3960 |
| 35 | 29.0 | 48.4280 | -22.4555 | -2.0533 | 32.2115 | 48.4880 | -22.3950 | -2.0490 | 32.2510 |
| 36 | 30.0 | 49.2908 | -23.0989 | -2.0171 | 33.0435 | 49.3450 | -23.0350 | -2.0127 | 33.0840 |
| 37 | 31.0 | 50.1353 | -23.7266 | -1.9772 | 33.8553 | 50.1920 | -23.6600 | -1.9728 | 33.8980 |
| 38 | 32.0 | 50.9776 | -24.3396 | -1.9341 | 34.6487 | 51.0290 | -24.2710 | -1.9296 | 34.6930 |
| 39 | 33.0 | 51.8059 | -24.9393 | -1.8881 | 35.4249 | 51.8590 | -24.8680 | -1.8837 | 35.4710 |
| 40 | 34.0 | 52.6310 | -25.5259 | -1.8399 | 36.1854 | 52.6810 | -25.4530 | -1.8353 | 36.2330 |
| 41 | 35.0 | 53.4447 | -26.1001 | -1.7896 | 36.9314 | 53.4970 | -26.0250 | -1.7846 | 36.9810 |
| 42 | 37.0 | 54.8120 | -27.1895 | -1.6789 | 38.3359 | 54.8840 | -27.1130 | -1.6739 | 38.3950 |
| 43 | 39.0 | 56.0498 | -28.1995 | -1.5543 | 39.6305 | 56.1490 | -28.1230 | -1.5489 | 39.6980 |
| 44 | 41.0 | 57.2796 | -29.1469 | -1.4205 | 40.8481 | 57.3670 | -29.0710 | -1.4157 | 40.9180 |
| 45 | 43.0 | 58.4592 | -30.0395 | -1.2806 | 41.9988 | 58.5540 | -29.9610 | -1.2772 | 42.0710 |
| 46 | 45.0 | 59.6298 | -30.8845 | -1.1368 | 43.0945 | 59.7200 | -30.8030 | -1.1342 | 43.1680 |
| 47 | 47.5 | 60.7285 | -31.8445 | -0.9471 | 44.3289 | 60.8070 | -31.7590 | -0.9434 | 44.4040 |
| 48 | 50.0 | 61.6862 | -32.6931 | -0.7447 | 45.4136 | 61.7880 | -32.6020 | -0.7419 | 45.4910 |
| 49 | 52.5 | 62.6274 | -33.4584 | -0.5370 | 46.3983 | 62.7230 | -33.3640 | -0.5341 | 46.4750 |
| 50 | 55.0 | 63.5234 | -34.1535 | -0.3282 | 47.3002 | 63.6250 | -34.0570 | -0.3268 | 47.3780 |
| 51 | 57.5 | 64.4033 | -34.7907 | -0.1216 | 48.1376 | 64.4970 | -34.6940 | -0.1202 | 48.2150 |
| 52 | 60.0 | 65.2538 | -35.3790 | 0.0807 | 48.9211 | 65.3460 | -35.2810 | 0.0820 | 49.0000 |
| 53 | 62.5 | 66.0886 | -35.9260 | 0.2778 | 49.6610 | 66.1750 | -35.8250 | 0.2798 | 49.7390 |
| 54 | 65.0 | 66.9005 | -36.4382 | 0.4694 | 50.3636 | 66.9870 | -36.3350 | 0.4717 | 50.4420 |

| | | | | | | | | | |
|-----|-------|---------|----------|--------|---------|---------|----------|--------|---------|
| 55 | 67.5 | 67.6976 | -36.9208 | 0.8552 | 51.0350 | 67.7800 | -36.8170 | 0.8588 | 51.1160 |
| 56 | 70.0 | 68.4757 | -37.3779 | 0.8352 | 51.6792 | 68.5550 | -37.2720 | 0.8405 | 51.7630 |
| 57 | 73.0 | 68.5993 | -37.7934 | 1.0649 | 52.2359 | 68.5870 | -37.6730 | 1.0745 | 52.3010 |
| 58 | 76.0 | 68.4224 | -38.0344 | 1.3181 | 52.5313 | 68.4640 | -37.9120 | 1.3315 | 52.6050 |
| 59 | 79.0 | 68.2913 | -38.1635 | 1.5770 | 52.6848 | 68.2940 | -38.0310 | 1.5932 | 52.7540 |
| 60 | 82.0 | 68.0826 | -38.2026 | 1.8314 | 52.7259 | 68.1010 | -38.0620 | 1.8496 | 52.7970 |
| 61 | 85.0 | 67.9047 | -38.1766 | 2.0746 | 52.6940 | 67.8990 | -38.0280 | 2.0938 | 52.7640 |
| 62 | 88.0 | 67.6859 | -38.1006 | 2.3037 | 52.6065 | 67.6920 | -37.9460 | 2.3236 | 52.6780 |
| 63 | 91.0 | 67.4924 | -37.9880 | 2.5179 | 52.4824 | 67.4850 | -37.8280 | 2.5386 | 52.5520 |
| 64 | 94.0 | 67.2718 | -37.8479 | 2.7171 | 52.3299 | 67.2780 | -37.6840 | 2.7385 | 52.4010 |
| 65 | 97.0 | 67.0726 | -37.6882 | 2.9021 | 52.1596 | 67.0710 | -37.5200 | 2.9236 | 52.2300 |
| 66 | 100.0 | 66.8550 | -37.5144 | 3.0734 | 51.9754 | 66.8600 | -37.3460 | 3.0950 | 52.0460 |
| 67 | 105.0 | 65.8049 | -37.0845 | 3.3560 | 51.4426 | 65.7510 | -36.9070 | 3.3802 | 51.4970 |
| 68 | 110.0 | 64.5479 | -36.4802 | 3.6365 | 50.6566 | 64.5510 | -36.3010 | 3.6608 | 50.7200 |
| 69 | 115.0 | 63.3927 | -35.7940 | 3.8899 | 49.7770 | 63.3570 | -35.6060 | 3.9138 | 49.8370 |
| 70 | 120.0 | 62.2004 | -35.0619 | 4.1086 | 48.8451 | 62.1850 | -34.8650 | 4.1316 | 48.9090 |
| 71 | 125.0 | 61.0870 | -34.3168 | 4.2921 | 47.9063 | 61.0420 | -34.1110 | 4.3157 | 47.9700 |
| 72 | 130.0 | 59.9658 | -33.5727 | 4.4443 | 46.9718 | 59.9350 | -33.3620 | 4.4689 | 47.0390 |
| 73 | 135.0 | 58.9133 | -32.8432 | 4.5687 | 46.0578 | 58.8620 | -32.6260 | 4.5939 | 46.1260 |
| 74 | 140.0 | 57.8636 | -32.1337 | 4.6685 | 45.1669 | 57.8240 | -31.9110 | 4.6935 | 45.2360 |
| 75 | 145.0 | 56.8759 | -31.4492 | 4.7473 | 44.3052 | 56.8220 | -31.2190 | 4.7715 | 44.3740 |
| 76 | 150.0 | 55.8956 | -30.7906 | 4.8074 | 43.4722 | 55.8550 | -30.5520 | 4.8311 | 43.5400 |
| 77 | 155.0 | 54.9720 | -30.1595 | 4.8516 | 42.6706 | 54.9190 | -29.9120 | 4.8749 | 42.7360 |
| 78 | 160.0 | 54.0581 | -29.5554 | 4.8819 | 41.8983 | 54.0100 | -29.2960 | 4.9054 | 41.9620 |
| 79 | 165.0 | 52.4812 | -28.8549 | 4.9249 | 40.9458 | 52.3330 | -28.5660 | 4.9538 | 40.9730 |
| 80 | 170.0 | 50.7175 | -28.0160 | 4.9870 | 39.7784 | 50.6210 | -27.7130 | 5.0162 | 39.8050 |
| 81 | 175.0 | 49.0794 | -27.1206 | 5.0410 | 38.5458 | 48.9380 | -26.8010 | 5.0683 | 38.5630 |
| 82 | 180.0 | 47.4203 | -26.1967 | 5.0768 | 37.2818 | 47.2980 | -25.8680 | 5.1019 | 37.2980 |
| 83 | 185.0 | 45.8600 | -25.2715 | 5.0923 | 36.0275 | 45.7060 | -24.9340 | 5.1171 | 36.0390 |
| 84 | 190.0 | 44.3051 | -24.3567 | 5.0897 | 34.7913 | 44.1620 | -24.0100 | 5.1158 | 34.8010 |
| 85 | 195.0 | 42.8366 | -23.4630 | 5.0707 | 33.5870 | 42.6680 | -23.1100 | 5.0976 | 33.5930 |
| 86 | 200.0 | 41.3830 | -22.5945 | 5.0377 | 32.4154 | 41.2220 | -22.2370 | 5.0634 | 32.4210 |
| 87 | 210.0 | 38.6622 | -20.9460 | 4.9384 | 30.1870 | 38.4850 | -20.5820 | 4.9625 | 30.1960 |
| 88 | 220.0 | 36.0922 | -19.4181 | 4.8041 | 28.1083 | 35.9250 | -19.0400 | 4.8292 | 28.1140 |
| 89 | 230.0 | 33.7198 | -18.0093 | 4.6457 | 26.1780 | 33.5340 | -17.6180 | 4.6717 | 26.1810 |
| 90 | 240.0 | 31.4796 | -16.7116 | 4.4714 | 24.3852 | 31.2960 | -16.3070 | 4.4969 | 24.3840 |
| 91 | 250.0 | 29.4137 | -15.5169 | 4.2874 | 22.7222 | 29.2060 | -15.1000 | 4.3135 | 22.7170 |
| 92 | 260.0 | 27.4615 | -14.4156 | 4.0981 | 21.1773 | 27.2470 | -13.9860 | 4.1251 | 21.1650 |
| 93 | 270.0 | 25.6625 | -13.3994 | 3.9072 | 19.7431 | 25.4220 | -12.9560 | 3.9354 | 19.7240 |
| 94 | 280.0 | 23.9611 | -12.4607 | 3.7172 | 18.4093 | 23.7150 | -11.9990 | 3.7467 | 18.3790 |
| 95 | 290.0 | 22.3939 | -11.5931 | 3.5301 | 17.1698 | 22.1260 | -11.1140 | 3.5614 | 17.1310 |
| 96 | 300.0 | 20.9096 | -10.7897 | 3.3472 | 16.0160 | 20.6420 | -10.2930 | 3.3808 | 15.9690 |
| 97 | 320.0 | 18.2564 | -9.3543 | 2.9981 | 13.9407 | 18.0060 | -8.8546 | 3.0408 | 13.9140 |
| 98 | 340.0 | 15.9242 | -8.1191 | 2.6743 | 12.1401 | 15.7040 | -7.6180 | 2.7235 | 12.1260 |
| 99 | 360.0 | 13.9089 | -7.0538 | 2.3779 | 10.5773 | 13.6540 | -6.5300 | 2.4266 | 10.5400 |
| 100 | 380.0 | 12.1321 | -6.1328 | 2.1090 | 9.2184 | 11.8990 | -5.6138 | 2.1609 | 9.1955 |
| 101 | 400.0 | 10.6003 | -5.3358 | 1.8668 | 8.0370 | 10.3290 | -4.8059 | 1.9151 | 8.0023 |
| 102 | 420.0 | 9.2456 | -4.6447 | 1.6496 | 7.0082 | 8.9768 | -4.1123 | 1.6966 | 6.9720 |
| 103 | 440.0 | 8.0812 | -4.0451 | 1.4558 | 6.1129 | 7.8081 | -3.5130 | 1.5022 | 6.0773 |
| 104 | 460.0 | 7.0476 | -3.5240 | 1.2832 | 5.3324 | 6.7717 | -2.9850 | 1.3262 | 5.2835 |
| 105 | 480.0 | 6.1624 | -3.0714 | 1.1301 | 4.6530 | 5.8771 | -2.5405 | 1.1733 | 4.6075 |
| 106 | 500.0 | 5.3728 | -2.6776 | 0.9944 | 4.0601 | 5.0711 | -2.1485 | 1.0351 | 4.0057 |

表4. 6(4) 評価断面6の応力テンソル成分4

FINAS解と簡易計算値との比較 (コールドショック)

断面6の応力成分4

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|--------|---------|--------|--------|--------|---------|--------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.0588 | 0.0018 | 0.0000 | 0.0096 | 0.0705 | 0.0019 | 0.0000 | 0.0104 |
| 3 | 1.0 | 0.1683 | 0.0066 | 0.0004 | 0.0348 | 0.1743 | 0.0066 | 0.0005 | 0.0356 |
| 4 | 1.5 | 0.2820 | 0.0135 | 0.0011 | 0.0712 | 0.2898 | 0.0136 | 0.0010 | 0.0718 |
| 5 | 2.0 | 0.4055 | 0.0225 | 0.0016 | 0.1169 | 0.4114 | 0.0225 | 0.0016 | 0.1172 |
| 6 | 2.5 | 0.5298 | 0.0331 | 0.0021 | 0.1708 | 0.5363 | 0.0331 | 0.0020 | 0.1706 |
| 7 | 3.0 | 0.6569 | 0.0454 | 0.0024 | 0.2320 | 0.6625 | 0.0454 | 0.0023 | 0.2312 |
| 8 | 3.5 | 0.7838 | 0.0592 | 0.0026 | 0.2997 | 0.7890 | 0.0592 | 0.0025 | 0.2983 |
| 9 | 4.0 | 0.9108 | 0.0744 | 0.0027 | 0.3736 | 0.9151 | 0.0745 | 0.0025 | 0.3715 |
| 10 | 4.5 | 1.0369 | 0.0909 | 0.0027 | 0.4530 | 1.0404 | 0.0912 | 0.0025 | 0.4505 |
| 11 | 5.0 | 1.1623 | 0.1087 | 0.0026 | 0.5378 | 1.1650 | 0.1096 | 0.0023 | 0.5343 |
| 12 | 6.0 | 1.3331 | 0.1443 | 0.0020 | 0.7051 | 1.3291 | 0.1466 | 0.0016 | 0.6996 |
| 13 | 7.0 | 1.4478 | 0.1787 | 0.0005 | 0.8647 | 1.4516 | 0.1825 | 0.0001 | 0.8588 |
| 14 | 8.0 | 1.5614 | 0.2123 | -0.0011 | 1.0235 | 1.5615 | 0.2176 | -0.0015 | 1.0171 |
| 15 | 9.0 | 1.6623 | 0.2447 | -0.0026 | 1.1819 | 1.6647 | 0.2510 | -0.0031 | 1.1755 |
| 16 | 10.0 | 1.7624 | 0.2755 | -0.0043 | 1.3403 | 1.7626 | 0.2822 | -0.0048 | 1.3336 |
| 17 | 11.0 | 1.8563 | 0.3045 | -0.0059 | 1.4983 | 1.8567 | 0.3114 | -0.0065 | 1.4914 |
| 18 | 12.0 | 1.9492 | 0.3316 | -0.0075 | 1.6556 | 1.9479 | 0.3386 | -0.0081 | 1.6482 |
| 19 | 13.0 | 2.0381 | 0.3567 | -0.0092 | 1.8119 | 2.0367 | 0.3639 | -0.0098 | 1.8039 |
| 20 | 14.0 | 2.1258 | 0.3799 | -0.0108 | 1.9672 | 2.1236 | 0.3874 | -0.0114 | 1.9584 |
| 21 | 15.0 | 2.2108 | 0.4015 | -0.0124 | 2.1212 | 2.2090 | 0.4094 | -0.0131 | 2.1118 |
| 22 | 16.0 | 2.2715 | 0.4205 | -0.0141 | 2.2691 | 2.2652 | 0.4289 | -0.0148 | 2.2584 |
| 23 | 17.0 | 2.3147 | 0.4365 | -0.0159 | 2.4082 | 2.3114 | 0.4460 | -0.0166 | 2.3972 |
| 24 | 18.0 | 2.3581 | 0.4500 | -0.0177 | 2.5413 | 2.3538 | 0.4607 | -0.0184 | 2.5301 |
| 25 | 19.0 | 2.3975 | 0.4613 | -0.0194 | 2.6693 | 2.3936 | 0.4729 | -0.0201 | 2.6581 |
| 26 | 20.0 | 2.4373 | 0.4706 | -0.0210 | 2.7927 | 2.4319 | 0.4827 | -0.0217 | 2.7815 |
| 27 | 21.0 | 2.4753 | 0.4780 | -0.0225 | 2.9120 | 2.4696 | 0.4906 | -0.0233 | 2.9008 |
| 28 | 22.0 | 2.5136 | 0.4838 | -0.0240 | 3.0277 | 2.5069 | 0.4969 | -0.0248 | 3.0163 |
| 29 | 23.0 | 2.5510 | 0.4882 | -0.0255 | 3.1400 | 2.5440 | 0.5017 | -0.0263 | 3.1283 |
| 30 | 24.0 | 2.5883 | 0.4914 | -0.0269 | 3.2492 | 2.5811 | 0.5054 | -0.0277 | 3.2370 |
| 31 | 25.0 | 2.6250 | 0.4935 | -0.0283 | 3.3558 | 2.6183 | 0.5083 | -0.0291 | 3.3429 |
| 32 | 26.0 | 2.6541 | 0.4943 | -0.0297 | 3.4582 | 2.6461 | 0.5099 | -0.0305 | 3.4446 |
| 33 | 27.0 | 2.6776 | 0.4939 | -0.0310 | 3.5560 | 2.6711 | 0.5103 | -0.0319 | 3.5420 |
| 34 | 28.0 | 2.7016 | 0.4924 | -0.0324 | 3.6501 | 2.6953 | 0.5098 | -0.0332 | 3.6359 |
| 35 | 29.0 | 2.7245 | 0.4900 | -0.0337 | 3.7411 | 2.7195 | 0.5084 | -0.0345 | 3.7269 |
| 36 | 30.0 | 2.7478 | 0.4869 | -0.0349 | 3.8293 | 2.7438 | 0.5062 | -0.0357 | 3.8152 |
| 37 | 31.0 | 2.7708 | 0.4831 | -0.0361 | 3.9151 | 2.7683 | 0.5031 | -0.0369 | 3.9009 |
| 38 | 32.0 | 2.7941 | 0.4787 | -0.0373 | 3.9986 | 2.7929 | 0.4992 | -0.0380 | 3.9843 |
| 39 | 33.0 | 2.8173 | 0.4737 | -0.0385 | 4.0800 | 2.8175 | 0.4947 | -0.0391 | 4.0654 |
| 40 | 34.0 | 2.8406 | 0.4684 | -0.0396 | 4.1596 | 2.8422 | 0.4900 | -0.0402 | 4.1446 |
| 41 | 35.0 | 2.8639 | 0.4628 | -0.0407 | 4.2375 | 2.8667 | 0.4850 | -0.0412 | 4.2222 |
| 42 | 37.0 | 2.8922 | 0.4498 | -0.0429 | 4.3835 | 2.8993 | 0.4731 | -0.0433 | 4.3686 |
| 43 | 39.0 | 2.9119 | 0.4346 | -0.0451 | 4.5167 | 2.9233 | 0.4583 | -0.0452 | 4.5028 |
| 44 | 41.0 | 2.9348 | 0.4180 | -0.0471 | 4.6413 | 2.9482 | 0.4423 | -0.0471 | 4.6280 |
| 45 | 43.0 | 2.9570 | 0.4005 | -0.0490 | 4.7585 | 2.9746 | 0.4259 | -0.0488 | 4.7455 |
| 46 | 45.0 | 2.9813 | 0.3824 | -0.0508 | 4.8697 | 3.0022 | 0.4093 | -0.0505 | 4.8567 |
| 47 | 47.5 | 2.9876 | 0.3582 | -0.0530 | 4.9939 | 3.0096 | 0.3866 | -0.0527 | 4.9808 |
| 48 | 50.0 | 2.9859 | 0.3321 | -0.0551 | 5.1012 | 3.0137 | 0.3609 | -0.0546 | 5.0887 |
| 49 | 52.5 | 2.9895 | 0.3053 | -0.0569 | 5.1977 | 3.0193 | 0.3341 | -0.0564 | 5.1849 |
| 50 | 55.0 | 2.9940 | 0.2784 | -0.0587 | 5.2855 | 3.0274 | 0.3072 | -0.0579 | 5.2721 |
| 51 | 57.5 | 3.0018 | 0.2521 | -0.0603 | 5.3666 | 3.0375 | 0.2808 | -0.0594 | 5.3522 |
| 52 | 60.0 | 3.0107 | 0.2267 | -0.0618 | 5.4426 | 3.0490 | 0.2561 | -0.0608 | 5.4276 |
| 53 | 62.5 | 3.0218 | 0.2026 | -0.0632 | 5.5145 | 3.0619 | 0.2324 | -0.0622 | 5.4987 |
| 54 | 65.0 | 3.0338 | 0.1797 | -0.0646 | 5.5833 | 3.0763 | 0.2096 | -0.0635 | 5.5670 |

| | | | | | | | | | |
|-----|-------|--------|---------|---------|--------|--------|---------|---------|--------|
| 55 | 67.5 | 3.0472 | 0.1581 | -0.0659 | 5.6493 | 3.0912 | 0.1878 | -0.0648 | 5.6329 |
| 56 | 70.0 | 3.0612 | 0.1377 | -0.0672 | 5.7131 | 3.1063 | 0.1676 | -0.0661 | 5.6965 |
| 57 | 73.0 | 3.0182 | 0.1104 | -0.0688 | 5.7656 | 3.0559 | 0.1404 | -0.0678 | 5.7461 |
| 58 | 76.0 | 2.9546 | 0.0786 | -0.0703 | 5.7873 | 3.0025 | 0.1088 | -0.0690 | 5.7682 |
| 59 | 79.0 | 2.9057 | 0.0452 | -0.0713 | 5.7924 | 2.9528 | 0.0750 | -0.0699 | 5.7722 |
| 60 | 82.0 | 2.8571 | 0.0116 | -0.0721 | 5.7847 | 2.9076 | 0.0416 | -0.0706 | 5.7638 |
| 61 | 85.0 | 2.8175 | -0.0204 | -0.0727 | 5.7693 | 2.8686 | 0.0105 | -0.0710 | 5.7478 |
| 62 | 88.0 | 2.7794 | -0.0503 | -0.0732 | 5.7487 | 2.8348 | -0.0186 | -0.0714 | 5.7271 |
| 63 | 91.0 | 2.7474 | -0.0776 | -0.0735 | 5.7253 | 2.8048 | -0.0453 | -0.0716 | 5.7031 |
| 64 | 94.0 | 2.7168 | -0.1026 | -0.0738 | 5.7001 | 2.7770 | -0.0693 | -0.0718 | 5.6777 |
| 65 | 97.0 | 2.6904 | -0.1251 | -0.0740 | 5.6740 | 2.7512 | -0.0905 | -0.0720 | 5.6517 |
| 66 | 100.0 | 2.6652 | -0.1454 | -0.0742 | 5.6474 | 2.7281 | -0.1096 | -0.0720 | 5.6251 |
| 67 | 105.0 | 2.5746 | -0.1799 | -0.0745 | 5.5784 | 2.6348 | -0.1430 | -0.0722 | 5.5547 |
| 68 | 110.0 | 2.4771 | -0.2158 | -0.0744 | 5.4805 | 2.5465 | -0.1775 | -0.0719 | 5.4578 |
| 69 | 115.0 | 2.3998 | -0.2489 | -0.0739 | 5.3726 | 2.4681 | -0.2087 | -0.0712 | 5.3496 |
| 70 | 120.0 | 2.3256 | -0.2773 | -0.0732 | 5.2604 | 2.3988 | -0.2346 | -0.0704 | 5.2383 |
| 71 | 125.0 | 2.2631 | -0.3006 | -0.0724 | 5.1496 | 2.3362 | -0.2555 | -0.0695 | 5.1277 |
| 72 | 130.0 | 2.2031 | -0.3194 | -0.0715 | 5.0412 | 2.2783 | -0.2723 | -0.0685 | 5.0194 |
| 73 | 135.0 | 2.1508 | -0.3344 | -0.0705 | 4.9364 | 2.2256 | -0.2855 | -0.0675 | 4.9143 |
| 74 | 140.0 | 2.1002 | -0.3462 | -0.0696 | 4.8353 | 2.1785 | -0.2954 | -0.0664 | 4.8127 |
| 75 | 145.0 | 2.0551 | -0.3554 | -0.0686 | 4.7382 | 2.1352 | -0.3031 | -0.0653 | 4.7150 |
| 76 | 150.0 | 2.0113 | -0.3624 | -0.0676 | 4.6449 | 2.0953 | -0.3091 | -0.0643 | 4.6212 |
| 77 | 155.0 | 1.9717 | -0.3676 | -0.0666 | 4.5554 | 2.0587 | -0.3136 | -0.0632 | 4.5313 |
| 78 | 160.0 | 1.9331 | -0.3713 | -0.0656 | 4.4695 | 2.0250 | -0.3169 | -0.0620 | 4.4452 |
| 79 | 165.0 | 1.8437 | -0.3787 | -0.0647 | 4.3624 | 1.9298 | -0.3241 | -0.0610 | 4.3333 |
| 80 | 170.0 | 1.7443 | -0.3911 | -0.0635 | 4.2292 | 1.8384 | -0.3352 | -0.0595 | 4.1982 |
| 81 | 175.0 | 1.6638 | -0.4036 | -0.0619 | 4.0881 | 1.7557 | -0.3464 | -0.0579 | 4.0543 |
| 82 | 180.0 | 1.5848 | -0.4140 | -0.0603 | 3.9443 | 1.6812 | -0.3562 | -0.0561 | 3.9093 |
| 83 | 185.0 | 1.5166 | -0.4211 | -0.0586 | 3.8032 | 1.6137 | -0.3637 | -0.0542 | 3.7670 |
| 84 | 190.0 | 1.4501 | -0.4255 | -0.0569 | 3.6657 | 1.5521 | -0.3692 | -0.0523 | 3.6290 |
| 85 | 195.0 | 1.3908 | -0.4275 | -0.0552 | 3.5328 | 1.4945 | -0.3721 | -0.0505 | 3.4954 |
| 86 | 200.0 | 1.3330 | -0.4274 | -0.0535 | 3.4045 | 1.4400 | -0.3727 | -0.0488 | 3.3659 |
| 87 | 210.0 | 1.2297 | -0.4227 | -0.0502 | 3.1620 | 1.3392 | -0.3696 | -0.0455 | 3.1218 |
| 88 | 220.0 | 1.1351 | -0.4135 | -0.0471 | 2.9375 | 1.2478 | -0.3625 | -0.0422 | 2.8955 |
| 89 | 230.0 | 1.0512 | -0.4016 | -0.0441 | 2.7299 | 1.1659 | -0.3509 | -0.0391 | 2.6866 |
| 90 | 240.0 | 0.9730 | -0.3878 | -0.0412 | 2.5380 | 1.0929 | -0.3357 | -0.0361 | 2.4936 |
| 91 | 250.0 | 0.9032 | -0.3729 | -0.0385 | 2.3606 | 1.0247 | -0.3203 | -0.0334 | 2.3153 |
| 92 | 260.0 | 0.8375 | -0.3575 | -0.0359 | 2.1964 | 0.9591 | -0.3054 | -0.0309 | 2.1491 |
| 93 | 270.0 | 0.7785 | -0.3417 | -0.0335 | 2.0444 | 0.8995 | -0.2900 | -0.0286 | 1.9952 |
| 94 | 280.0 | 0.7228 | -0.3260 | -0.0313 | 1.9035 | 0.8465 | -0.2742 | -0.0263 | 1.8523 |
| 95 | 290.0 | 0.6727 | -0.3104 | -0.0292 | 1.7729 | 0.7968 | -0.2580 | -0.0241 | 1.7202 |
| 96 | 300.0 | 0.6250 | -0.2952 | -0.0272 | 1.6517 | 0.7487 | -0.2417 | -0.0222 | 1.5978 |
| 97 | 320.0 | 0.5418 | -0.2659 | -0.0236 | 1.4344 | 0.6648 | -0.2110 | -0.0187 | 1.3824 |
| 98 | 340.0 | 0.4691 | -0.2386 | -0.0205 | 1.2467 | 0.5950 | -0.1825 | -0.0156 | 1.1967 |
| 99 | 360.0 | 0.4077 | -0.2133 | -0.0178 | 1.0844 | 0.5342 | -0.1552 | -0.0129 | 1.0328 |
| 100 | 380.0 | 0.3535 | -0.1903 | -0.0154 | 0.9438 | 0.4849 | -0.1295 | -0.0105 | 0.8939 |
| 101 | 400.0 | 0.3078 | -0.1694 | -0.0134 | 0.8218 | 0.4422 | -0.1052 | -0.0084 | 0.7707 |
| 102 | 420.0 | 0.2672 | -0.1506 | -0.0116 | 0.7159 | 0.4048 | -0.0838 | -0.0065 | 0.6638 |
| 103 | 440.0 | 0.2330 | -0.1337 | -0.0101 | 0.6239 | 0.3709 | -0.0651 | -0.0050 | 0.5704 |
| 104 | 460.0 | 0.2024 | -0.1185 | -0.0087 | 0.5438 | 0.3405 | -0.0486 | -0.0037 | 0.4873 |
| 105 | 480.0 | 0.1767 | -0.1050 | -0.0076 | 0.4742 | 0.3168 | -0.0350 | -0.0026 | 0.4179 |
| 106 | 500.0 | 0.1535 | -0.0929 | -0.0066 | 0.4135 | 0.2972 | -0.0230 | -0.0018 | 0.3570 |

表4. 7(1) 評価断面7の応力テンソル成分1

F I N A S解と簡易計算値との比較 (コールドショック)

断面7の応力成分1

| ステップ | 時間(S) | F I N A S解 | | | | 簡易計算値 | | | |
|------|-------|------------|--------|--------|--------|--------|--------|--------|--------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.2442 | 0.0000 | 0.0096 | 0.0238 | 0.3072 | 0.0000 | 0.0109 | 0.0282 |
| 3 | 1.0 | 0.4669 | 0.0001 | 0.0219 | 0.0498 | 0.4816 | 0.0001 | 0.0220 | 0.0505 |
| 4 | 1.5 | 0.5484 | 0.0003 | 0.0343 | 0.0694 | 0.6026 | 0.0003 | 0.0356 | 0.0736 |
| 5 | 2.0 | 0.6569 | 0.0005 | 0.0506 | 0.0954 | 0.6942 | 0.0004 | 0.0506 | 0.0971 |
| 6 | 2.5 | 0.7133 | 0.0007 | 0.0664 | 0.1178 | 0.7671 | 0.0006 | 0.0667 | 0.1205 |
| 7 | 3.0 | 0.7777 | 0.0009 | 0.0838 | 0.1418 | 0.8267 | 0.0009 | 0.0835 | 0.1434 |
| 8 | 3.5 | 0.8208 | 0.0012 | 0.1013 | 0.1640 | 0.8781 | 0.0011 | 0.1009 | 0.1658 |
| 9 | 4.0 | 0.8650 | 0.0015 | 0.1195 | 0.1864 | 0.9218 | 0.0014 | 0.1187 | 0.1876 |
| 10 | 4.5 | 0.8996 | 0.0018 | 0.1379 | 0.2077 | 0.9614 | 0.0017 | 0.1368 | 0.2087 |
| 11 | 5.0 | 0.9334 | 0.0021 | 0.1567 | 0.2286 | 0.9972 | 0.0020 | 0.1552 | 0.2293 |
| 12 | 6.0 | 0.7680 | 0.0027 | 0.1844 | 0.2445 | 0.8020 | 0.0025 | 0.1804 | 0.2408 |
| 13 | 7.0 | 0.6968 | 0.0033 | 0.2094 | 0.2587 | 0.7476 | 0.0030 | 0.2041 | 0.2543 |
| 14 | 8.0 | 0.7037 | 0.0041 | 0.2328 | 0.2723 | 0.7294 | 0.0035 | 0.2261 | 0.2661 |
| 15 | 9.0 | 0.6753 | 0.0048 | 0.2548 | 0.2817 | 0.7249 | 0.0039 | 0.2476 | 0.2771 |
| 16 | 10.0 | 0.6950 | 0.0056 | 0.2778 | 0.2944 | 0.7256 | 0.0044 | 0.2689 | 0.2876 |
| 17 | 11.0 | 0.6844 | 0.0062 | 0.2996 | 0.3035 | 0.7299 | 0.0050 | 0.2902 | 0.2977 |
| 18 | 12.0 | 0.7022 | 0.0072 | 0.3224 | 0.3149 | 0.7368 | 0.0055 | 0.3116 | 0.3078 |
| 19 | 13.0 | 0.7002 | 0.0082 | 0.3442 | 0.3238 | 0.7456 | 0.0060 | 0.3329 | 0.3175 |
| 20 | 14.0 | 0.7151 | 0.0092 | 0.3667 | 0.3342 | 0.7563 | 0.0064 | 0.3542 | 0.3268 |
| 21 | 15.0 | 0.7175 | 0.0104 | 0.3886 | 0.3429 | 0.7693 | 0.0074 | 0.3754 | 0.3356 |
| 22 | 16.0 | 0.6634 | 0.0116 | 0.4077 | 0.3452 | 0.7174 | 0.0093 | 0.3938 | 0.3373 |
| 23 | 17.0 | 0.6323 | 0.0132 | 0.4254 | 0.3465 | 0.7021 | 0.0112 | 0.4108 | 0.3389 |
| 24 | 18.0 | 0.6328 | 0.0150 | 0.4425 | 0.3486 | 0.6979 | 0.0131 | 0.4273 | 0.3405 |
| 25 | 19.0 | 0.6191 | 0.0168 | 0.4588 | 0.3494 | 0.6985 | 0.0151 | 0.4435 | 0.3420 |
| 26 | 20.0 | 0.6246 | 0.0190 | 0.4754 | 0.3517 | 0.7017 | 0.0177 | 0.4595 | 0.3437 |
| 27 | 21.0 | 0.6183 | 0.0213 | 0.4912 | 0.3529 | 0.7070 | 0.0212 | 0.4754 | 0.3454 |
| 28 | 22.0 | 0.6235 | 0.0239 | 0.5073 | 0.3552 | 0.7126 | 0.0256 | 0.4911 | 0.3471 |
| 29 | 23.0 | 0.6216 | 0.0264 | 0.5228 | 0.3569 | 0.7188 | 0.0304 | 0.5066 | 0.3487 |
| 30 | 24.0 | 0.6266 | 0.0292 | 0.5385 | 0.3593 | 0.7262 | 0.0351 | 0.5219 | 0.3504 |
| 31 | 25.0 | 0.6270 | 0.0319 | 0.5538 | 0.3612 | 0.7340 | 0.0393 | 0.5371 | 0.3522 |
| 32 | 26.0 | 0.6096 | 0.0350 | 0.5680 | 0.3612 | 0.7184 | 0.0429 | 0.5509 | 0.3517 |
| 33 | 27.0 | 0.5991 | 0.0382 | 0.5816 | 0.3610 | 0.7146 | 0.0464 | 0.5641 | 0.3511 |
| 34 | 28.0 | 0.6000 | 0.0414 | 0.5949 | 0.3612 | 0.7140 | 0.0506 | 0.5771 | 0.3505 |
| 35 | 29.0 | 0.5959 | 0.0447 | 0.6079 | 0.3610 | 0.7149 | 0.0552 | 0.5898 | 0.3501 |
| 36 | 30.0 | 0.5982 | 0.0480 | 0.6207 | 0.3614 | 0.7168 | 0.0597 | 0.6025 | 0.3500 |
| 37 | 31.0 | 0.5969 | 0.0515 | 0.6333 | 0.3616 | 0.7194 | 0.0639 | 0.6150 | 0.3501 |
| 38 | 32.0 | 0.5997 | 0.0549 | 0.6458 | 0.3623 | 0.7219 | 0.0679 | 0.6273 | 0.3502 |
| 39 | 33.0 | 0.5998 | 0.0584 | 0.6581 | 0.3627 | 0.7250 | 0.0717 | 0.6393 | 0.3504 |
| 40 | 34.0 | 0.6026 | 0.0619 | 0.6703 | 0.3635 | 0.7294 | 0.0758 | 0.6511 | 0.3507 |
| 41 | 35.0 | 0.6037 | 0.0659 | 0.6823 | 0.3642 | 0.7338 | 0.0800 | 0.6627 | 0.3511 |
| 42 | 37.0 | 0.5727 | 0.0731 | 0.7036 | 0.3614 | 0.6874 | 0.0879 | 0.6830 | 0.3473 |
| 43 | 39.0 | 0.5684 | 0.0802 | 0.7233 | 0.3590 | 0.6823 | 0.0947 | 0.7016 | 0.3447 |
| 44 | 41.0 | 0.5692 | 0.0871 | 0.7421 | 0.3572 | 0.6844 | 0.1028 | 0.7193 | 0.3428 |
| 45 | 43.0 | 0.5669 | 0.0943 | 0.7605 | 0.3559 | 0.6877 | 0.1121 | 0.7366 | 0.3411 |
| 46 | 45.0 | 0.5713 | 0.1013 | 0.7783 | 0.3555 | 0.6916 | 0.1216 | 0.7536 | 0.3398 |
| 47 | 47.5 | 0.5301 | 0.1092 | 0.7966 | 0.3492 | 0.6546 | 0.1313 | 0.7707 | 0.3327 |
| 48 | 50.0 | 0.5300 | 0.1170 | 0.8129 | 0.3443 | 0.6466 | 0.1366 | 0.7857 | 0.3267 |
| 49 | 52.5 | 0.5256 | 0.1243 | 0.8282 | 0.3400 | 0.6416 | 0.1420 | 0.7996 | 0.3216 |
| 50 | 55.0 | 0.5252 | 0.1313 | 0.8429 | 0.3373 | 0.6363 | 0.1499 | 0.8129 | 0.3176 |
| 51 | 57.5 | 0.5257 | 0.1383 | 0.8569 | 0.3349 | 0.6355 | 0.1581 | 0.8260 | 0.3147 |
| 52 | 60.0 | 0.5257 | 0.1447 | 0.8703 | 0.3334 | 0.6362 | 0.1650 | 0.8384 | 0.3124 |
| 53 | 62.5 | 0.5276 | 0.1507 | 0.8832 | 0.3324 | 0.6376 | 0.1711 | 0.8503 | 0.3105 |
| 54 | 65.0 | 0.5284 | 0.1562 | 0.8957 | 0.3318 | 0.6426 | 0.1774 | 0.8622 | 0.3093 |

| | | | | | | | | | |
|-----|-------|--------|--------|--------|--------|---------|---------|---------|---------|
| 55 | 67.5 | 0.5311 | 0.1616 | 0.9078 | 0.3316 | 0.6480 | 0.1827 | 0.8738 | 0.3086 |
| 56 | 70.0 | 0.5321 | 0.1666 | 0.9194 | 0.3316 | 0.6506 | 0.1856 | 0.8846 | 0.3079 |
| 57 | 73.0 | 0.4450 | 0.1720 | 0.9251 | 0.3181 | 0.5825 | 0.1884 | 0.8887 | 0.2939 |
| 58 | 76.0 | 0.4395 | 0.1771 | 0.9268 | 0.3060 | 0.5598 | 0.1928 | 0.8899 | 0.2813 |
| 59 | 79.0 | 0.4288 | 0.1819 | 0.9276 | 0.2960 | 0.5465 | 0.1968 | 0.8899 | 0.2711 |
| 60 | 82.0 | 0.4195 | 0.1862 | 0.9276 | 0.2880 | 0.5378 | 0.1999 | 0.8888 | 0.2624 |
| 61 | 85.0 | 0.4187 | 0.1901 | 0.9269 | 0.2814 | 0.5308 | 0.2037 | 0.8873 | 0.2546 |
| 62 | 88.0 | 0.4095 | 0.1935 | 0.9257 | 0.2756 | 0.5243 | 0.2054 | 0.8855 | 0.2478 |
| 63 | 91.0 | 0.4114 | 0.1965 | 0.9242 | 0.2712 | 0.5193 | 0.2035 | 0.8838 | 0.2423 |
| 64 | 94.0 | 0.4030 | 0.1991 | 0.9224 | 0.2668 | 0.5123 | 0.2012 | 0.8815 | 0.2372 |
| 65 | 97.0 | 0.4058 | 0.2011 | 0.9205 | 0.2638 | 0.5044 | 0.2007 | 0.8784 | 0.2323 |
| 66 | 100.0 | 0.3981 | 0.2029 | 0.9181 | 0.2604 | 0.5021 | 0.1991 | 0.8753 | 0.2284 |
| 67 | 105.0 | 0.3416 | 0.2050 | 0.9070 | 0.2454 | 0.4515 | 0.1973 | 0.8623 | 0.2121 |
| 68 | 110.0 | 0.3386 | 0.2061 | 0.8924 | 0.2325 | 0.4311 | 0.1957 | 0.8471 | 0.1989 |
| 69 | 115.0 | 0.3276 | 0.2066 | 0.8779 | 0.2233 | 0.4142 | 0.1920 | 0.8311 | 0.1882 |
| 70 | 120.0 | 0.3182 | 0.2064 | 0.8628 | 0.2153 | 0.4010 | 0.1853 | 0.8146 | 0.1794 |
| 71 | 125.0 | 0.3151 | 0.2054 | 0.8479 | 0.2091 | 0.3879 | 0.1779 | 0.7982 | 0.1717 |
| 72 | 130.0 | 0.3045 | 0.2037 | 0.8330 | 0.2033 | 0.3737 | 0.1717 | 0.7821 | 0.1649 |
| 73 | 135.0 | 0.3043 | 0.2019 | 0.8185 | 0.1989 | 0.3638 | 0.1663 | 0.7664 | 0.1591 |
| 74 | 140.0 | 0.2938 | 0.1995 | 0.8042 | 0.1943 | 0.3629 | 0.1616 | 0.7512 | 0.1544 |
| 75 | 145.0 | 0.2950 | 0.1970 | 0.7904 | 0.1909 | 0.3617 | 0.1578 | 0.7362 | 0.1499 |
| 76 | 150.0 | 0.2847 | 0.1940 | 0.7768 | 0.1871 | 0.3556 | 0.1555 | 0.7210 | 0.1452 |
| 77 | 155.0 | 0.2860 | 0.1912 | 0.7639 | 0.1843 | 0.3472 | 0.1540 | 0.7059 | 0.1408 |
| 78 | 160.0 | 0.2765 | 0.1885 | 0.7511 | 0.1809 | 0.3367 | 0.1536 | 0.6908 | 0.1366 |
| 79 | 165.0 | 0.2196 | 0.1854 | 0.7315 | 0.1673 | 0.2940 | 0.1537 | 0.6677 | 0.1209 |
| 80 | 170.0 | 0.2153 | 0.1825 | 0.7091 | 0.1550 | 0.2735 | 0.1535 | 0.6435 | 0.1079 |
| 81 | 175.0 | 0.2037 | 0.1794 | 0.6874 | 0.1460 | 0.2583 | 0.1532 | 0.6194 | 0.0966 |
| 82 | 180.0 | 0.1924 | 0.1761 | 0.6653 | 0.1377 | 0.2448 | 0.1521 | 0.5956 | 0.0866 |
| 83 | 185.0 | 0.1887 | 0.1725 | 0.6439 | 0.1312 | 0.2306 | 0.1473 | 0.5725 | 0.0785 |
| 84 | 190.0 | 0.1764 | 0.1684 | 0.6228 | 0.1248 | 0.2157 | 0.1385 | 0.5500 | 0.0729 |
| 85 | 195.0 | 0.1753 | 0.1643 | 0.6023 | 0.1197 | 0.2009 | 0.1299 | 0.5280 | 0.0677 |
| 86 | 200.0 | 0.1628 | 0.1598 | 0.5822 | 0.1144 | 0.1861 | 0.1233 | 0.5065 | 0.0619 |
| 87 | 210.0 | 0.1571 | 0.1509 | 0.5441 | 0.1059 | 0.1616 | 0.1077 | 0.4652 | 0.0517 |
| 88 | 220.0 | 0.1402 | 0.1422 | 0.5082 | 0.0977 | 0.1444 | 0.0892 | 0.4261 | 0.0435 |
| 89 | 230.0 | 0.1367 | 0.1333 | 0.4748 | 0.0913 | 0.1270 | 0.0673 | 0.3894 | 0.0364 |
| 90 | 240.0 | 0.1217 | 0.1249 | 0.4433 | 0.0845 | 0.1070 | 0.0427 | 0.3553 | 0.0300 |
| 91 | 250.0 | 0.1193 | 0.1170 | 0.4142 | 0.0791 | 0.0839 | 0.0203 | 0.3231 | 0.0238 |
| 92 | 260.0 | 0.1054 | 0.1098 | 0.3867 | 0.0732 | 0.0598 | 0.0035 | 0.2925 | 0.0171 |
| 93 | 270.0 | 0.1043 | 0.1029 | 0.3614 | 0.0687 | 0.0411 | -0.0102 | 0.2644 | 0.0106 |
| 94 | 280.0 | 0.0917 | 0.0965 | 0.3374 | 0.0635 | 0.0291 | -0.0217 | 0.2387 | 0.0048 |
| 95 | 290.0 | 0.0912 | 0.0905 | 0.3154 | 0.0596 | 0.0166 | -0.0328 | 0.2155 | 0.0003 |
| 96 | 300.0 | 0.0795 | 0.0848 | 0.2946 | 0.0551 | 0.0018 | -0.0450 | 0.1943 | -0.0026 |
| 97 | 320.0 | 0.0750 | 0.0744 | 0.2574 | 0.0483 | -0.0258 | -0.0702 | 0.1558 | -0.0085 |
| 98 | 340.0 | 0.0600 | 0.0655 | 0.2247 | 0.0415 | -0.0486 | -0.0971 | 0.1210 | -0.0146 |
| 99 | 360.0 | 0.0576 | 0.0576 | 0.1964 | 0.0365 | -0.0671 | -0.1242 | 0.0893 | -0.0203 |
| 100 | 380.0 | 0.0452 | 0.0508 | 0.1715 | 0.0313 | -0.0725 | -0.1518 | 0.0630 | -0.0239 |
| 101 | 400.0 | 0.0448 | 0.0448 | 0.1500 | 0.0277 | -0.0703 | -0.1788 | 0.0401 | -0.0262 |
| 102 | 420.0 | 0.0339 | 0.0395 | 0.1310 | 0.0236 | -0.0659 | -0.2056 | 0.0201 | -0.0277 |
| 103 | 440.0 | 0.0349 | 0.0349 | 0.1147 | 0.0210 | -0.0630 | -0.2334 | 0.0023 | -0.0286 |
| 104 | 460.0 | 0.0255 | 0.0310 | 0.1002 | 0.0178 | -0.0633 | -0.2597 | -0.0143 | -0.0297 |
| 105 | 480.0 | 0.0275 | 0.0277 | 0.0878 | 0.0159 | -0.0716 | -0.2774 | -0.0293 | -0.0326 |
| 106 | 500.0 | 0.0190 | 0.0242 | 0.0767 | 0.0133 | -0.0847 | -0.2896 | -0.0432 | -0.0364 |

表4. 7(2) 評価断面7の応力テンソル成分2

FINAS解と簡易計算値との比較(コールドショック)

断面7の応力成分2

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|---------|----------|--------|---------|---------|----------|--------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.8303 | -0.0166 | 0.0156 | 0.0991 | 1.0101 | -0.0179 | 0.0180 | 0.1118 |
| 3 | 1.0 | 2.2075 | -0.0597 | 0.0416 | 0.3101 | 2.2894 | -0.0609 | 0.0425 | 0.3171 |
| 4 | 1.5 | 3.5425 | -0.1224 | 0.0693 | 0.5803 | 3.6742 | -0.1236 | 0.0713 | 0.5907 |
| 5 | 2.0 | 5.0188 | -0.2026 | 0.1012 | 0.9110 | 5.1186 | -0.2037 | 0.1018 | 0.9178 |
| 6 | 2.5 | 6.4850 | -0.2982 | 0.1321 | 1.2814 | 6.6028 | -0.2992 | 0.1329 | 1.2887 |
| 7 | 3.0 | 8.0067 | -0.4079 | 0.1636 | 1.6913 | 8.1122 | -0.4083 | 0.1636 | 1.6964 |
| 8 | 3.5 | 9.5279 | -0.5304 | 0.1941 | 2.1320 | 9.6391 | -0.5299 | 0.1938 | 2.1359 |
| 9 | 4.0 | 11.0718 | -0.6652 | 0.2242 | 2.6019 | 11.1760 | -0.6639 | 0.2232 | 2.6040 |
| 10 | 4.5 | 12.6166 | -0.8113 | 0.2532 | 3.0969 | 12.7210 | -0.8091 | 0.2516 | 3.0977 |
| 11 | 5.0 | 14.1701 | -0.9683 | 0.2815 | 3.6154 | 14.2700 | -0.9645 | 0.2792 | 3.6140 |
| 12 | 6.0 | 16.2643 | -1.2846 | 0.3159 | 4.5673 | 16.2670 | -1.2765 | 0.3097 | 4.5536 |
| 13 | 7.0 | 17.8528 | -1.5960 | 0.3356 | 5.4311 | 17.9550 | -1.5847 | 0.3284 | 5.4211 |
| 14 | 8.0 | 19.5074 | -1.9133 | 0.3517 | 6.2765 | 19.5490 | -1.8986 | 0.3424 | 6.2620 |
| 15 | 9.0 | 21.0121 | -2.2387 | 0.3648 | 7.1066 | 21.0940 | -2.2210 | 0.3548 | 7.0941 |
| 16 | 10.0 | 22.5542 | -2.5739 | 0.3783 | 7.9390 | 22.6060 | -2.5528 | 0.3662 | 7.9243 |
| 17 | 11.0 | 24.0191 | -2.9198 | 0.3900 | 8.7683 | 24.0940 | -2.8955 | 0.3773 | 8.7561 |
| 18 | 12.0 | 25.5038 | -3.2761 | 0.4022 | 9.6031 | 25.5610 | -3.2492 | 0.3879 | 9.5905 |
| 19 | 13.0 | 26.9404 | -3.6434 | 0.4130 | 10.4386 | 27.0100 | -3.6146 | 0.3980 | 10.4280 |
| 20 | 14.0 | 28.3851 | -4.0213 | 0.4240 | 11.2793 | 28.4440 | -3.9919 | 0.4075 | 11.2690 |
| 21 | 15.0 | 29.7967 | -4.4095 | 0.4341 | 12.1218 | 29.8640 | -4.3809 | 0.4166 | 12.1130 |
| 22 | 16.0 | 30.9054 | -4.7990 | 0.4384 | 12.9248 | 30.9160 | -4.7698 | 0.4191 | 12.9110 |
| 23 | 17.0 | 31.8384 | -5.1845 | 0.4384 | 13.6813 | 31.8860 | -5.1545 | 0.4186 | 13.6690 |
| 24 | 18.0 | 32.7909 | -5.5695 | 0.4382 | 14.4164 | 32.8180 | -5.5373 | 0.4175 | 14.4020 |
| 25 | 19.0 | 33.6836 | -5.9545 | 0.4374 | 15.1318 | 33.7280 | -5.9193 | 0.4165 | 15.1180 |
| 26 | 20.0 | 34.5871 | -6.3395 | 0.4374 | 15.8352 | 34.6220 | -6.3008 | 0.4157 | 15.8200 |
| 27 | 21.0 | 35.4572 | -6.7252 | 0.4371 | 16.5256 | 35.5030 | -6.6828 | 0.4153 | 16.5110 |
| 28 | 22.0 | 36.3320 | -7.1109 | 0.4373 | 17.2070 | 36.3740 | -7.0665 | 0.4149 | 17.1910 |
| 29 | 23.0 | 37.1857 | -7.4968 | 0.4374 | 17.8785 | 37.2350 | -7.4503 | 0.4147 | 17.8630 |
| 30 | 24.0 | 38.0401 | -7.8821 | 0.4379 | 18.5424 | 38.0870 | -7.8333 | 0.4145 | 18.5260 |
| 31 | 25.0 | 38.8791 | -8.2668 | 0.4383 | 19.1980 | 38.9300 | -8.2152 | 0.4145 | 19.1810 |
| 32 | 26.0 | 39.6152 | -8.6478 | 0.4370 | 19.8323 | 39.6470 | -8.5923 | 0.4122 | 19.8130 |
| 33 | 27.0 | 40.2893 | -9.0229 | 0.4345 | 20.4433 | 40.3340 | -8.9635 | 0.4092 | 20.4240 |
| 34 | 28.0 | 40.9678 | -9.3934 | 0.4322 | 21.0400 | 41.0050 | -9.3300 | 0.4063 | 21.0200 |
| 35 | 29.0 | 41.6231 | -9.7597 | 0.4298 | 21.6232 | 41.6650 | -9.6923 | 0.4036 | 21.6030 |
| 36 | 30.0 | 42.2798 | -10.1216 | 0.4278 | 22.1960 | 42.3170 | -10.0500 | 0.4012 | 22.1750 |
| 37 | 31.0 | 42.9231 | -10.4792 | 0.4259 | 22.7582 | 42.9630 | -10.4030 | 0.3992 | 22.7370 |
| 38 | 32.0 | 43.5659 | -10.8321 | 0.4244 | 23.3115 | 43.6030 | -10.7510 | 0.3975 | 23.2900 |
| 39 | 33.0 | 44.1990 | -11.1809 | 0.4230 | 23.8558 | 44.2380 | -11.0930 | 0.3958 | 23.8340 |
| 40 | 34.0 | 44.8302 | -11.5253 | 0.4218 | 24.3923 | 44.8700 | -11.4310 | 0.3941 | 24.3700 |
| 41 | 35.0 | 45.4540 | -11.8651 | 0.4207 | 24.9209 | 45.4970 | -11.7650 | 0.3925 | 24.8980 |
| 42 | 37.0 | 46.4557 | -12.5225 | 0.4145 | 25.9147 | 46.5120 | -12.4120 | 0.3861 | 25.8960 |
| 43 | 39.0 | 47.3502 | -13.1486 | 0.4068 | 26.8372 | 47.4300 | -13.0300 | 0.3775 | 26.8240 |
| 44 | 41.0 | 48.2524 | -13.7487 | 0.4006 | 27.7168 | 48.3200 | -13.6220 | 0.3698 | 27.7030 |
| 45 | 43.0 | 49.1172 | -14.3241 | 0.3954 | 28.5578 | 49.1930 | -14.1900 | 0.3634 | 28.5430 |
| 46 | 45.0 | 49.9852 | -14.8771 | 0.3911 | 29.3672 | 50.0500 | -14.7370 | 0.3580 | 29.3500 |
| 47 | 47.5 | 50.7321 | -15.5242 | 0.3807 | 30.2786 | 50.7740 | -15.3800 | 0.3454 | 30.2600 |
| 48 | 50.0 | 51.3705 | -16.1195 | 0.3694 | 31.0903 | 51.4290 | -15.9730 | 0.3329 | 31.0730 |
| 49 | 52.5 | 52.0164 | -16.6733 | 0.3606 | 31.8430 | 52.0620 | -16.5270 | 0.3220 | 31.8250 |
| 50 | 55.0 | 52.6334 | -17.1890 | 0.3534 | 32.5445 | 52.6790 | -17.0420 | 0.3128 | 32.5270 |
| 51 | 57.5 | 53.2526 | -17.6697 | 0.3476 | 33.2042 | 53.2880 | -17.5230 | 0.3054 | 33.1860 |
| 52 | 60.0 | 53.8545 | -18.1190 | 0.3430 | 33.8270 | 53.8900 | -17.9700 | 0.2990 | 33.8090 |
| 53 | 62.5 | 54.4549 | -18.5397 | 0.3392 | 34.4183 | 54.4860 | -18.3870 | 0.2937 | 34.4000 |
| 54 | 65.0 | 55.0416 | -18.9342 | 0.3363 | 34.9813 | 55.0760 | -18.7750 | 0.2897 | 34.9630 |

| | | | | | | | | | |
|-----|-------|---------|----------|--------|---------|---------|----------|---------|---------|
| 55 | 67.5 | 55.6248 | -19.3052 | 0.3341 | 35.5196 | 55.6570 | -19.1410 | 0.2864 | 35.5010 |
| 56 | 70.0 | 56.1961 | -19.6550 | 0.3325 | 36.0355 | 56.2240 | -19.4870 | 0.2833 | 36.0180 |
| 57 | 73.0 | 56.1176 | -20.0119 | 0.3162 | 36.4723 | 56.0550 | -19.8370 | 0.2630 | 36.4360 |
| 58 | 76.0 | 55.7943 | -20.2911 | 0.2964 | 36.7278 | 55.7810 | -20.1200 | 0.2436 | 36.7030 |
| 59 | 79.0 | 55.5514 | -20.5162 | 0.2824 | 36.9057 | 55.4970 | -20.3440 | 0.2279 | 36.8800 |
| 60 | 82.0 | 55.2524 | -20.6926 | 0.2705 | 37.0147 | 55.2170 | -20.5210 | 0.2147 | 36.9910 |
| 61 | 85.0 | 55.0099 | -20.8274 | 0.2613 | 37.0770 | 54.9460 | -20.6540 | 0.2038 | 37.0530 |
| 62 | 88.0 | 54.7383 | -20.9250 | 0.2535 | 37.0983 | 54.6850 | -20.7490 | 0.1949 | 37.0760 |
| 63 | 91.0 | 54.5087 | -20.9902 | 0.2474 | 37.0904 | 54.4360 | -20.8050 | 0.1884 | 37.0660 |
| 64 | 94.0 | 54.2609 | -21.0273 | 0.2423 | 37.0562 | 54.1970 | -20.8360 | 0.1826 | 37.0330 |
| 65 | 97.0 | 54.0457 | -21.0411 | 0.2384 | 37.0038 | 53.9670 | -20.8460 | 0.1772 | 36.9810 |
| 66 | 100.0 | 53.8173 | -21.0352 | 0.2350 | 36.9344 | 53.7510 | -20.8400 | 0.1726 | 36.9120 |
| 67 | 105.0 | 52.8051 | -20.9465 | 0.2181 | 36.6287 | 52.6880 | -20.7510 | 0.1524 | 36.5940 |
| 68 | 110.0 | 51.6462 | -20.7646 | 0.2014 | 36.1469 | 51.5830 | -20.5740 | 0.1366 | 36.1260 |
| 69 | 115.0 | 50.6196 | -20.5245 | 0.1920 | 35.6119 | 50.5190 | -20.3340 | 0.1246 | 35.5890 |
| 70 | 120.0 | 49.5752 | -20.2380 | 0.1838 | 35.0298 | 49.4990 | -20.0440 | 0.1150 | 35.0120 |
| 71 | 125.0 | 48.6249 | -19.9189 | 0.1785 | 34.4320 | 48.5250 | -19.7220 | 0.1076 | 34.4160 |
| 72 | 130.0 | 47.6717 | -19.5779 | 0.1740 | 33.8226 | 47.5950 | -19.3820 | 0.1019 | 33.8110 |
| 73 | 135.0 | 46.7946 | -19.2240 | 0.1710 | 33.2165 | 46.7030 | -19.0320 | 0.0973 | 33.2060 |
| 74 | 140.0 | 45.9193 | -18.8651 | 0.1683 | 32.6146 | 45.8480 | -18.6790 | 0.0935 | 32.6080 |
| 75 | 145.0 | 45.1079 | -18.5064 | 0.1666 | 32.0254 | 45.0260 | -18.3260 | 0.0899 | 32.0200 |
| 76 | 150.0 | 44.3005 | -18.1515 | 0.1649 | 31.4478 | 44.2320 | -17.9780 | 0.0860 | 31.4440 |
| 77 | 155.0 | 43.5486 | -17.8030 | 0.1638 | 30.8870 | 43.4660 | -17.6380 | 0.0820 | 30.8830 |
| 78 | 160.0 | 42.8017 | -17.4625 | 0.1626 | 30.3410 | 42.7270 | -17.3060 | 0.0778 | 30.3390 |
| 79 | 165.0 | 41.4298 | -17.0864 | 0.1488 | 29.6469 | 41.2640 | -16.9320 | 0.0579 | 29.6150 |
| 80 | 170.0 | 39.9160 | -16.6587 | 0.1341 | 28.8164 | 39.8020 | -16.5120 | 0.0423 | 28.7930 |
| 81 | 175.0 | 38.5446 | -16.2053 | 0.1257 | 27.9640 | 38.3880 | -16.0640 | 0.0298 | 27.9340 |
| 82 | 180.0 | 37.1614 | -15.7303 | 0.1177 | 27.0892 | 37.0290 | -15.5960 | 0.0198 | 27.0600 |
| 83 | 185.0 | 35.8840 | -15.2419 | 0.1123 | 26.2189 | 35.7230 | -15.1140 | 0.0117 | 26.1870 |
| 84 | 190.0 | 34.6113 | -14.7466 | 0.1073 | 25.3536 | 34.4700 | -14.6260 | 0.0052 | 25.3240 |
| 85 | 195.0 | 33.4251 | -14.2508 | 0.1036 | 24.5057 | 33.2640 | -14.1380 | -0.0007 | 24.4760 |
| 86 | 200.0 | 32.2484 | -13.7598 | 0.1001 | 23.6738 | 32.1020 | -13.6550 | -0.0062 | 23.6460 |
| 87 | 210.0 | 30.0694 | -12.8052 | 0.0947 | 22.0788 | 29.9090 | -12.7150 | -0.0162 | 22.0560 |
| 88 | 220.0 | 28.0157 | -11.8984 | 0.0900 | 20.5752 | 27.8640 | -11.8170 | -0.0252 | 20.5540 |
| 89 | 230.0 | 26.1351 | -11.0469 | 0.0863 | 19.1697 | 25.9660 | -10.9700 | -0.0330 | 19.1490 |
| 90 | 240.0 | 24.3577 | -10.2528 | 0.0824 | 17.8562 | 24.2040 | -10.1750 | -0.0398 | 17.8370 |
| 91 | 250.0 | 22.7291 | -9.5145 | 0.0791 | 16.6339 | 22.5620 | -9.4379 | -0.0463 | 16.6140 |
| 92 | 260.0 | 21.1876 | -8.8289 | 0.0756 | 15.4944 | 21.0250 | -8.7557 | -0.0532 | 15.4720 |
| 93 | 270.0 | 19.7759 | -8.1934 | 0.0726 | 14.4354 | 19.5910 | -8.1249 | -0.0595 | 14.4090 |
| 94 | 280.0 | 18.4374 | -7.6041 | 0.0693 | 13.4482 | 18.2490 | -7.5403 | -0.0651 | 13.4160 |
| 95 | 290.0 | 17.2123 | -7.0580 | 0.0665 | 12.5311 | 17.0040 | -6.9986 | -0.0691 | 12.4940 |
| 96 | 300.0 | 16.0490 | -6.5519 | 0.0635 | 11.6762 | 15.8490 | -6.4942 | -0.0714 | 11.6360 |
| 97 | 320.0 | 13.9822 | -5.6464 | 0.0583 | 10.1397 | 13.8000 | -5.6042 | -0.0770 | 10.1170 |
| 98 | 340.0 | 12.1659 | -4.8680 | 0.0531 | 8.8070 | 12.0130 | -4.8323 | -0.0837 | 8.7948 |
| 99 | 360.0 | 10.6067 | -4.1986 | 0.0486 | 7.6529 | 10.4270 | -4.1483 | -0.0909 | 7.6207 |
| 100 | 380.0 | 9.2307 | -3.6223 | 0.0441 | 6.6505 | 9.0833 | -3.5672 | -0.0968 | 6.6235 |
| 101 | 400.0 | 8.0527 | -3.1259 | 0.0404 | 5.7819 | 7.8926 | -3.0519 | -0.1020 | 5.7374 |
| 102 | 420.0 | 7.0086 | -2.6985 | 0.0366 | 5.0268 | 6.8650 | -2.6103 | -0.1070 | 4.9761 |
| 103 | 440.0 | 6.1183 | -2.3298 | 0.0334 | 4.3722 | 5.9744 | -2.2297 | -0.1120 | 4.3198 |
| 104 | 460.0 | 5.3249 | -2.0118 | 0.0303 | 3.8025 | 5.1821 | -1.8974 | -0.1175 | 3.7409 |
| 105 | 480.0 | 4.6518 | -1.7375 | 0.0277 | 3.3088 | 4.4962 | -1.6309 | -0.1237 | 3.2501 |
| 106 | 500.0 | 4.0480 | -1.5013 | 0.0250 | 2.8786 | 3.8779 | -1.4057 | -0.1300 | 2.8147 |

表4. 7(3) 評価断面7の応力テンソル成分3

F I N A S解と簡易計算値との比較 (コールドショック)

断面7の応力成分3

| ステップ | 時間(S) | F I N A S解 | | | | 簡易計算値 | | | |
|------|-------|------------|----------|--------|---------|---------|----------|--------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.8362 | -0.0186 | 0.0179 | 0.1035 | 1.0162 | -0.0200 | 0.0203 | 0.1165 |
| 3 | 1.0 | 2.2285 | -0.0668 | 0.0495 | 0.3259 | 2.3101 | -0.0681 | 0.0504 | 0.3329 |
| 4 | 1.5 | 3.5851 | -0.1371 | 0.0855 | 0.6127 | 3.7166 | -0.1382 | 0.0874 | 0.6229 |
| 5 | 2.0 | 5.0894 | -0.2269 | 0.1280 | 0.9645 | 5.1889 | -0.2278 | 0.1285 | 0.9709 |
| 6 | 2.5 | 6.5891 | -0.3340 | 0.1716 | 1.3602 | 6.7065 | -0.3346 | 0.1721 | 1.3669 |
| 7 | 3.0 | 8.1494 | -0.4569 | 0.2178 | 1.7992 | 8.2549 | -0.4569 | 0.2177 | 1.8037 |
| 8 | 3.5 | 9.7142 | -0.5944 | 0.2647 | 2.2725 | 9.8254 | -0.5935 | 0.2643 | 2.2759 |
| 9 | 4.0 | 11.3060 | -0.7456 | 0.3128 | 2.7784 | 11.4110 | -0.7438 | 0.3119 | 2.7801 |
| 10 | 4.5 | 12.9031 | -0.9097 | 0.3615 | 3.3125 | 13.0080 | -0.9070 | 0.3603 | 3.3132 |
| 11 | 5.0 | 14.5129 | -1.0862 | 0.4108 | 3.8730 | 14.6140 | -1.0819 | 0.4092 | 3.8719 |
| 12 | 6.0 | 16.7208 | -1.4419 | 0.4874 | 4.9097 | 16.7280 | -1.4333 | 0.4830 | 4.8975 |
| 13 | 7.0 | 18.4218 | -1.7927 | 0.5482 | 5.8571 | 18.5320 | -1.7811 | 0.5444 | 5.8503 |
| 14 | 8.0 | 20.1910 | -2.1505 | 0.6057 | 6.7874 | 20.2410 | -2.1355 | 0.6005 | 6.7768 |
| 15 | 9.0 | 21.8119 | -2.5176 | 0.6603 | 7.7036 | 21.9040 | -2.4995 | 0.6550 | 7.6957 |
| 16 | 10.0 | 23.4725 | -2.8957 | 0.7157 | 8.6239 | 23.5350 | -2.8745 | 0.7086 | 8.6144 |
| 17 | 11.0 | 25.0580 | -3.2857 | 0.7696 | 9.5428 | 25.1450 | -3.2622 | 0.7620 | 9.5366 |
| 18 | 12.0 | 26.6653 | -3.6875 | 0.8243 | 10.4688 | 26.7360 | -3.6627 | 0.8151 | 10.4630 |
| 19 | 13.0 | 28.2266 | -4.1015 | 0.8780 | 11.3971 | 28.3110 | -4.0761 | 0.8680 | 11.3950 |
| 20 | 14.0 | 29.7979 | -4.5271 | 0.9323 | 12.3322 | 29.8730 | -4.5026 | 0.9207 | 12.3310 |
| 21 | 15.0 | 31.3379 | -4.9642 | 0.9859 | 13.2705 | 31.4220 | -4.9419 | 0.9731 | 13.2730 |
| 22 | 16.0 | 32.5734 | -5.4027 | 1.0327 | 14.1682 | 32.6020 | -5.3811 | 1.0176 | 14.1660 |
| 23 | 17.0 | 33.6302 | -5.8366 | 1.0738 | 15.0174 | 33.6950 | -5.8154 | 1.0578 | 15.0170 |
| 24 | 18.0 | 34.7048 | -6.2699 | 1.1136 | 15.8440 | 34.7490 | -6.2473 | 1.0965 | 15.8420 |
| 25 | 19.0 | 35.7179 | -6.7031 | 1.1519 | 16.6498 | 35.7790 | -6.6782 | 1.1343 | 16.6490 |
| 26 | 20.0 | 36.7404 | -7.1364 | 1.1901 | 17.4430 | 36.7920 | -7.1089 | 1.1716 | 17.4410 |
| 27 | 21.0 | 37.7286 | -7.5706 | 1.2272 | 18.2224 | 37.7920 | -7.5400 | 1.2086 | 18.2210 |
| 28 | 22.0 | 38.7202 | -8.0048 | 1.2643 | 18.9923 | 38.7800 | -7.9726 | 1.2451 | 18.9900 |
| 29 | 23.0 | 39.6897 | -8.4391 | 1.3007 | 19.7515 | 39.7580 | -8.4055 | 1.2813 | 19.7500 |
| 30 | 24.0 | 40.6591 | -8.8731 | 1.3368 | 20.5029 | 40.7250 | -8.8377 | 1.3168 | 20.5020 |
| 31 | 25.0 | 41.6123 | -9.3066 | 1.3723 | 21.2455 | 41.6830 | -9.2687 | 1.3520 | 21.2440 |
| 32 | 26.0 | 42.4606 | -9.7361 | 1.4053 | 21.9655 | 42.5130 | -9.6943 | 1.3844 | 21.9620 |
| 33 | 27.0 | 43.2447 | -10.1593 | 1.4360 | 22.6608 | 43.3110 | -10.1140 | 1.4150 | 22.6580 |
| 34 | 28.0 | 44.0315 | -10.5776 | 1.4660 | 23.3406 | 44.0900 | -10.5280 | 1.4445 | 23.3370 |
| 35 | 29.0 | 44.7934 | -10.9916 | 1.4951 | 24.0058 | 44.8580 | -10.9390 | 1.4735 | 24.0030 |
| 36 | 30.0 | 45.5552 | -11.4010 | 1.5238 | 24.6597 | 45.6160 | -11.3450 | 1.5021 | 24.6570 |
| 37 | 31.0 | 46.3021 | -11.8060 | 1.5520 | 25.3021 | 46.3660 | -11.7460 | 1.5303 | 25.3000 |
| 38 | 32.0 | 47.0473 | -12.2063 | 1.5799 | 25.9350 | 47.1090 | -12.1420 | 1.5580 | 25.9340 |
| 39 | 33.0 | 47.7815 | -12.6024 | 1.6072 | 26.5581 | 47.8470 | -12.5330 | 1.5854 | 26.5580 |
| 40 | 34.0 | 48.5128 | -12.9940 | 1.6342 | 27.1727 | 48.5800 | -12.9190 | 1.6122 | 27.1720 |
| 41 | 35.0 | 49.2354 | -13.3808 | 1.6608 | 27.7788 | 49.3060 | -13.3000 | 1.6385 | 27.7790 |
| 42 | 37.0 | 50.4282 | -14.1308 | 1.7069 | 28.9229 | 50.5140 | -14.0410 | 1.6848 | 28.9280 |
| 43 | 39.0 | 51.5051 | -14.8477 | 1.7479 | 29.9899 | 51.6130 | -14.7500 | 1.7250 | 30.0000 |
| 44 | 41.0 | 52.5829 | -15.5371 | 1.7874 | 31.0095 | 52.6800 | -15.4340 | 1.7623 | 31.0210 |
| 45 | 43.0 | 53.6172 | -16.2007 | 1.8252 | 31.9865 | 53.7230 | -16.0940 | 1.7981 | 31.9990 |
| 46 | 45.0 | 54.6492 | -16.8407 | 1.8618 | 32.9285 | 54.7450 | -16.7300 | 1.8331 | 32.9410 |
| 47 | 47.5 | 55.5896 | -17.5935 | 1.8976 | 33.9975 | 55.6640 | -17.4810 | 1.8669 | 34.0100 |
| 48 | 50.0 | 56.4079 | -18.2909 | 1.9271 | 34.9574 | 56.5010 | -18.1780 | 1.8957 | 34.9730 |
| 49 | 52.5 | 57.2228 | -18.9437 | 1.9550 | 35.8507 | 57.3050 | -18.8330 | 1.9218 | 35.8680 |
| 50 | 55.0 | 57.9997 | -19.5557 | 1.9810 | 36.6866 | 58.0840 | -19.4470 | 1.9461 | 36.7070 |
| 51 | 57.5 | 58.7710 | -20.1306 | 2.0054 | 37.4753 | 58.8460 | -20.0230 | 1.9692 | 37.4970 |
| 52 | 60.0 | 59.5177 | -20.6718 | 2.0283 | 38.2224 | 59.5950 | -20.5630 | 1.9911 | 38.2450 |
| 53 | 62.5 | 60.2570 | -21.1826 | 2.0500 | 38.9335 | 60.3300 | -21.0700 | 2.0118 | 38.9560 |
| 54 | 65.0 | 60.9771 | -21.6655 | 2.0706 | 39.6127 | 61.0540 | -21.5480 | 2.0312 | 39.6350 |

| | | | | | | | | | |
|-----|-------|---------|----------|---------|---------|---------|----------|---------|---------|
| 55 | 67.5 | 61.6890 | -22.1231 | 2.0902 | 40.2638 | 61.7630 | -22.0020 | 2.0493 | 40.2880 |
| 56 | 70.0 | 62.3844 | -22.5582 | 2.1088 | 40.8893 | 62.4560 | -22.4370 | 2.0661 | 40.9170 |
| 57 | 73.0 | 62.4363 | -23.0108 | 2.1100 | 41.4438 | 62.4180 | -22.8870 | 2.0626 | 41.4550 |
| 58 | 76.0 | 62.2189 | -23.3771 | 2.0989 | 41.7990 | 62.2520 | -23.2590 | 2.0522 | 41.8240 |
| 59 | 79.0 | 62.0652 | -23.6831 | 2.0879 | 42.0643 | 62.0570 | -23.5650 | 2.0399 | 42.0880 |
| 60 | 82.0 | 61.8415 | -23.9347 | 2.0746 | 42.2502 | 61.8530 | -23.8180 | 2.0258 | 42.2770 |
| 61 | 85.0 | 61.6630 | -24.1399 | 2.0606 | 42.3811 | 61.6470 | -24.0230 | 2.0105 | 42.4090 |
| 62 | 88.0 | 61.4458 | -24.3035 | 2.0454 | 42.4637 | 61.4420 | -24.1860 | 1.9946 | 42.4950 |
| 63 | 91.0 | 61.2628 | -24.4308 | 2.0299 | 42.5110 | 61.2400 | -24.3080 | 1.9783 | 42.5430 |
| 64 | 94.0 | 61.0549 | -24.5266 | 2.0137 | 42.5266 | 61.0420 | -24.4000 | 1.9615 | 42.5620 |
| 65 | 97.0 | 60.8740 | -24.5957 | 1.9975 | 42.5195 | 60.8480 | -24.4680 | 1.9441 | 42.5570 |
| 66 | 100.0 | 60.6751 | -24.6424 | 1.9809 | 42.4915 | 60.6620 | -24.5160 | 1.9263 | 42.5310 |
| 67 | 105.0 | 59.6873 | -24.6295 | 1.9346 | 42.2350 | 59.6230 | -24.5060 | 1.8762 | 42.2640 |
| 68 | 110.0 | 58.5222 | -24.5092 | 1.8796 | 41.7783 | 58.5150 | -24.3950 | 1.8220 | 41.8250 |
| 69 | 115.0 | 57.4703 | -24.3199 | 1.8277 | 41.2530 | 57.4270 | -24.2080 | 1.7678 | 41.2990 |
| 70 | 120.0 | 56.3865 | -24.0749 | 1.7745 | 40.6686 | 56.3700 | -23.9610 | 1.7139 | 40.7220 |
| 71 | 125.0 | 55.3869 | -23.7895 | 1.7234 | 40.0593 | 55.3470 | -23.6750 | 1.6608 | 40.1150 |
| 72 | 130.0 | 54.3773 | -23.4755 | 1.6729 | 39.4314 | 54.3600 | -23.3640 | 1.6086 | 39.4930 |
| 73 | 135.0 | 53.4387 | -23.1427 | 1.6245 | 38.8012 | 53.4050 | -23.0370 | 1.5581 | 38.8650 |
| 74 | 140.0 | 52.4981 | -22.7998 | 1.5774 | 38.1709 | 52.4850 | -22.7010 | 1.5097 | 38.2380 |
| 75 | 145.0 | 51.6192 | -22.4524 | 1.5324 | 37.5497 | 51.5930 | -22.3580 | 1.4629 | 37.6170 |
| 76 | 150.0 | 50.7426 | -22.1047 | 1.4889 | 36.9373 | 50.7260 | -22.0150 | 1.4174 | 37.0030 |
| 77 | 155.0 | 49.9207 | -21.7600 | 1.4475 | 36.3396 | 49.8850 | -21.6750 | 1.3735 | 36.4020 |
| 78 | 160.0 | 49.1031 | -21.4200 | 1.4074 | 35.7548 | 49.0710 | -21.3400 | 1.3310 | 35.8150 |
| 79 | 165.0 | 47.6445 | -21.0361 | 1.3504 | 35.0086 | 47.5160 | -20.9540 | 1.2676 | 35.0340 |
| 80 | 170.0 | 46.0226 | -20.5902 | 1.2862 | 34.1088 | 45.9440 | -20.5150 | 1.2031 | 34.1420 |
| 81 | 175.0 | 44.5318 | -20.1116 | 1.2261 | 33.1774 | 44.4090 | -20.0400 | 1.1395 | 33.2010 |
| 82 | 180.0 | 43.0212 | -19.6052 | 1.1656 | 32.2166 | 42.9200 | -19.5390 | 1.0775 | 32.2410 |
| 83 | 185.0 | 41.6118 | -19.0807 | 1.1080 | 31.2553 | 41.4810 | -19.0190 | 1.0180 | 31.2750 |
| 84 | 190.0 | 40.2042 | -18.5451 | 1.0516 | 30.2956 | 40.0900 | -18.4850 | 0.9614 | 30.3150 |
| 85 | 195.0 | 38.8822 | -18.0057 | 0.9979 | 29.3512 | 38.7480 | -17.9480 | 0.9071 | 29.3670 |
| 86 | 200.0 | 37.5694 | -17.4680 | 0.9458 | 28.4213 | 37.4510 | -17.4150 | 0.8548 | 28.4380 |
| 87 | 210.0 | 35.1208 | -16.4137 | 0.8487 | 26.6288 | 34.9910 | -16.3690 | 0.7570 | 26.6480 |
| 88 | 220.0 | 32.8038 | -15.4000 | 0.7595 | 24.9278 | 32.6840 | -15.3590 | 0.6670 | 24.9470 |
| 89 | 230.0 | 30.6684 | -14.4371 | 0.6786 | 23.3274 | 30.5340 | -14.3970 | 0.5853 | 23.3460 |
| 90 | 240.0 | 28.6461 | -13.5284 | 0.6047 | 21.8229 | 28.5270 | -13.4820 | 0.5114 | 21.8410 |
| 91 | 250.0 | 26.7831 | -12.6741 | 0.5379 | 20.4148 | 26.6510 | -12.6250 | 0.4435 | 20.4300 |
| 92 | 260.0 | 25.0177 | -11.8718 | 0.4770 | 19.0949 | 24.8880 | -11.8230 | 0.3801 | 19.1060 |
| 93 | 270.0 | 23.3924 | -11.1199 | 0.4221 | 17.8614 | 23.2400 | -11.0750 | 0.3232 | 17.8670 |
| 94 | 280.0 | 21.8508 | -10.4152 | 0.3721 | 16.7060 | 21.6980 | -10.3730 | 0.2727 | 16.7060 |
| 95 | 290.0 | 20.4327 | -9.7553 | 0.3273 | 15.6270 | 20.2620 | -9.7157 | 0.2279 | 15.6220 |
| 96 | 300.0 | 19.0860 | -9.1373 | 0.2864 | 14.6163 | 18.9210 | -9.0961 | 0.1878 | 14.6050 |
| 97 | 320.0 | 16.6803 | -8.0156 | 0.2165 | 12.7874 | 16.5380 | -7.9859 | 0.1206 | 12.7940 |
| 98 | 340.0 | 14.5599 | -7.0320 | 0.1596 | 11.1869 | 14.4570 | -7.0043 | 0.0668 | 11.2060 |
| 99 | 360.0 | 12.7283 | -6.1698 | 0.1139 | 9.7885 | 12.6020 | -6.1205 | 0.0218 | 9.7860 |
| 100 | 380.0 | 11.1092 | -5.4135 | 0.0771 | 8.5640 | 11.0210 | -5.3563 | -0.0133 | 8.5683 |
| 101 | 400.0 | 9.7145 | -4.7501 | 0.0482 | 7.4942 | 9.6128 | -4.6685 | -0.0425 | 7.4779 |
| 102 | 420.0 | 8.4774 | -4.1683 | 0.0251 | 6.5572 | 8.3934 | -4.0676 | -0.0650 | 6.5331 |
| 103 | 440.0 | 7.4155 | -3.6576 | 0.0076 | 5.7385 | 7.3326 | -3.5388 | -0.0821 | 5.7109 |
| 104 | 460.0 | 6.4698 | -3.2093 | -0.0062 | 5.0210 | 6.3868 | -3.0675 | -0.0957 | 4.9798 |
| 105 | 480.0 | 5.6617 | -2.8159 | -0.0161 | 4.3945 | 5.5677 | -2.6751 | -0.1060 | 4.3544 |
| 106 | 500.0 | 4.9383 | -2.4709 | -0.0236 | 3.8450 | 4.8285 | -2.3323 | -0.1141 | 3.7953 |

表4. 7(4) 評価断面7の応力テンソル成分4

FINAS解と簡易計算値との比較 (コールドショック)

断面7の応力成分4

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|---------|--------|---------|---------|---------|--------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.0127 | 0.0003 | -0.0001 | -0.0016 | -0.0153 | 0.0003 | -0.0001 | -0.0017 |
| 3 | 1.0 | -0.0369 | 0.0009 | -0.0002 | -0.0053 | -0.0383 | 0.0009 | -0.0002 | -0.0053 |
| 4 | 1.5 | -0.0617 | 0.0019 | -0.0002 | -0.0101 | -0.0637 | 0.0018 | -0.0002 | -0.0101 |
| 5 | 2.0 | -0.0882 | 0.0031 | -0.0002 | -0.0160 | -0.0898 | 0.0030 | -0.0002 | -0.0158 |
| 6 | 2.5 | -0.1145 | 0.0045 | 0.0000 | -0.0224 | -0.1163 | 0.0044 | -0.0001 | -0.0222 |
| 7 | 3.0 | -0.1409 | 0.0062 | 0.0002 | -0.0295 | -0.1424 | 0.0059 | 0.0002 | -0.0290 |
| 8 | 3.5 | -0.1669 | 0.0079 | 0.0006 | -0.0370 | -0.1677 | 0.0076 | 0.0005 | -0.0362 |
| 9 | 4.0 | -0.1926 | 0.0099 | 0.0010 | -0.0449 | -0.1926 | 0.0095 | 0.0009 | -0.0439 |
| 10 | 4.5 | -0.2180 | 0.0120 | 0.0015 | -0.0533 | -0.2171 | 0.0115 | 0.0014 | -0.0519 |
| 11 | 5.0 | -0.2429 | 0.0143 | 0.0020 | -0.0619 | -0.2414 | 0.0136 | 0.0020 | -0.0602 |
| 12 | 6.0 | -0.2746 | 0.0188 | 0.0035 | -0.0774 | -0.2691 | 0.0175 | 0.0035 | -0.0744 |
| 13 | 7.0 | -0.2936 | 0.0230 | 0.0051 | -0.0907 | -0.2870 | 0.0212 | 0.0051 | -0.0866 |
| 14 | 8.0 | -0.3127 | 0.0271 | 0.0068 | -0.1033 | -0.3024 | 0.0247 | 0.0069 | -0.0978 |
| 15 | 9.0 | -0.3295 | 0.0312 | 0.0085 | -0.1155 | -0.3176 | 0.0284 | 0.0086 | -0.1089 |
| 16 | 10.0 | -0.3462 | 0.0354 | 0.0103 | -0.1274 | -0.3322 | 0.0320 | 0.0103 | -0.1196 |
| 17 | 11.0 | -0.3621 | 0.0396 | 0.0120 | -0.1392 | -0.3468 | 0.0358 | 0.0120 | -0.1305 |
| 18 | 12.0 | -0.3777 | 0.0438 | 0.0138 | -0.1508 | -0.3615 | 0.0396 | 0.0137 | -0.1415 |
| 19 | 13.0 | -0.3928 | 0.0480 | 0.0155 | -0.1623 | -0.3757 | 0.0434 | 0.0154 | -0.1522 |
| 20 | 14.0 | -0.4076 | 0.0523 | 0.0173 | -0.1737 | -0.3894 | 0.0473 | 0.0172 | -0.1629 |
| 21 | 15.0 | -0.4220 | 0.0565 | 0.0191 | -0.1850 | -0.4024 | 0.0512 | 0.0189 | -0.1734 |
| 22 | 16.0 | -0.4313 | 0.0607 | 0.0209 | -0.1956 | -0.4088 | 0.0550 | 0.0208 | -0.1829 |
| 23 | 17.0 | -0.4368 | 0.0646 | 0.0227 | -0.2051 | -0.4131 | 0.0586 | 0.0226 | -0.1916 |
| 24 | 18.0 | -0.4427 | 0.0684 | 0.0245 | -0.2142 | -0.4171 | 0.0621 | 0.0244 | -0.1999 |
| 25 | 19.0 | -0.4480 | 0.0721 | 0.0262 | -0.2229 | -0.4214 | 0.0655 | 0.0261 | -0.2081 |
| 26 | 20.0 | -0.4536 | 0.0758 | 0.0279 | -0.2314 | -0.4257 | 0.0688 | 0.0278 | -0.2160 |
| 27 | 21.0 | -0.4591 | 0.0794 | 0.0296 | -0.2396 | -0.4304 | 0.0720 | 0.0294 | -0.2239 |
| 28 | 22.0 | -0.4648 | 0.0829 | 0.0312 | -0.2477 | -0.4353 | 0.0752 | 0.0310 | -0.2317 |
| 29 | 23.0 | -0.4704 | 0.0863 | 0.0327 | -0.2556 | -0.4402 | 0.0785 | 0.0325 | -0.2393 |
| 30 | 24.0 | -0.4761 | 0.0896 | 0.0343 | -0.2634 | -0.4451 | 0.0817 | 0.0341 | -0.2468 |
| 31 | 25.0 | -0.4818 | 0.0930 | 0.0358 | -0.2711 | -0.4500 | 0.0849 | 0.0356 | -0.2542 |
| 32 | 26.0 | -0.4859 | 0.0962 | 0.0373 | -0.2784 | -0.4525 | 0.0880 | 0.0371 | -0.2610 |
| 33 | 27.0 | -0.4890 | 0.0993 | 0.0388 | -0.2853 | -0.4543 | 0.0911 | 0.0387 | -0.2675 |
| 34 | 28.0 | -0.4922 | 0.1023 | 0.0402 | -0.2920 | -0.4560 | 0.0940 | 0.0401 | -0.2737 |
| 35 | 29.0 | -0.4954 | 0.1052 | 0.0416 | -0.2985 | -0.4578 | 0.0968 | 0.0416 | -0.2798 |
| 36 | 30.0 | -0.4986 | 0.1080 | 0.0430 | -0.3048 | -0.4597 | 0.0998 | 0.0430 | -0.2858 |
| 37 | 31.0 | -0.5019 | 0.1107 | 0.0443 | -0.3110 | -0.4619 | 0.1028 | 0.0443 | -0.2917 |
| 38 | 32.0 | -0.5054 | 0.1134 | 0.0456 | -0.3172 | -0.4641 | 0.1057 | 0.0457 | -0.2975 |
| 39 | 33.0 | -0.5089 | 0.1160 | 0.0469 | -0.3231 | -0.4664 | 0.1086 | 0.0470 | -0.3032 |
| 40 | 34.0 | -0.5125 | 0.1186 | 0.0481 | -0.3290 | -0.4687 | 0.1112 | 0.0483 | -0.3086 |
| 41 | 35.0 | -0.5161 | 0.1211 | 0.0493 | -0.3348 | -0.4709 | 0.1135 | 0.0495 | -0.3139 |
| 42 | 37.0 | -0.5195 | 0.1258 | 0.0517 | -0.3455 | -0.4723 | 0.1174 | 0.0520 | -0.3232 |
| 43 | 39.0 | -0.5214 | 0.1301 | 0.0540 | -0.3551 | -0.4717 | 0.1207 | 0.0543 | -0.3313 |
| 44 | 41.0 | -0.5244 | 0.1342 | 0.0561 | -0.3642 | -0.4719 | 0.1230 | 0.0564 | -0.3386 |
| 45 | 43.0 | -0.5274 | 0.1381 | 0.0581 | -0.3729 | -0.4726 | 0.1253 | 0.0583 | -0.3458 |
| 46 | 45.0 | -0.5310 | 0.1417 | 0.0600 | -0.3813 | -0.4737 | 0.1279 | 0.0602 | -0.3530 |
| 47 | 47.5 | -0.5307 | 0.1458 | 0.0622 | -0.3904 | -0.4685 | 0.1307 | 0.0625 | -0.3601 |
| 48 | 50.0 | -0.5289 | 0.1495 | 0.0643 | -0.3981 | -0.4644 | 0.1329 | 0.0646 | -0.3661 |
| 49 | 52.5 | -0.5289 | 0.1527 | 0.0661 | -0.4052 | -0.4609 | 0.1346 | 0.0665 | -0.3714 |
| 50 | 55.0 | -0.5292 | 0.1556 | 0.0679 | -0.4119 | -0.4580 | 0.1358 | 0.0682 | -0.3762 |
| 51 | 57.5 | -0.5304 | 0.1585 | 0.0694 | -0.4182 | -0.4557 | 0.1371 | 0.0698 | -0.3809 |
| 52 | 60.0 | -0.5319 | 0.1610 | 0.0709 | -0.4242 | -0.4537 | 0.1384 | 0.0713 | -0.3853 |
| 53 | 62.5 | -0.5339 | 0.1634 | 0.0723 | -0.4299 | -0.4523 | 0.1396 | 0.0728 | -0.3895 |
| 54 | 65.0 | -0.5362 | 0.1657 | 0.0736 | -0.4355 | -0.4519 | 0.1408 | 0.0741 | -0.3939 |

| | | | | | | | | | |
|-----|-------|---------|--------|--------|---------|---------|---------|--------|---------|
| 55 | 67.5 | -0.5388 | 0.1678 | 0.0749 | -0.4409 | -0.4520 | 0.1417 | 0.0753 | -0.3982 |
| 56 | 70.0 | -0.5415 | 0.1700 | 0.0761 | -0.4461 | -0.4522 | 0.1422 | 0.0765 | -0.4020 |
| 57 | 73.0 | -0.5321 | 0.1718 | 0.0774 | -0.4495 | -0.4378 | 0.1419 | 0.0777 | -0.4034 |
| 58 | 76.0 | -0.5191 | 0.1729 | 0.0784 | -0.4502 | -0.4240 | 0.1415 | 0.0787 | -0.4031 |
| 59 | 79.0 | -0.5102 | 0.1735 | 0.0791 | -0.4502 | -0.4120 | 0.1407 | 0.0794 | -0.4019 |
| 60 | 82.0 | -0.5015 | 0.1738 | 0.0796 | -0.4495 | -0.4008 | 0.1395 | 0.0799 | -0.3998 |
| 61 | 85.0 | -0.4949 | 0.1738 | 0.0799 | -0.4485 | -0.3907 | 0.1380 | 0.0802 | -0.3973 |
| 62 | 88.0 | -0.4887 | 0.1737 | 0.0801 | -0.4473 | -0.3818 | 0.1367 | 0.0804 | -0.3949 |
| 63 | 91.0 | -0.4838 | 0.1734 | 0.0802 | -0.4459 | -0.3740 | 0.1361 | 0.0806 | -0.3930 |
| 64 | 94.0 | -0.4792 | 0.1730 | 0.0803 | -0.4445 | -0.3665 | 0.1353 | 0.0806 | -0.3907 |
| 65 | 97.0 | -0.4753 | 0.1726 | 0.0803 | -0.4430 | -0.3593 | 0.1341 | 0.0807 | -0.3880 |
| 66 | 100.0 | -0.4716 | 0.1721 | 0.0802 | -0.4414 | -0.3524 | 0.1328 | 0.0807 | -0.3850 |
| 67 | 105.0 | -0.4552 | 0.1707 | 0.0799 | -0.4360 | -0.3305 | 0.1298 | 0.0804 | -0.3772 |
| 68 | 110.0 | -0.4381 | 0.1685 | 0.0792 | -0.4283 | -0.3129 | 0.1262 | 0.0796 | -0.3685 |
| 69 | 115.0 | -0.4257 | 0.1659 | 0.0783 | -0.4205 | -0.2972 | 0.1224 | 0.0787 | -0.3591 |
| 70 | 120.0 | -0.4138 | 0.1633 | 0.0772 | -0.4125 | -0.2823 | 0.1182 | 0.0776 | -0.3493 |
| 71 | 125.0 | -0.4041 | 0.1606 | 0.0760 | -0.4047 | -0.2688 | 0.1141 | 0.0765 | -0.3397 |
| 72 | 130.0 | -0.3946 | 0.1579 | 0.0748 | -0.3969 | -0.2574 | 0.1101 | 0.0753 | -0.3306 |
| 73 | 135.0 | -0.3866 | 0.1553 | 0.0736 | -0.3895 | -0.2471 | 0.1060 | 0.0741 | -0.3217 |
| 74 | 140.0 | -0.3786 | 0.1528 | 0.0723 | -0.3822 | -0.2375 | 0.1022 | 0.0728 | -0.3131 |
| 75 | 145.0 | -0.3716 | 0.1504 | 0.0711 | -0.3752 | -0.2280 | 0.0983 | 0.0717 | -0.3045 |
| 76 | 150.0 | -0.3647 | 0.1481 | 0.0699 | -0.3684 | -0.2180 | 0.0942 | 0.0706 | -0.2957 |
| 77 | 155.0 | -0.3586 | 0.1460 | 0.0688 | -0.3619 | -0.2079 | 0.0899 | 0.0697 | -0.2868 |
| 78 | 160.0 | -0.3524 | 0.1438 | 0.0676 | -0.3556 | -0.1979 | 0.0851 | 0.0687 | -0.2777 |
| 79 | 165.0 | -0.3355 | 0.1411 | 0.0664 | -0.3468 | -0.1749 | 0.0795 | 0.0676 | -0.2654 |
| 80 | 170.0 | -0.3174 | 0.1378 | 0.0649 | -0.3359 | -0.1552 | 0.0736 | 0.0661 | -0.2523 |
| 81 | 175.0 | -0.3036 | 0.1341 | 0.0632 | -0.3250 | -0.1372 | 0.0677 | 0.0645 | -0.2392 |
| 82 | 180.0 | -0.2898 | 0.1303 | 0.0614 | -0.3141 | -0.1208 | 0.0621 | 0.0627 | -0.2264 |
| 83 | 185.0 | -0.2784 | 0.1265 | 0.0596 | -0.3035 | -0.1066 | 0.0569 | 0.0610 | -0.2146 |
| 84 | 190.0 | -0.2670 | 0.1228 | 0.0578 | -0.2931 | -0.0953 | 0.0522 | 0.0594 | -0.2039 |
| 85 | 195.0 | -0.2571 | 0.1191 | 0.0559 | -0.2831 | -0.0850 | 0.0475 | 0.0577 | -0.1934 |
| 86 | 200.0 | -0.2472 | 0.1155 | 0.0541 | -0.2734 | -0.0748 | 0.0426 | 0.0559 | -0.1829 |
| 87 | 210.0 | -0.2295 | 0.1087 | 0.0507 | -0.2549 | -0.0554 | 0.0330 | 0.0525 | -0.1627 |
| 88 | 220.0 | -0.2132 | 0.1023 | 0.0474 | -0.2376 | -0.0376 | 0.0238 | 0.0492 | -0.1436 |
| 89 | 230.0 | -0.1987 | 0.0964 | 0.0443 | -0.2216 | -0.0219 | 0.0155 | 0.0461 | -0.1262 |
| 90 | 240.0 | -0.1849 | 0.0908 | 0.0414 | -0.2067 | -0.0078 | 0.0081 | 0.0434 | -0.1105 |
| 91 | 250.0 | -0.1725 | 0.0856 | 0.0387 | -0.1929 | 0.0055 | 0.0011 | 0.0408 | -0.0956 |
| 92 | 260.0 | -0.1607 | 0.0807 | 0.0362 | -0.1800 | 0.0192 | -0.0060 | 0.0382 | -0.0808 |
| 93 | 270.0 | -0.1500 | 0.0761 | 0.0338 | -0.1679 | 0.0315 | -0.0122 | 0.0358 | -0.0676 |
| 94 | 280.0 | -0.1399 | 0.0718 | 0.0315 | -0.1568 | 0.0418 | -0.0170 | 0.0335 | -0.0561 |
| 95 | 290.0 | -0.1308 | 0.0678 | 0.0294 | -0.1465 | 0.0491 | -0.0204 | 0.0313 | -0.0466 |
| 96 | 300.0 | -0.1221 | 0.0640 | 0.0275 | -0.1369 | 0.0533 | -0.0224 | 0.0292 | -0.0390 |
| 97 | 320.0 | -0.1067 | 0.0571 | 0.0239 | -0.1195 | 0.0625 | -0.0267 | 0.0256 | -0.0244 |
| 98 | 340.0 | -0.0932 | 0.0509 | 0.0208 | -0.1045 | 0.0726 | -0.0316 | 0.0224 | -0.0103 |
| 99 | 360.0 | -0.0817 | 0.0454 | 0.0180 | -0.0914 | 0.0837 | -0.0370 | 0.0196 | 0.0034 |
| 100 | 380.0 | -0.0715 | 0.0404 | 0.0156 | -0.0800 | 0.0945 | -0.0417 | 0.0173 | 0.0148 |
| 101 | 400.0 | -0.0628 | 0.0359 | 0.0135 | -0.0700 | 0.1050 | -0.0460 | 0.0154 | 0.0247 |
| 102 | 420.0 | -0.0552 | 0.0320 | 0.0117 | -0.0613 | 0.1148 | -0.0497 | 0.0137 | 0.0335 |
| 103 | 440.0 | -0.0486 | 0.0284 | 0.0101 | -0.0538 | 0.1234 | -0.0529 | 0.0124 | 0.0416 |
| 104 | 460.0 | -0.0428 | 0.0252 | 0.0087 | -0.0471 | 0.1320 | -0.0563 | 0.0113 | 0.0496 |
| 105 | 480.0 | -0.0378 | 0.0223 | 0.0075 | -0.0414 | 0.1408 | -0.0601 | 0.0105 | 0.0574 |
| 106 | 500.0 | -0.0333 | 0.0198 | 0.0064 | -0.0363 | 0.1493 | -0.0639 | 0.0098 | 0.0650 |

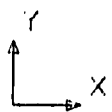
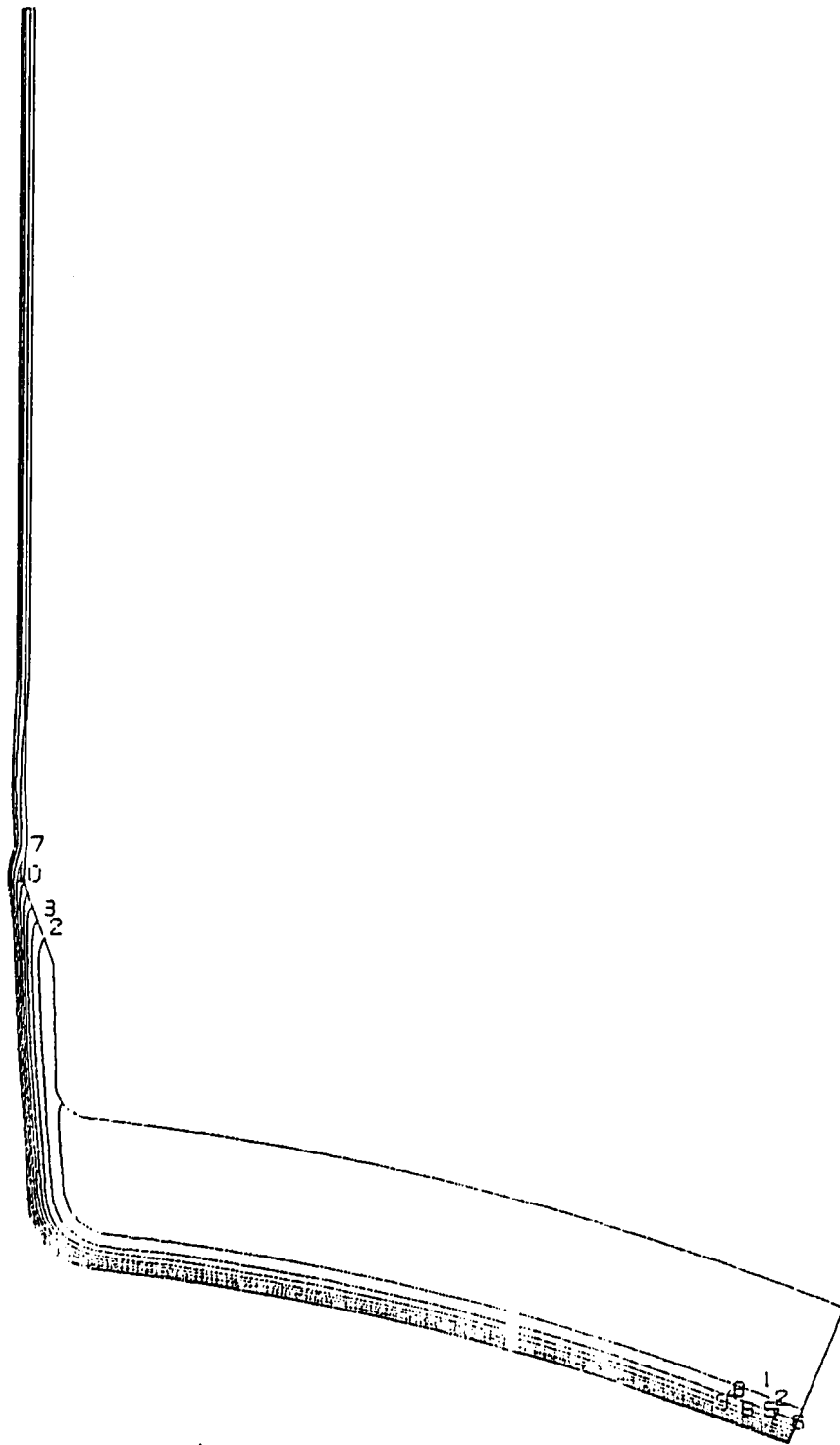
表5 温度曲げ成分が最大となる時点のF I N A S解と簡易計算値の比較 (コールドショック)

| 評価 断面 | 時点 t (sec) | 項目 | F I N A S 解 | | | | 簡易計算値 | | | |
|----------|---------------|-------------------|-------------|--------|--------|--------|--------|--------|--------|--------|
| | | | 内面值 | 外面値 | 平均値 | 曲げ | 内面值 | 外面値 | 平均値 | 曲げ |
| 1 | 5.0 | 温度 T | 562.08 | 572.58 | 568.90 | -5.32 | 562.00 | 572.56 | 568.88 | -5.43 |
| | | 応力 S ₁ | 0.014 | 0.015 | 0.025 | 0.003 | -0.003 | -0.007 | 0.024 | 0.002 |
| | | S ₂ | 3.249 | -1.576 | 0.113 | 2.445 | 3.271 | -1.587 | 0.114 | 2.496 |
| | | S ₃ | 3.249 | -1.577 | 0.097 | 2.442 | 3.271 | -1.586 | 0.098 | 2.493 |
| | | S ₄ | -0.000 | 0.000 | 0.000 | 0.000 | -0.000 | -0.000 | 0.000 | 0.000 |
| 2 | 5.0 | 温度 T | 563.28 | 573.86 | 570.35 | -5.29 | 563.16 | 573.98 | 570.33 | -5.41 |
| | | 応力 S ₁ | 0.018 | 0.023 | 0.252 | 0.175 | 0.006 | 0.006 | 0.258 | 0.177 |
| | | S ₂ | 6.853 | -4.208 | 0.122 | 5.395 | 6.945 | -4.301 | 0.122 | 5.477 |
| | | S ₃ | 3.726 | -2.994 | -0.525 | 3.374 | 3.777 | -3.075 | -0.529 | 3.436 |
| | | S ₄ | -0.050 | 0.031 | 0.149 | -0.002 | -0.055 | 0.030 | 0.152 | 0.002 |
| 3 | 5.0 | 温度 T | 562.92 | 577.35 | 572.66 | -7.05 | 562.70 | 577.41 | 572.66 | -7.19 |
| | | 応力 S ₁ | 0.016 | 0.062 | -0.217 | 0.031 | 0.033 | 0.039 | -0.221 | 0.038 |
| | | S ₂ | 5.721 | -4.481 | -0.038 | 4.928 | 5.823 | -4.507 | -0.039 | 4.989 |
| | | S ₃ | 4.569 | -3.115 | -0.393 | 3.747 | 4.667 | -3.158 | -0.404 | 3.811 |
| | | S ₄ | -0.031 | 0.107 | 0.169 | -0.134 | -0.032 | 0.106 | 0.171 | -0.141 |
| 4 | 16.0 | 温度 T | 513.89 | 558.62 | 543.65 | -22.33 | 513.57 | 558.41 | 543.68 | -22.33 |
| | | 応力 S ₁ | 0.28 | 0.24 | -0.38 | 0.21 | 0.39 | 0.25 | -0.37 | 0.23 |
| | | S ₂ | 27.78 | -20.33 | 0.37 | 24.51 | 27.94 | -20.34 | 0.38 | 24.54 |
| | | S ₃ | 14.90 | -13.81 | -3.39 | 14.48 | 15.11 | -13.72 | -3.37 | 14.50 |
| | | S ₄ | -2.38 | -0.34 | 1.74 | -1.78 | -2.40 | -0.35 | 1.74 | -1.81 |
| 5 | 37.0 | 温度 T | 450.82 | 515.66 | 492.86 | -33.01 | 450.75 | 515.39 | 492.82 | -33.13 |
| | | 応力 S ₁ | 14.88 | -0.66 | 2.04 | 9.84 | 14.75 | -0.63 | 2.02 | 9.84 |
| | | S ₂ | 18.36 | -44.01 | -1.06 | 26.93 | 18.03 | -44.17 | -1.10 | 26.96 |
| | | S ₃ | 26.12 | -30.78 | -4.17 | 27.80 | 26.05 | -30.70 | -4.13 | 27.85 |
| | | S ₄ | 16.07 | -2.87 | 1.98 | 11.79 | 16.07 | -2.87 | 1.98 | 11.80 |
| 6 | 73.0 | 温度 T | 373.27 | 516.66 | 475.42 | -69.51 | 373.26 | 516.76 | 475.63 | -69.71 |
| | | 応力 S ₁ | 0.54 | -0.03 | -2.44 | 1.20 | 0.47 | 0.04 | -2.42 | 1.23 |
| | | S ₂ | 31.09 | 1.22 | 1.02 | 14.36 | 30.91 | 1.42 | 1.04 | 14.35 |
| | | S ₃ | 68.60 | -37.79 | 1.06 | 52.24 | 68.59 | -37.67 | 1.07 | 52.30 |
| | | S ₄ | 3.02 | 0.11 | -0.07 | 5.77 | 3.06 | 0.14 | -0.07 | 5.75 |
| 7 | 97.0 | 温度 T | 352.60 | 548.20 | 484.62 | -97.44 | 352.90 | 548.19 | 484.89 | -97.62 |
| | | 応力 S ₁ | 0.41 | 0.20 | 0.92 | 0.26 | 0.50 | 0.20 | 0.88 | 0.23 |
| | | S ₂ | 54.05 | -21.04 | 0.24 | 37.00 | 53.97 | -20.85 | 0.18 | 36.98 |
| | | S ₃ | 60.87 | -24.60 | 2.00 | 42.52 | 60.85 | -24.47 | 1.94 | 42.56 |
| | | S ₄ | -0.48 | 0.17 | 0.08 | -0.44 | -0.36 | 0.13 | 0.08 | -0.39 |

FINAS
TEMPERATURE

CONTOUR VALUES

| | |
|----|-----------|
| 1 | 301.18994 |
| 2 | 305.18992 |
| 3 | 309.49990 |
| 4 | 313.29987 |
| 5 | 317.10986 |
| 6 | 320.18984 |
| 7 | 324.18982 |
| 8 | 328.49980 |
| 9 | 332.29978 |
| 10 | 336.09976 |



STEP NO. 10

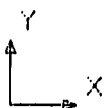
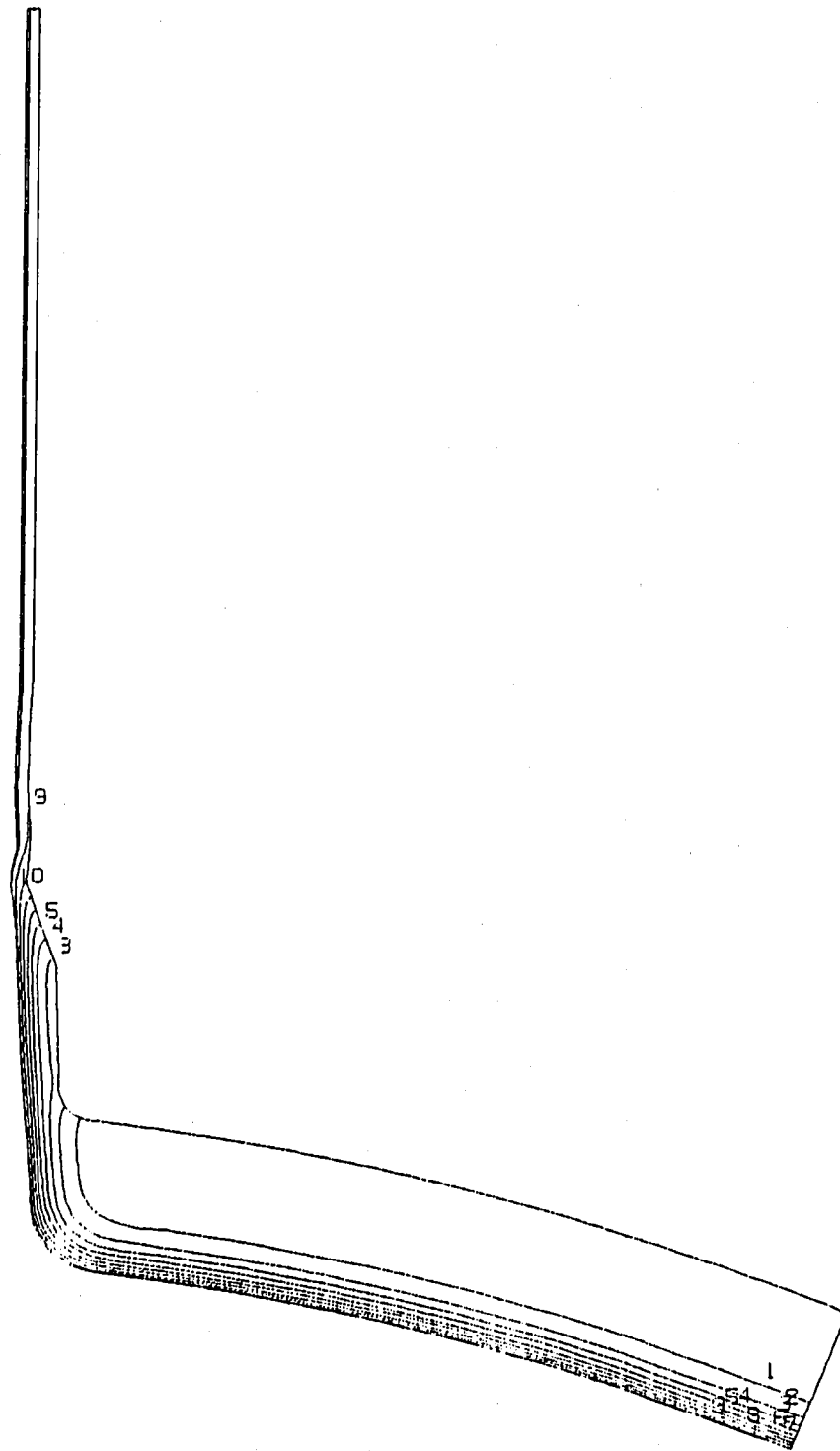
GEOM. SCALE 0 10 20 30 40 50.0000

図14.1 温度コンター t = 5 sec

FINAS
TEMPERATURE

CONTOUR VALUES

| | |
|----|----------|
| 1 | 304.3993 |
| 2 | 313.0993 |
| 3 | 321.7992 |
| 4 | 330.4992 |
| 5 | 339.1992 |
| 6 | 347.8991 |
| 7 | 356.5991 |
| 8 | 365.2991 |
| 9 | 373.9990 |
| 10 | 382.6990 |



STEP NO. 20

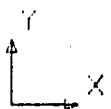
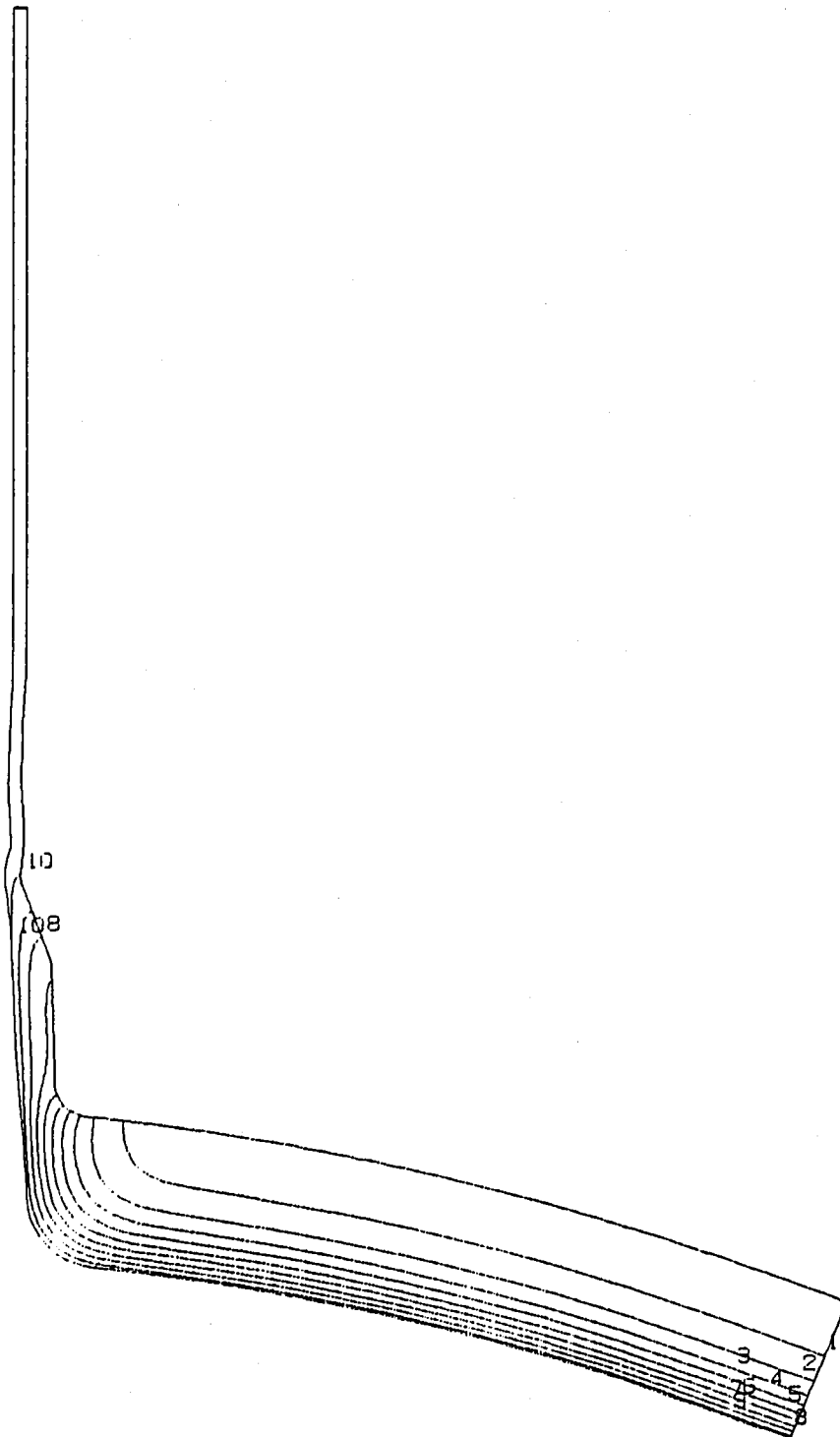
GEOM. SCALE 50.0000

図14.2 温度コンター t=10 sec

FINAS
TEMPERATURE

CONTOUR VALUES

| | |
|----|----------|
| 1 | 310.9999 |
| 2 | 330.0000 |
| 3 | 348.9999 |
| 4 | 368.0000 |
| 5 | 386.9999 |
| 6 | 406.0000 |
| 7 | 425.0000 |
| 8 | 444.0000 |
| 9 | 463.0000 |
| 10 | 482.0000 |



STEP NO. 40

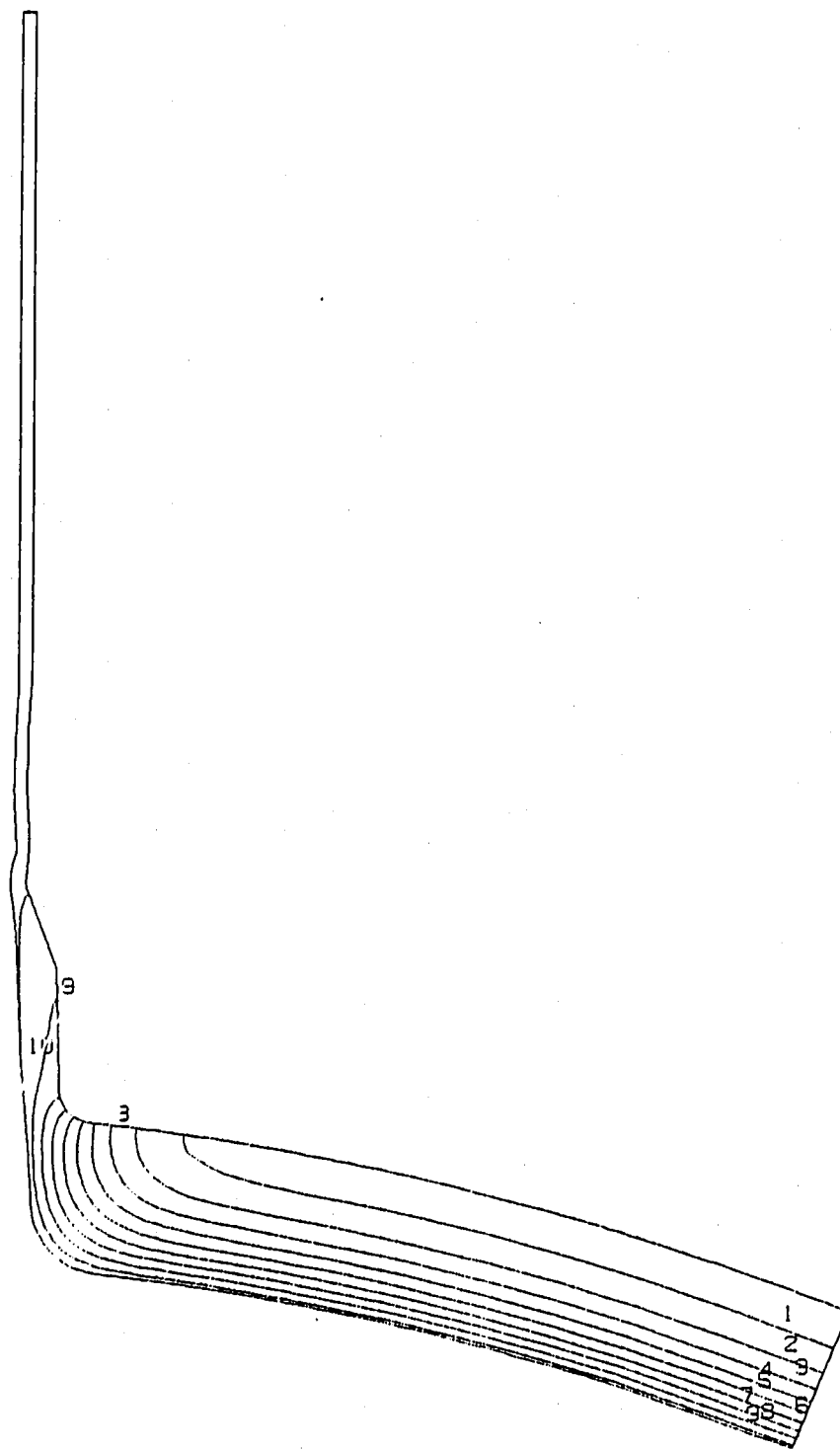
GEOM. SCALE 50.0000

図14.3 温度コンター t=30 sec

FINAS
TEMPERATURE

CONTOUR VALUES

| | |
|----|----------|
| 1 | 344.9999 |
| 2 | 372.0000 |
| 3 | 398.9999 |
| 4 | 426.0000 |
| 5 | 453.0000 |
| 6 | 480.0000 |
| 7 | 507.0000 |
| 8 | 534.0000 |
| 9 | 561.0000 |
| 10 | 588.0000 |



STEP NO. 60

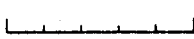
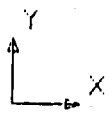
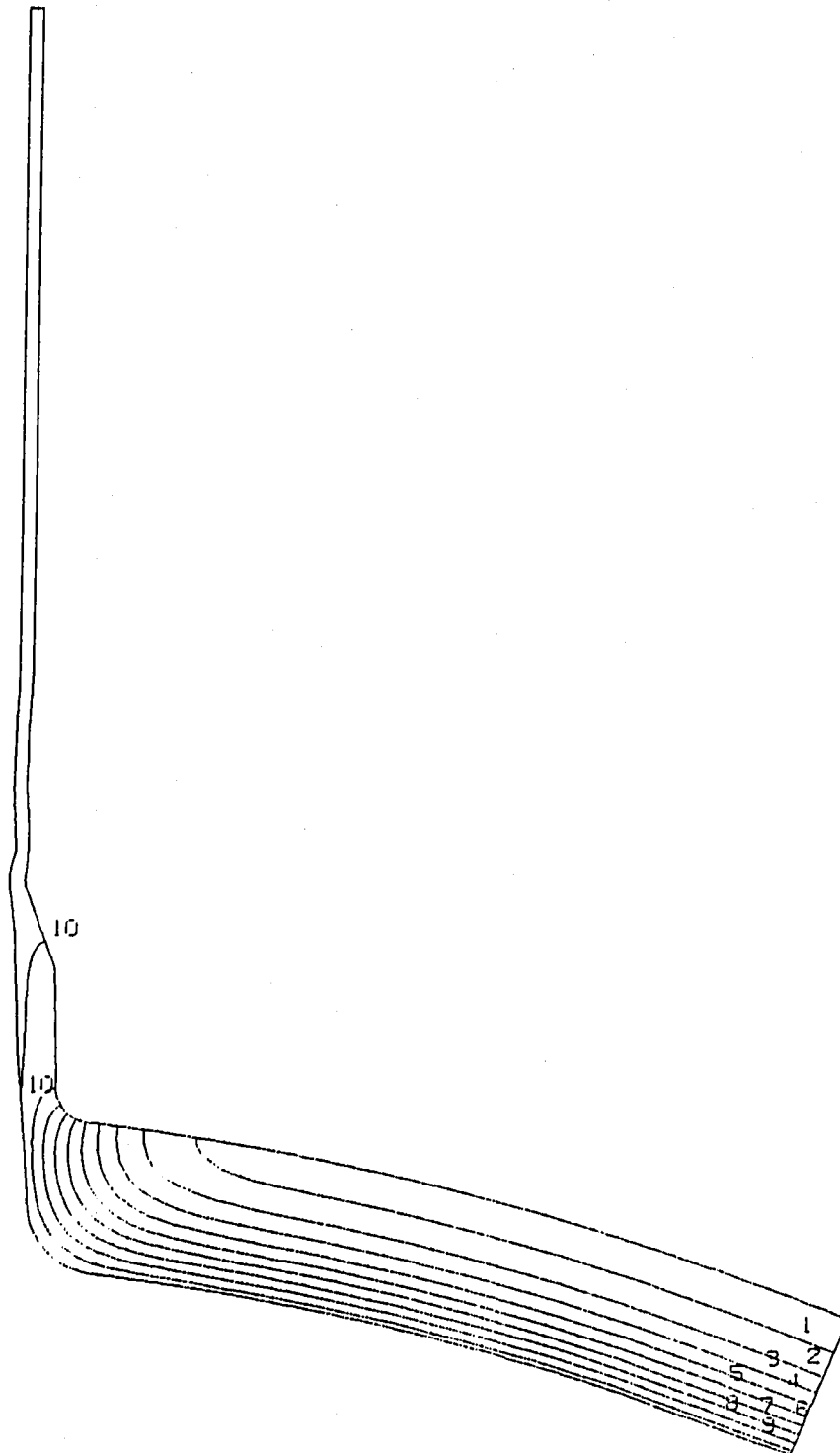
GEOM. SCALE  50.0000

図14.4 温度コンター t=70 sec

FIHHS
TEMPERATURE

CONTOUR VALUES

| | |
|----|----------|
| 1 | 358.0000 |
| 2 | 381.9999 |
| 3 | 407.9999 |
| 4 | 434.0000 |
| 5 | 460.0000 |
| 6 | 486.0000 |
| 7 | 512.0000 |
| 8 | 538.0000 |
| 9 | 564.0000 |
| 10 | 590.0000 |



STEP NO. 165

GEOM. SCALE 50.0000

図14.5 温度コンター t=80 sec

FINAS
TEMPERATURE

CONTOUR VALUES

- 1 380.0000
- 2 401.0000
- 3 422.0000
- 4 443.0000
- 5 464.0000
- 6 485.0000
- 7 506.0000
- 8 527.0000
- 9 548.0000
- 10 569.0000

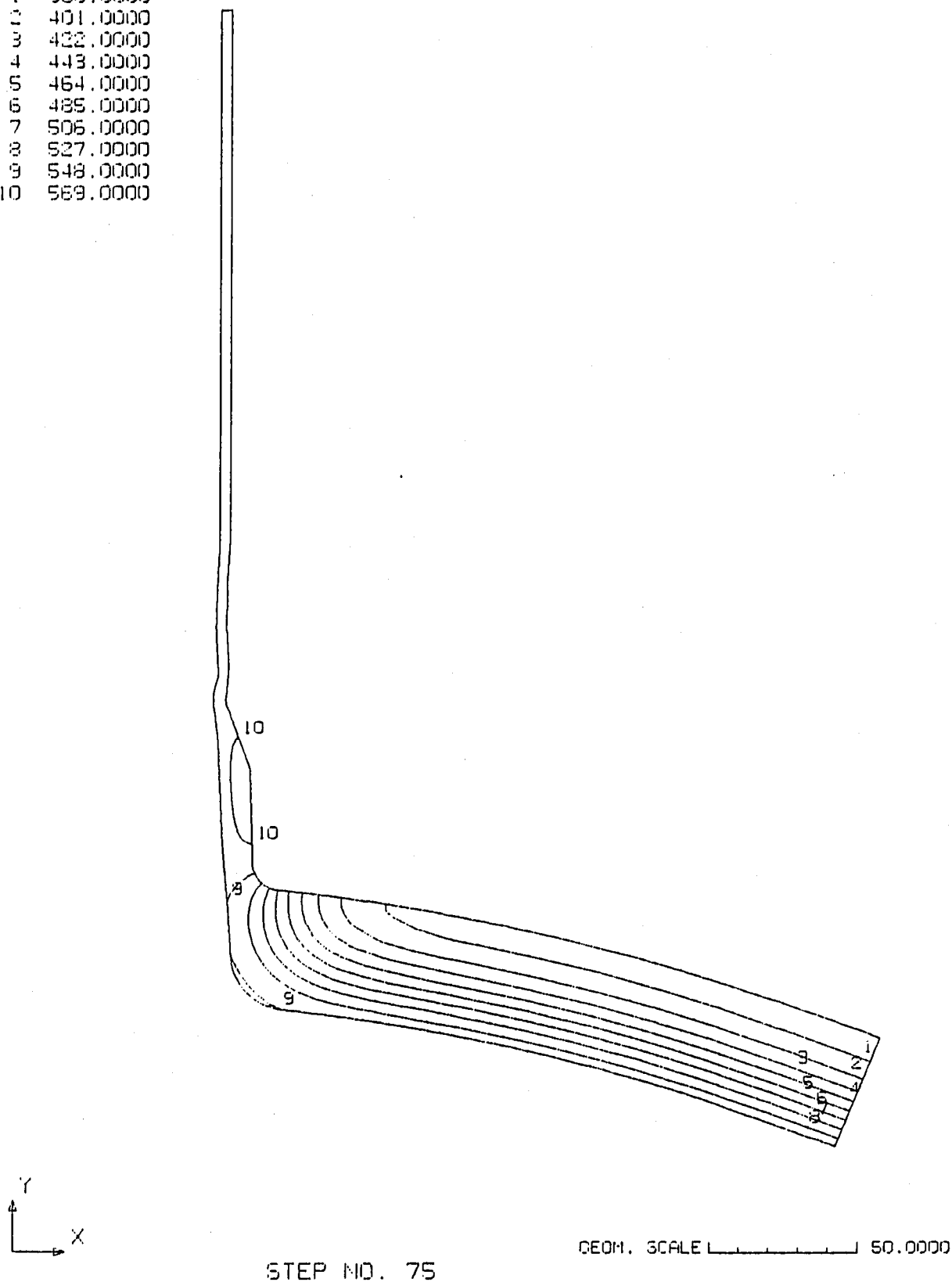


図14.6 温度コンター t = 100 sec

FIHAS
TEMPERATURE

CONTOUR VALUES

| | |
|----|----------|
| 1 | 442.0000 |
| 2 | 459.0000 |
| 3 | 476.0000 |
| 4 | 493.0000 |
| 5 | 510.0000 |
| 6 | 527.0000 |
| 7 | 544.0000 |
| 8 | 561.0000 |
| 9 | 578.0000 |
| 10 | 595.0000 |

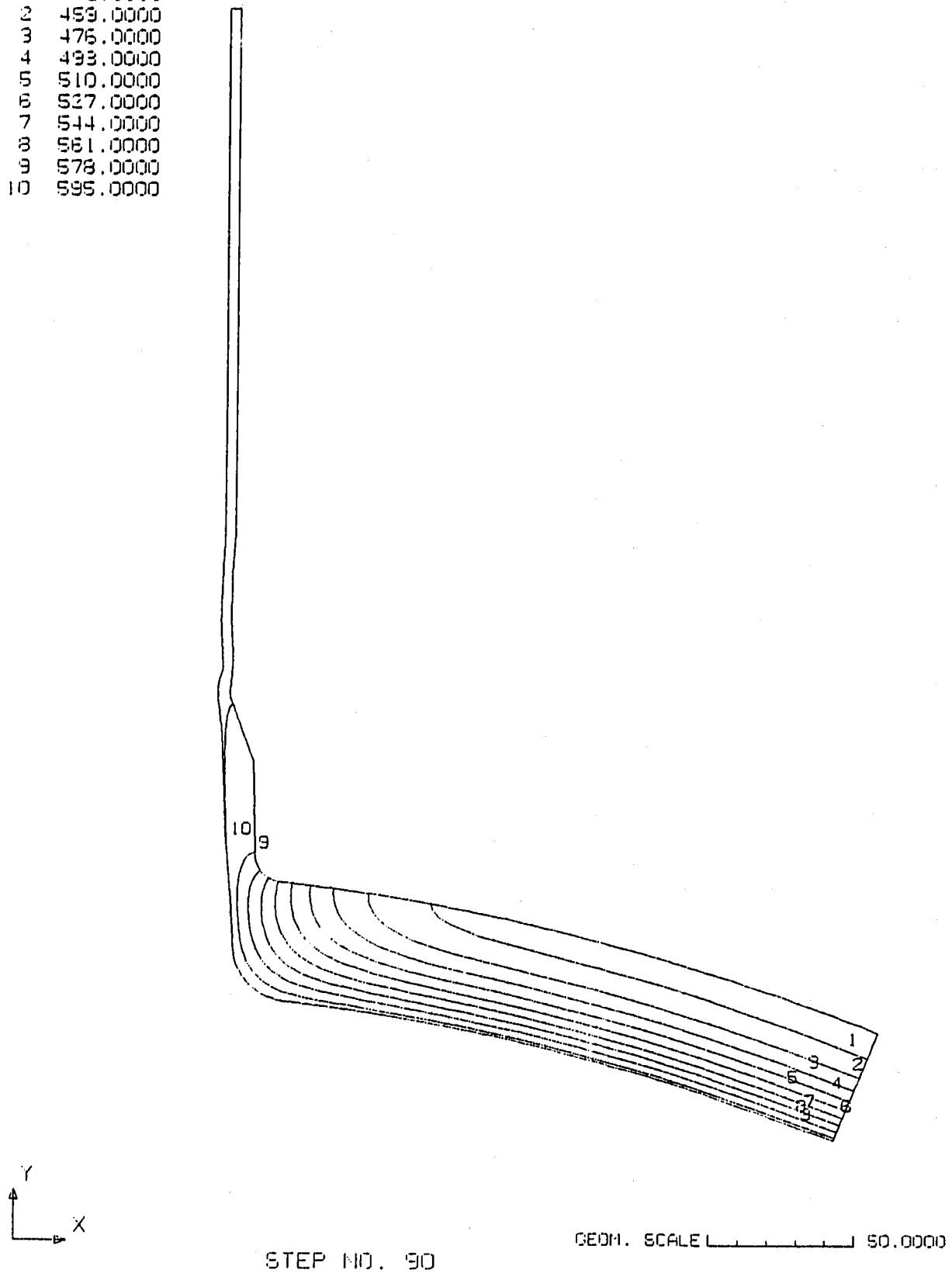
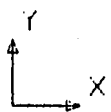
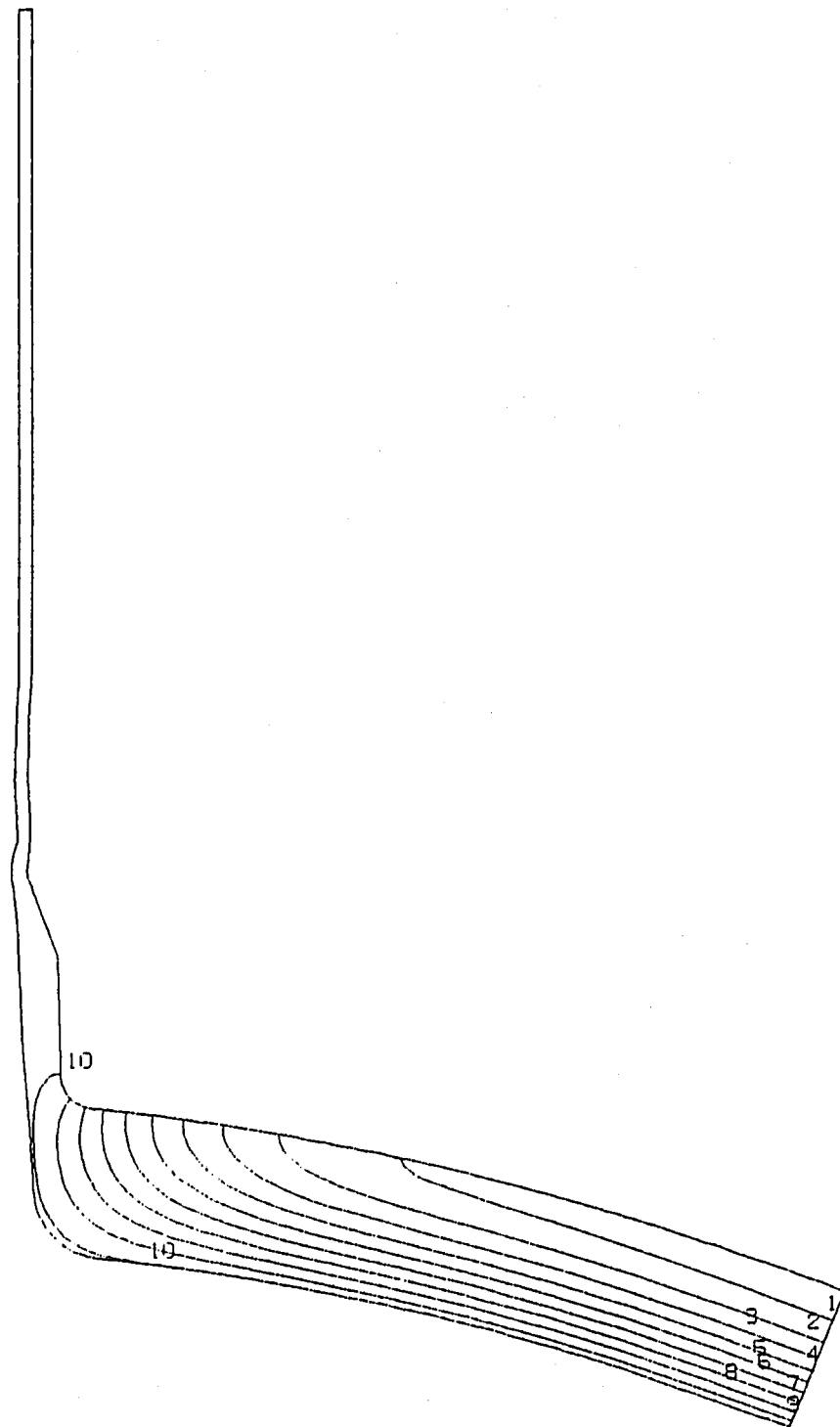


図14.7 温度コンター t = 160 sec

FIHAS
TEMPERATURE

CONTOUR VALUES

| | |
|----|----------|
| 1 | 534.8994 |
| 2 | 541.7993 |
| 3 | 548.6992 |
| 4 | 555.5991 |
| 5 | 562.4990 |
| 6 | 569.3989 |
| 7 | 576.2988 |
| 8 | 583.1987 |
| 9 | 590.0986 |
| 10 | 596.9985 |



GEOM. SCALE  50.0000

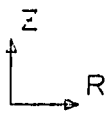
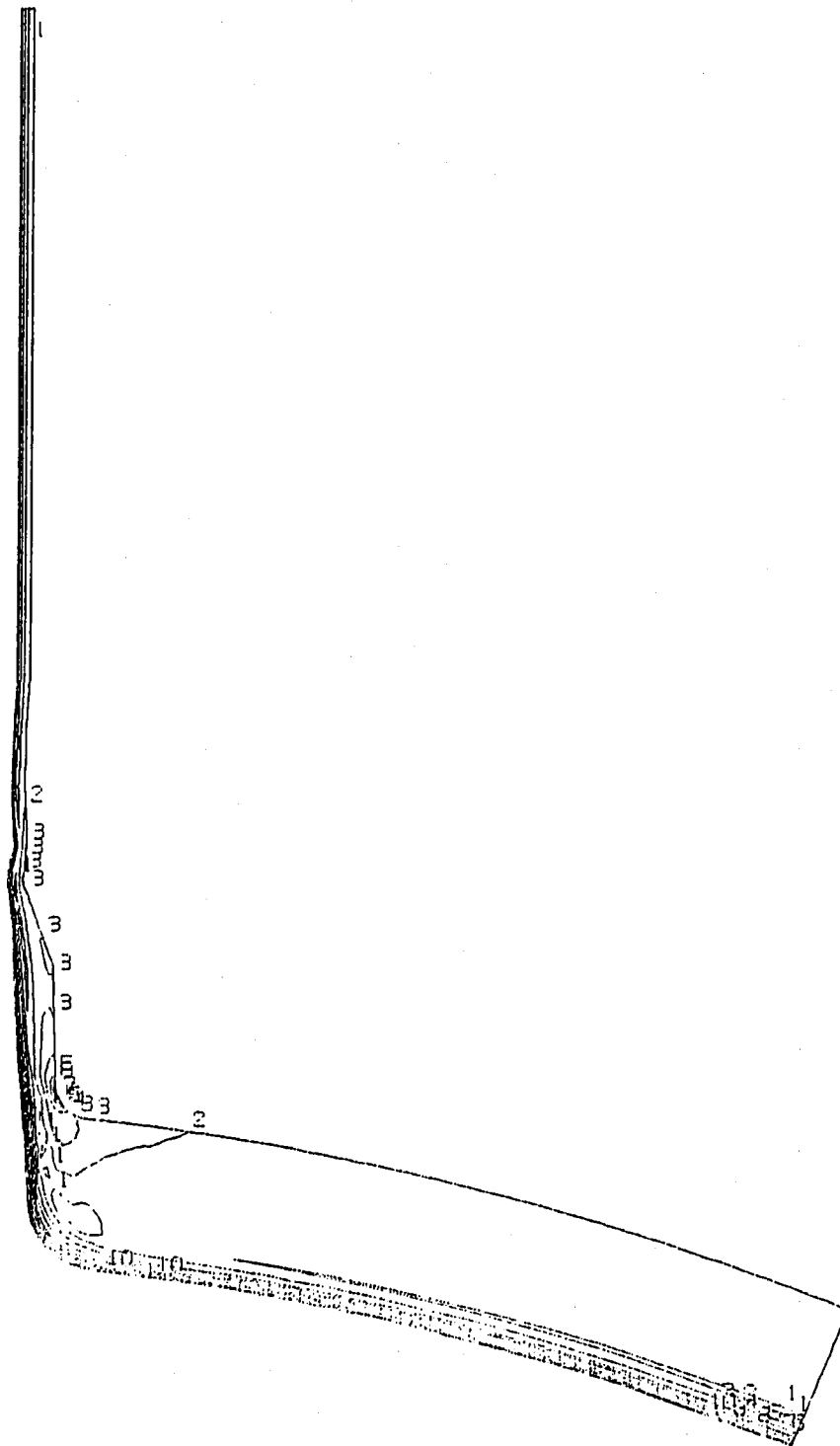
STEP NO. 104

図14.8 温度コンター t=300 sec

FINAS
VON MISES STRESS

CONTOUR VALUES

| | |
|----|----------|
| 1 | 0.700000 |
| 2 | 2.099997 |
| 3 | 3.499996 |
| 4 | 4.899994 |
| 5 | 6.299993 |
| 6 | 7.699992 |
| 7 | 9.099990 |
| 8 | 10.49998 |
| 9 | 11.89998 |
| 10 | 13.29998 |



GEOM. SCALE 1 _____ 50.0000

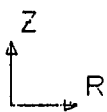
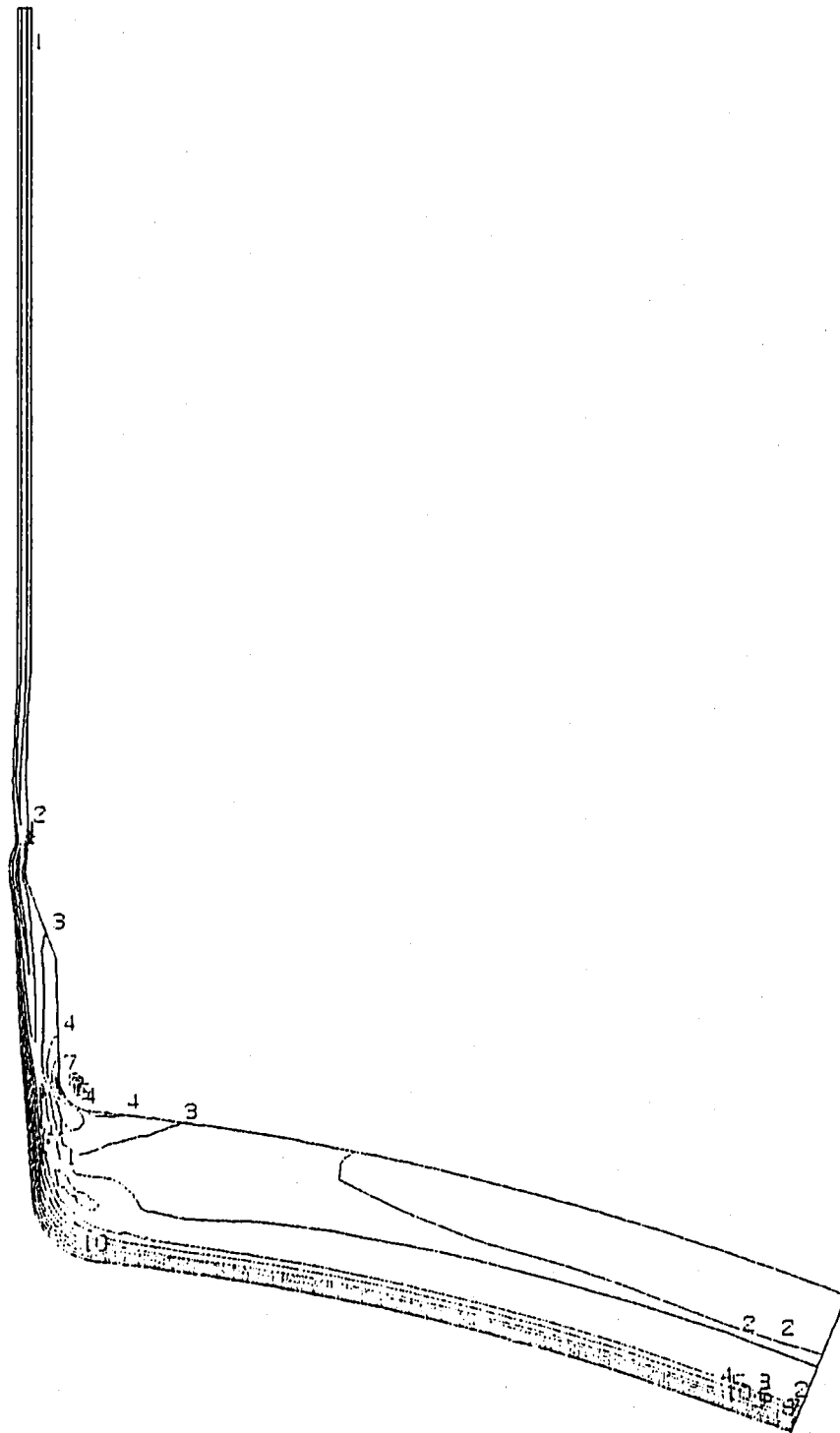
STEP NO. 11

図15.1 ミーゼスの等価応力コンター t=5 sec

FINAS
VON MISES STRESS

CONTOUR VALUES

| | |
|----|-----------|
| 1 | 1.199993 |
| 2 | 4.099997 |
| 3 | 6.999995 |
| 4 | 9.899994 |
| 5 | 12.799998 |
| 6 | 15.699993 |
| 7 | 18.599993 |
| 8 | 21.499993 |
| 9 | 24.399997 |
| 10 | 27.299997 |



GEOM. SCALE _____ 50.0000

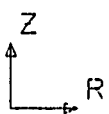
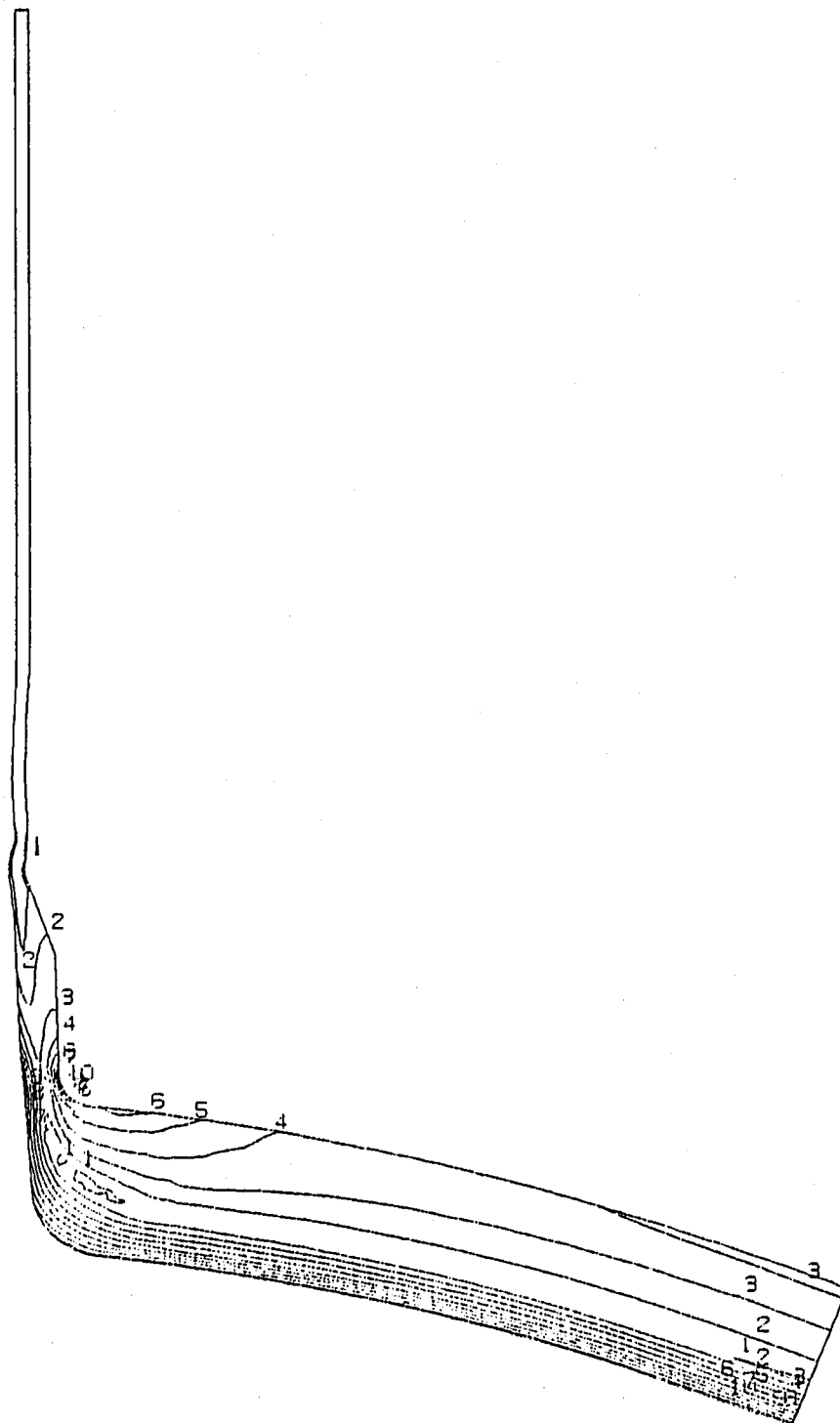
STEP NO. 21

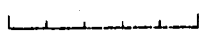
図15. 2 ミーゼスの等価応力コンター t = 10 sec

FINAS
VON MISES STRESS

CONTOUR VALUES

| | |
|----|-----------|
| 1 | 2.839998 |
| 2 | 8.699995 |
| 3 | 14.499993 |
| 4 | 20.299993 |
| 5 | 26.099997 |
| 6 | 31.899995 |
| 7 | 37.699995 |
| 8 | 43.499994 |
| 9 | 49.299993 |
| 10 | 55.099992 |



GEOM. SCALE  50.0000

STEP NO. 41

図15.3 ミーゼスの等価応力コンター t=30 sec

FINAS
VON MISES STRESS

CONTOUR VALUES

| | |
|----|-----------|
| 1 | 3.999993 |
| 2 | 11.899993 |
| 3 | 19.799993 |
| 4 | 27.699993 |
| 5 | 35.599997 |
| 6 | 43.499997 |
| 7 | 51.399997 |
| 8 | 59.299996 |
| 9 | 67.199996 |
| 10 | 75.099995 |

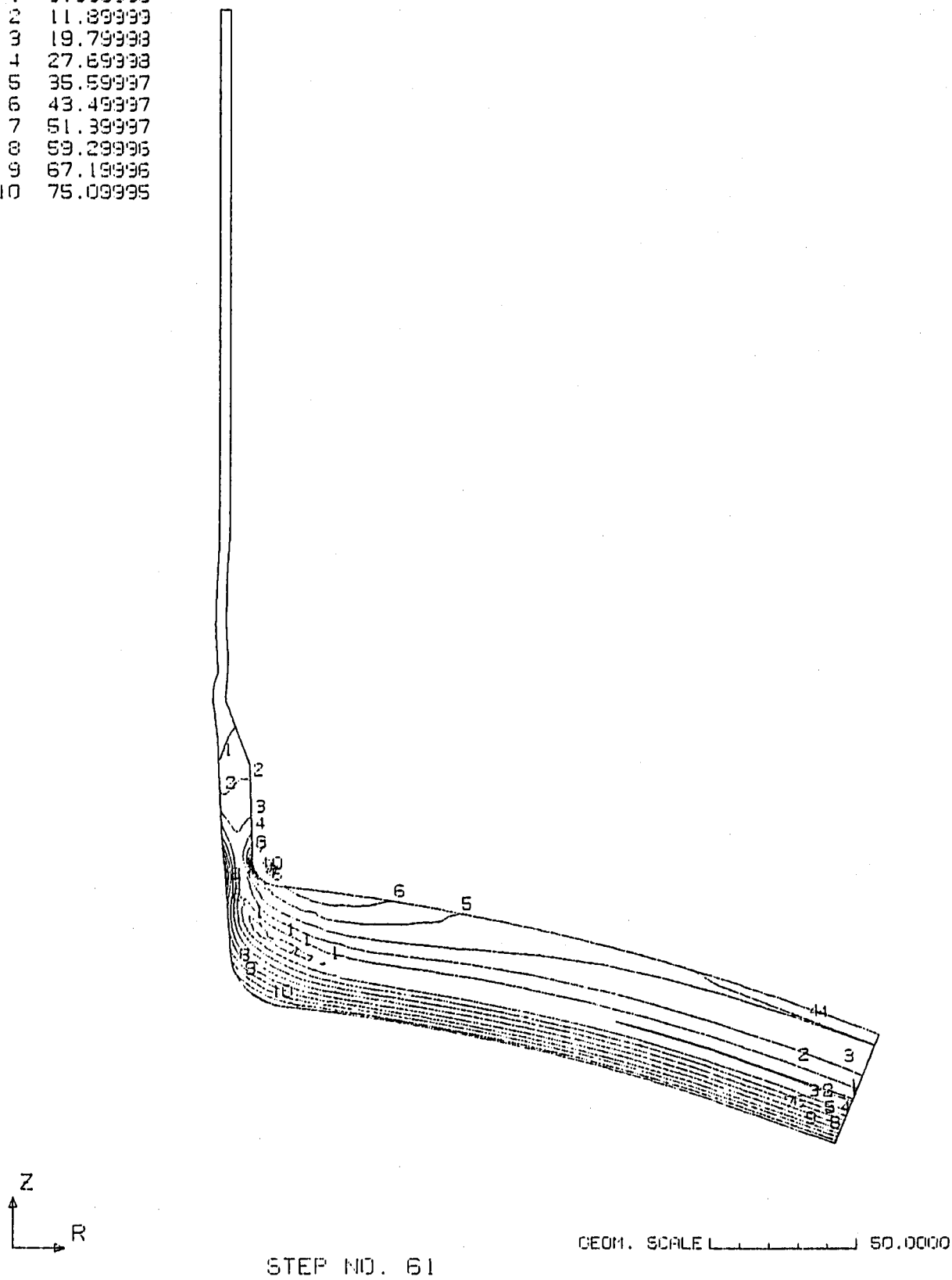


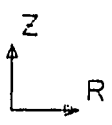
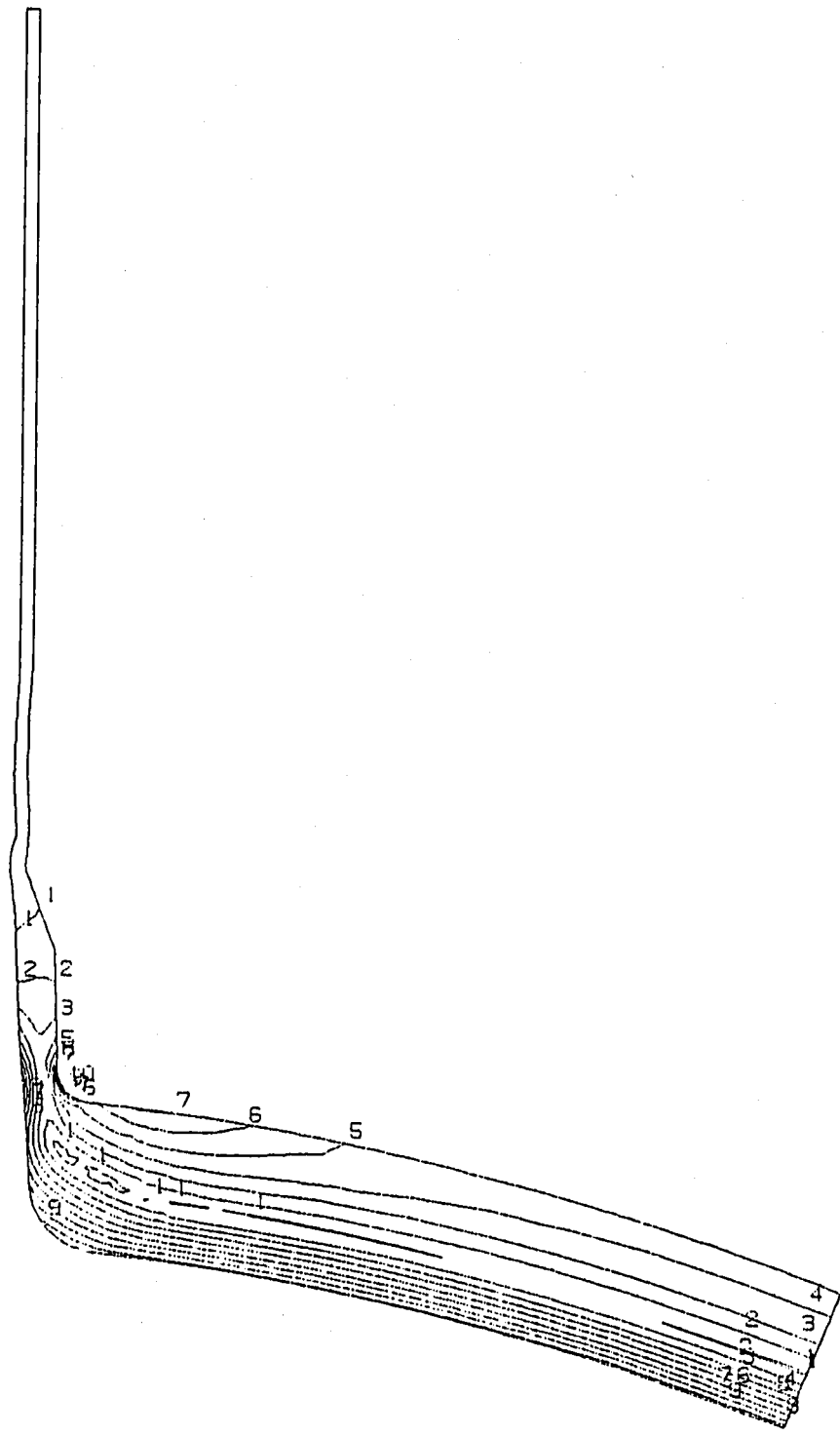
図15. 4 ミーゼスの等価応力コンター t = 70 sec

FINAS

VON MISES STRESS

CONTOUR VALUES

- 1 3.799998
- 2 11.599998
- 3 19.399997
- 4 27.199996
- 5 34.999996
- 6 42.799994
- 7 50.599993
- 8 58.399992
- 9 66.199991
- 10 73.999991



STEP NO. 66

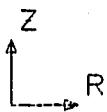
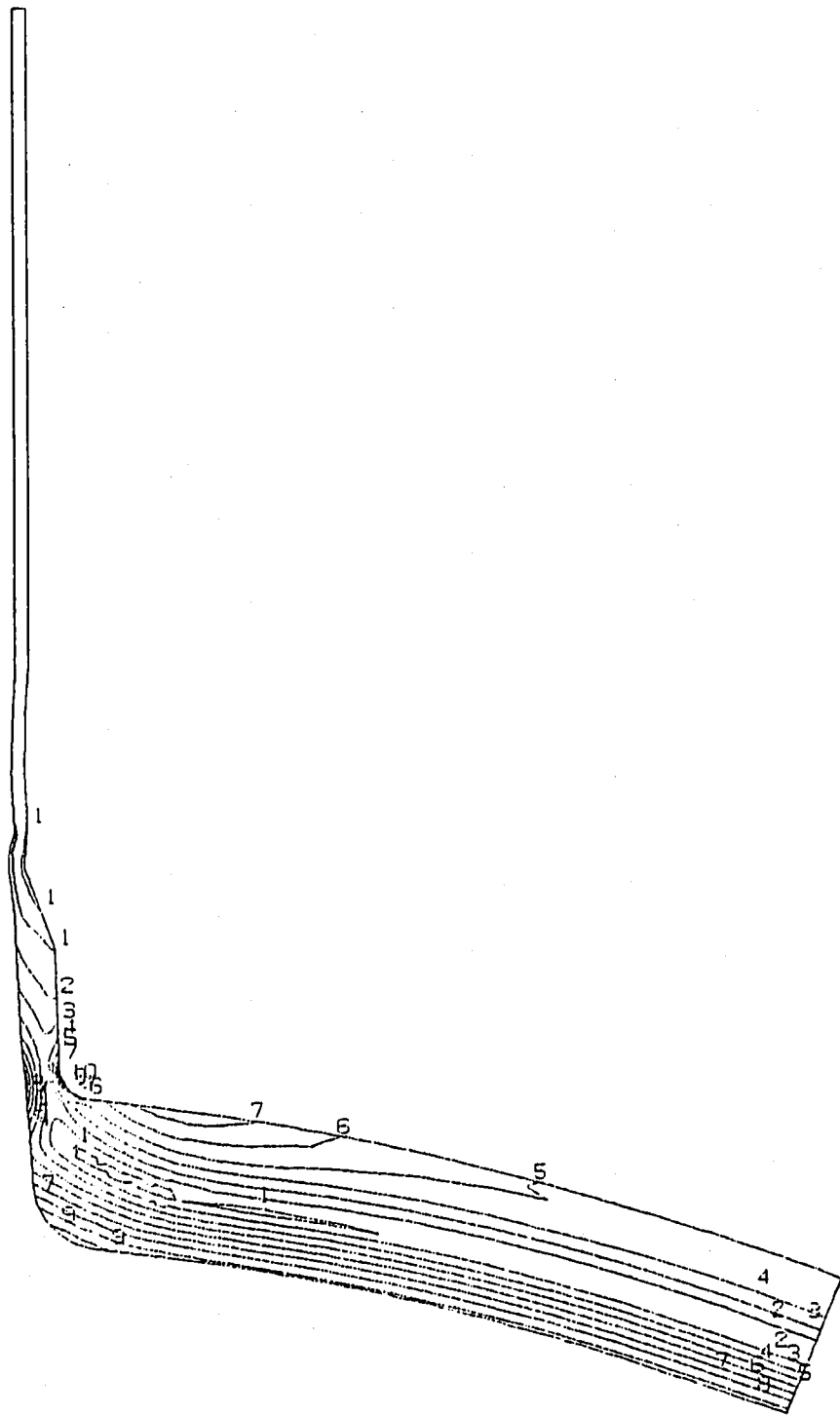
GEOM. SCALE 50.0000

図15.5 ミーゼスの等価応力コンター t=80 sec

FINAS
VON MISES STRESS

CONTOUR VALUES

| | |
|----|-----------|
| 1 | 2.899993 |
| 2 | 8.599996 |
| 3 | 14.299993 |
| 4 | 19.999993 |
| 5 | 25.699993 |
| 6 | 31.399993 |
| 7 | 37.099993 |
| 8 | 42.799997 |
| 9 | 48.499997 |
| 10 | 54.199997 |



GEOM. SCALE 1 50.0000

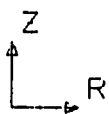
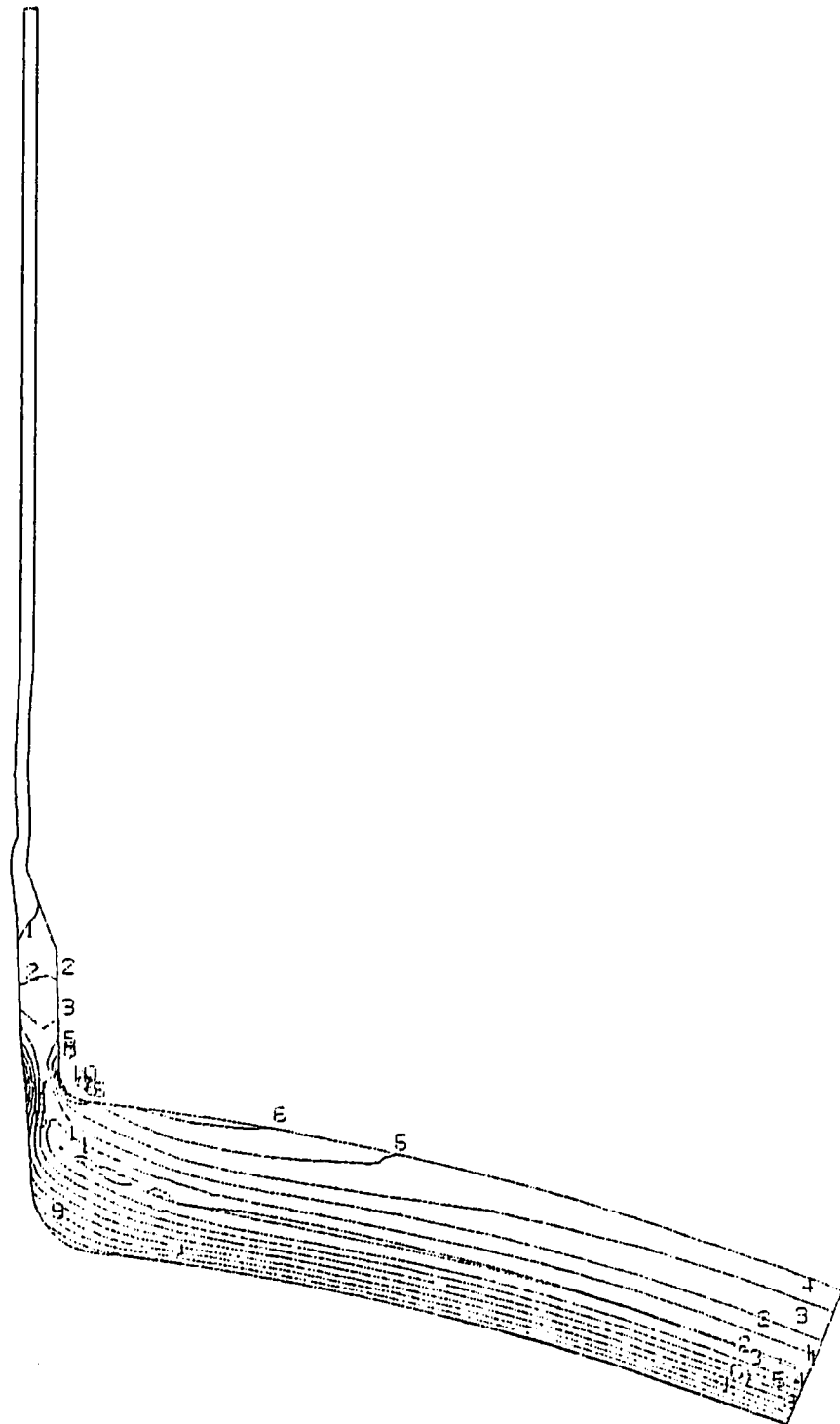
STEP NO. 76

図15.6 ミーゼスの等価応力コンター t=100 sec

FINAS
VON MISES STRESS

CONTOUR VALUES

- 1 2.499999
- 2 7.499997
- 3 12.49999
- 4 17.49998
- 5 22.49997
- 6 27.49996
- 7 32.49994
- 8 37.49992
- 9 42.49991
- 10 47.49989



GEOM. SCALE _____ 50.0000

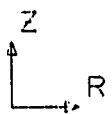
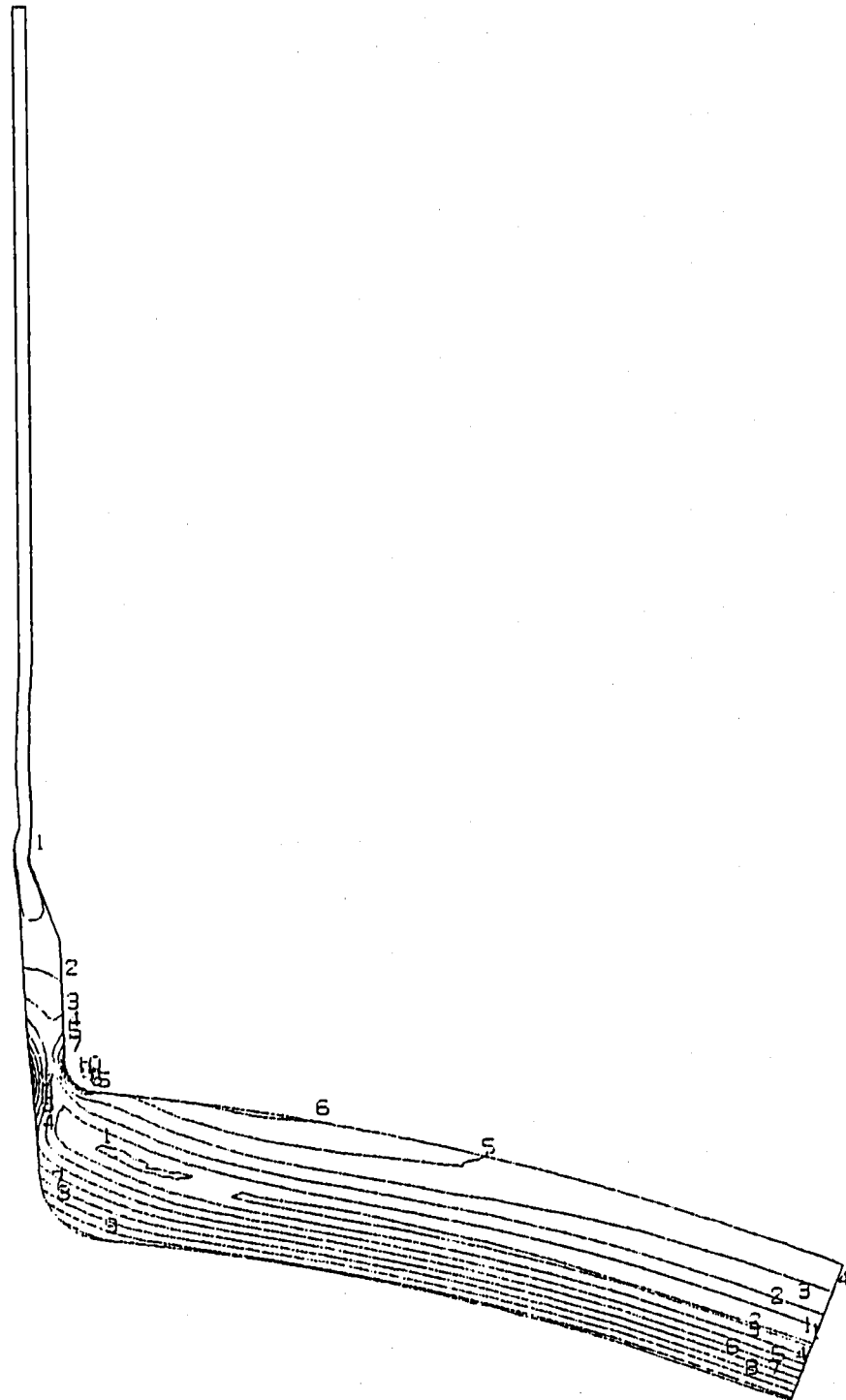
STEP NO. 91

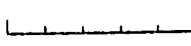
図15.7 ミーゼスの等価応力コンター t = 160 sec

FINAS
VON MISES STRESS

CONTOUR VALUES

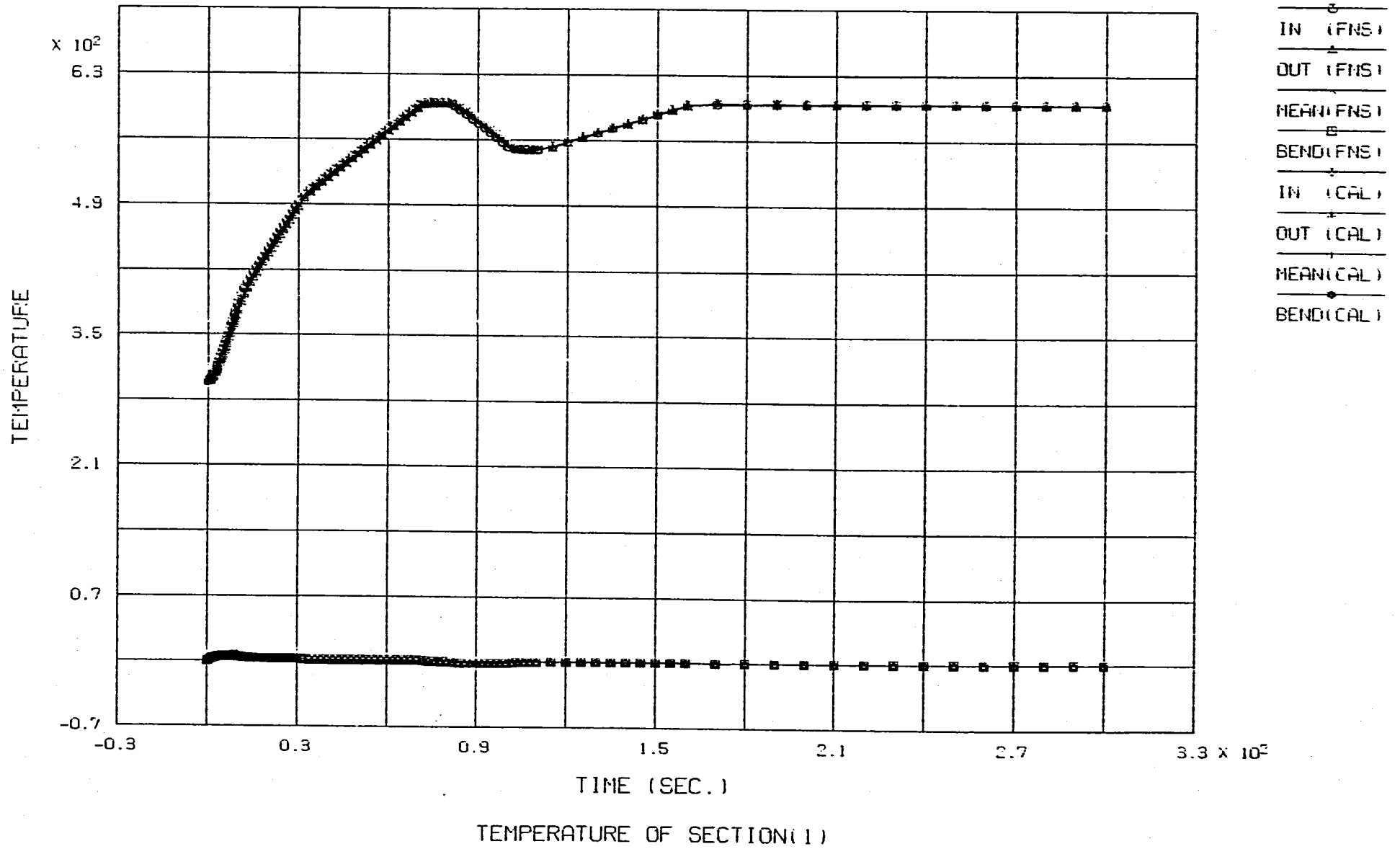
| | |
|----|-----------|
| 1 | 1.099999 |
| 2 | 3.199997 |
| 3 | 5.299996 |
| 4 | 7.399994 |
| 5 | 9.499993 |
| 6 | 11.599993 |
| 7 | 13.699993 |
| 8 | 15.799993 |
| 9 | 17.899993 |
| 10 | 19.999997 |



GEOM. SCALE  50.0000

STEP NO. 105

図15.8 ミーゼスの等価応力コンター t = 300 sec

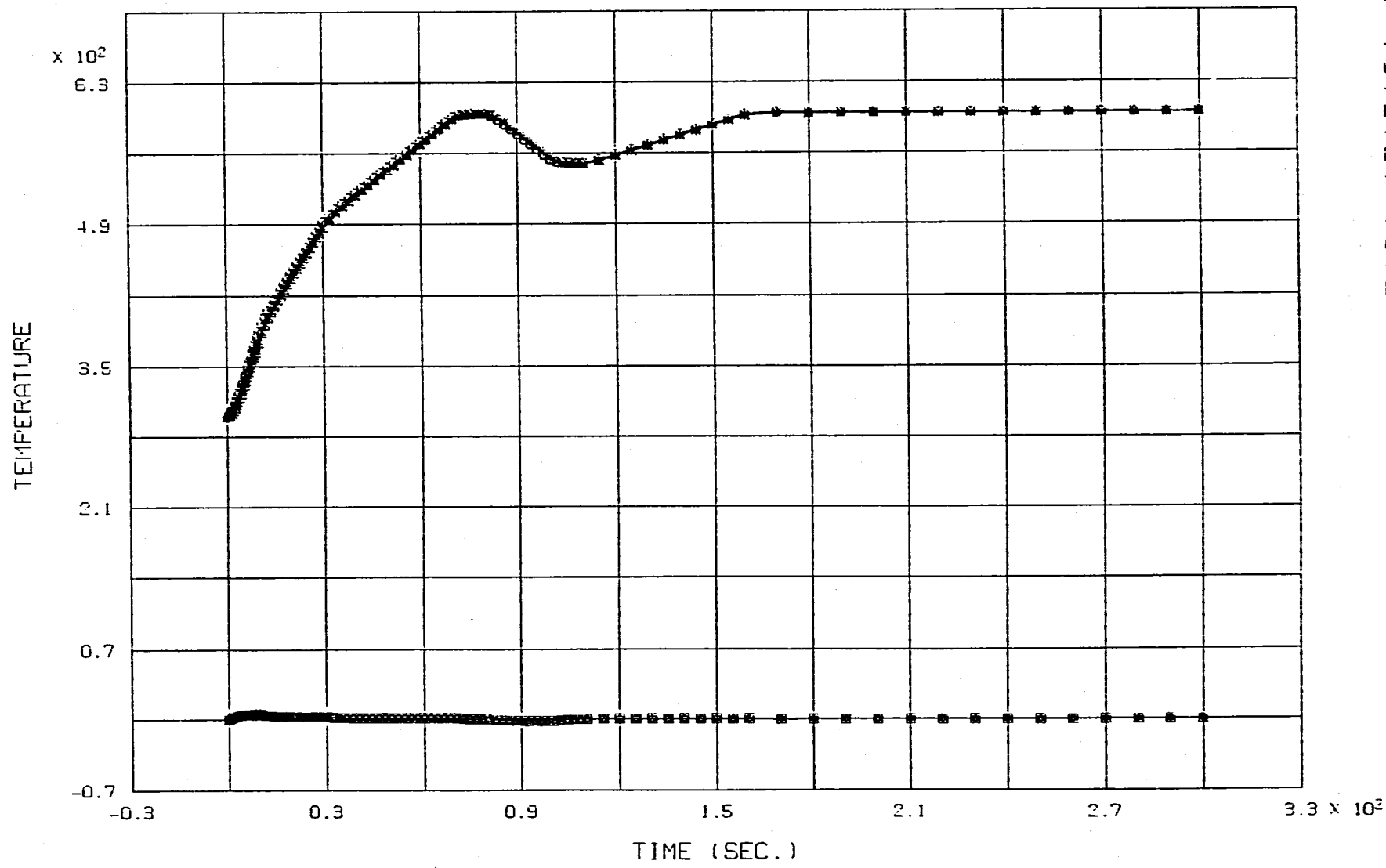


- 257 -

図16.1 評価断面1の温度

FINAS

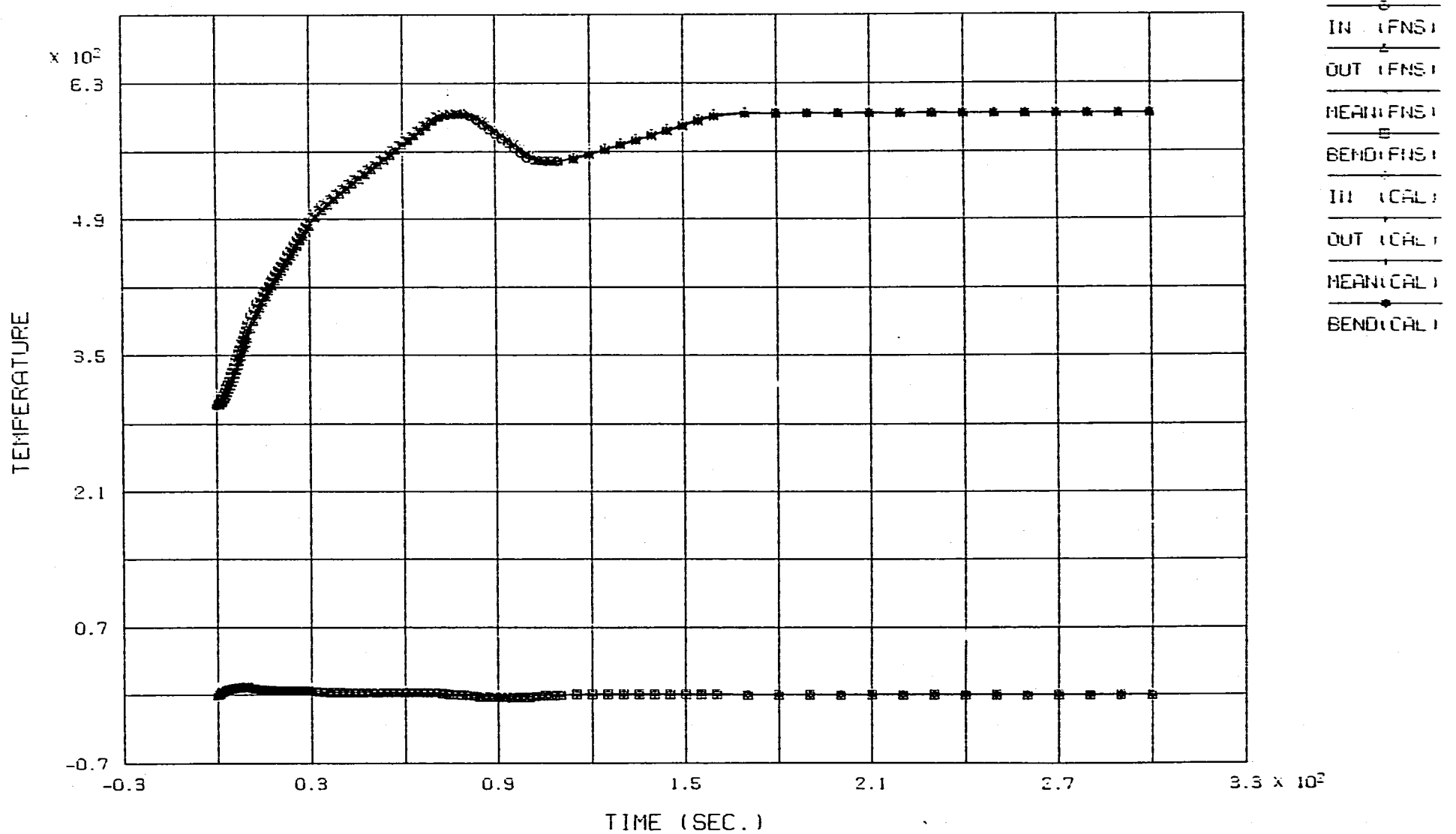
- IN (FNS)
- △ OUT (FNS)
- MEAN (FNS)
- ◇ BEND (FNS)
- IN (CAL)
- △ OUT (CAL)
- MEAN (CAL)
- ◇ BEND (CAL)



- 258 -

TEMPERATURE OF SECTION(2)

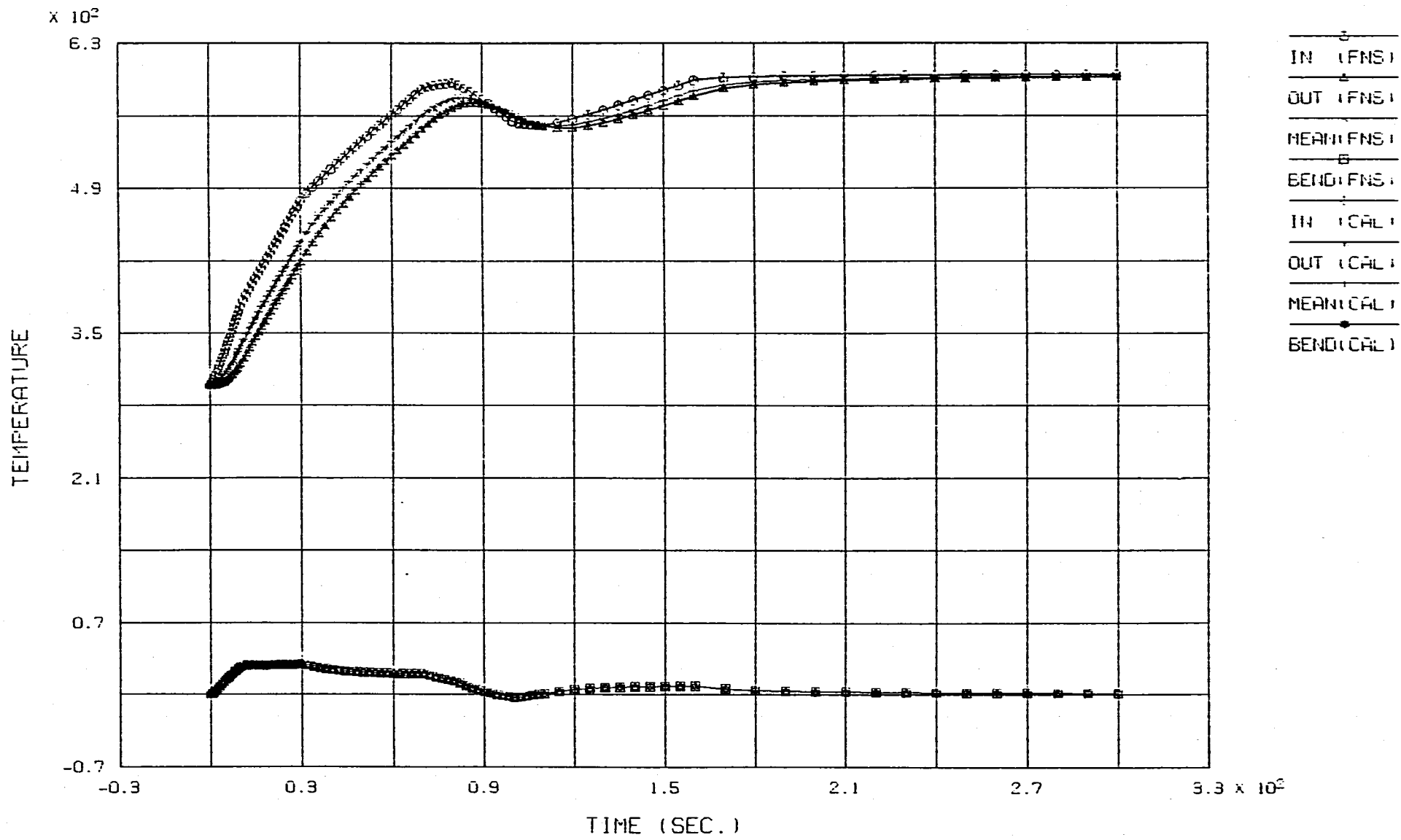
図16.2 評価断面2の温度



TEMPERATURE OF SECTION(3)

図16.3 評価断面3の温度

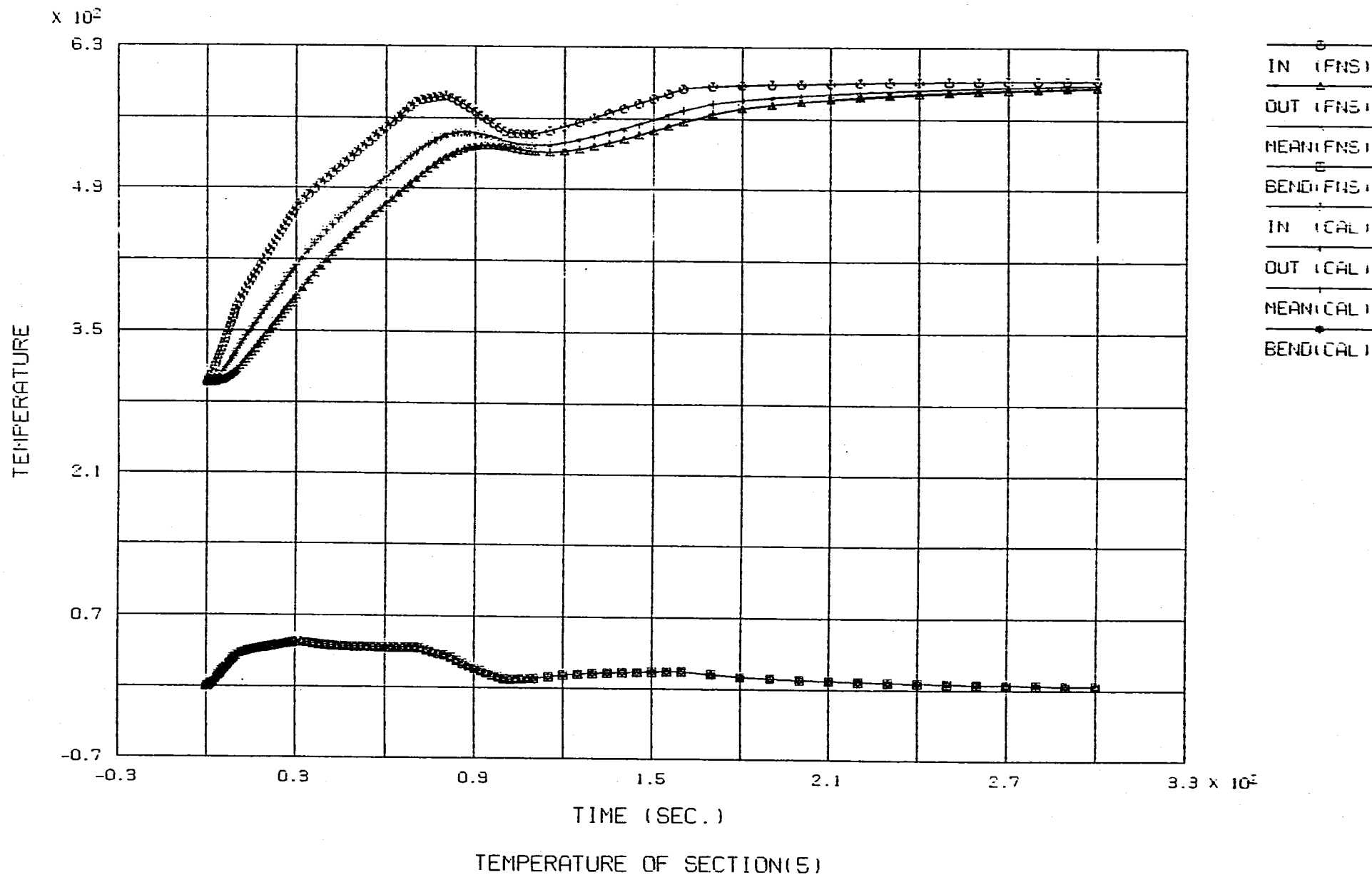
FINAS



- 260 -

図16.4 評価断面4の温度

FINAS



- 261 -

図16.5 評価断面5の温度

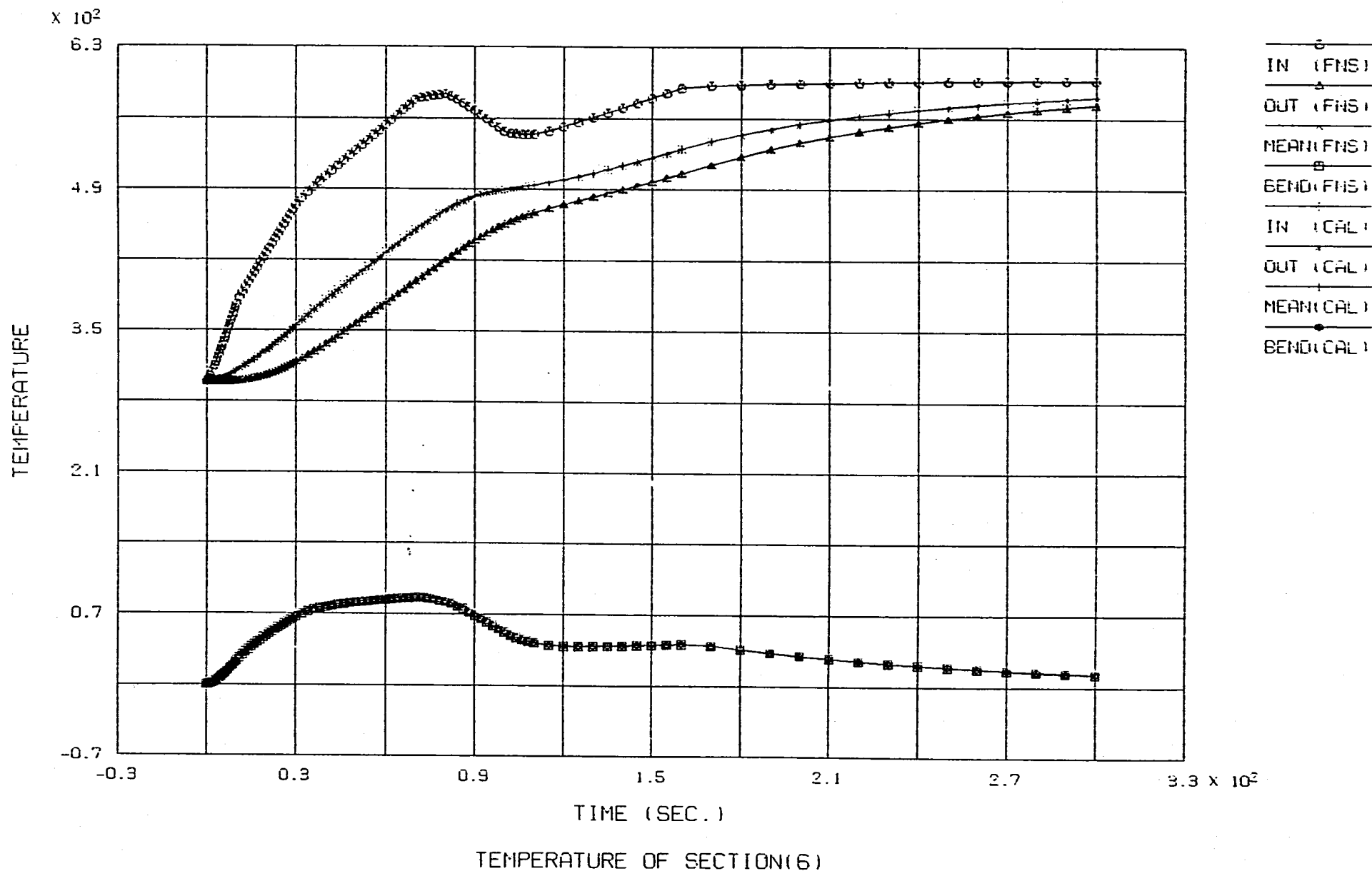
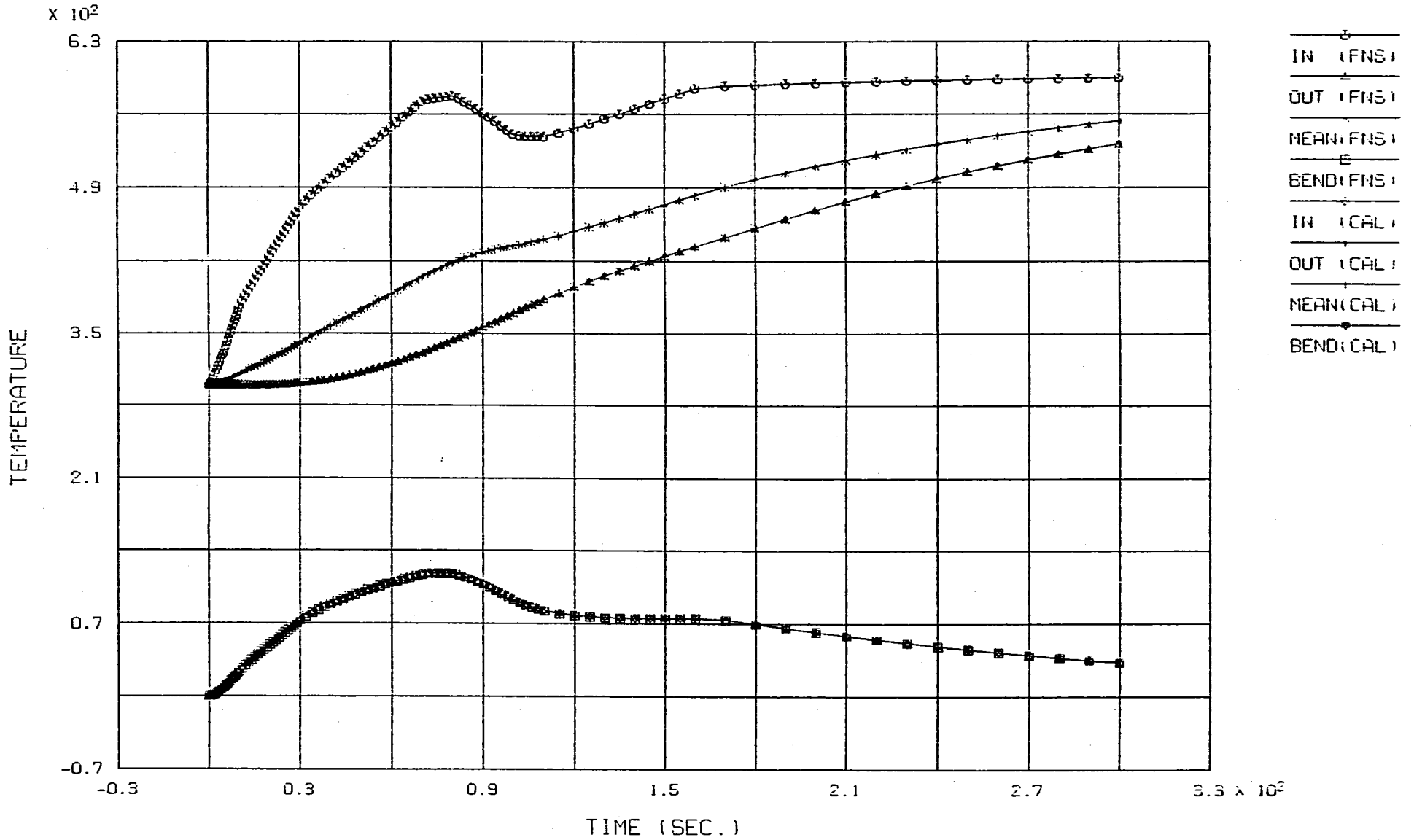
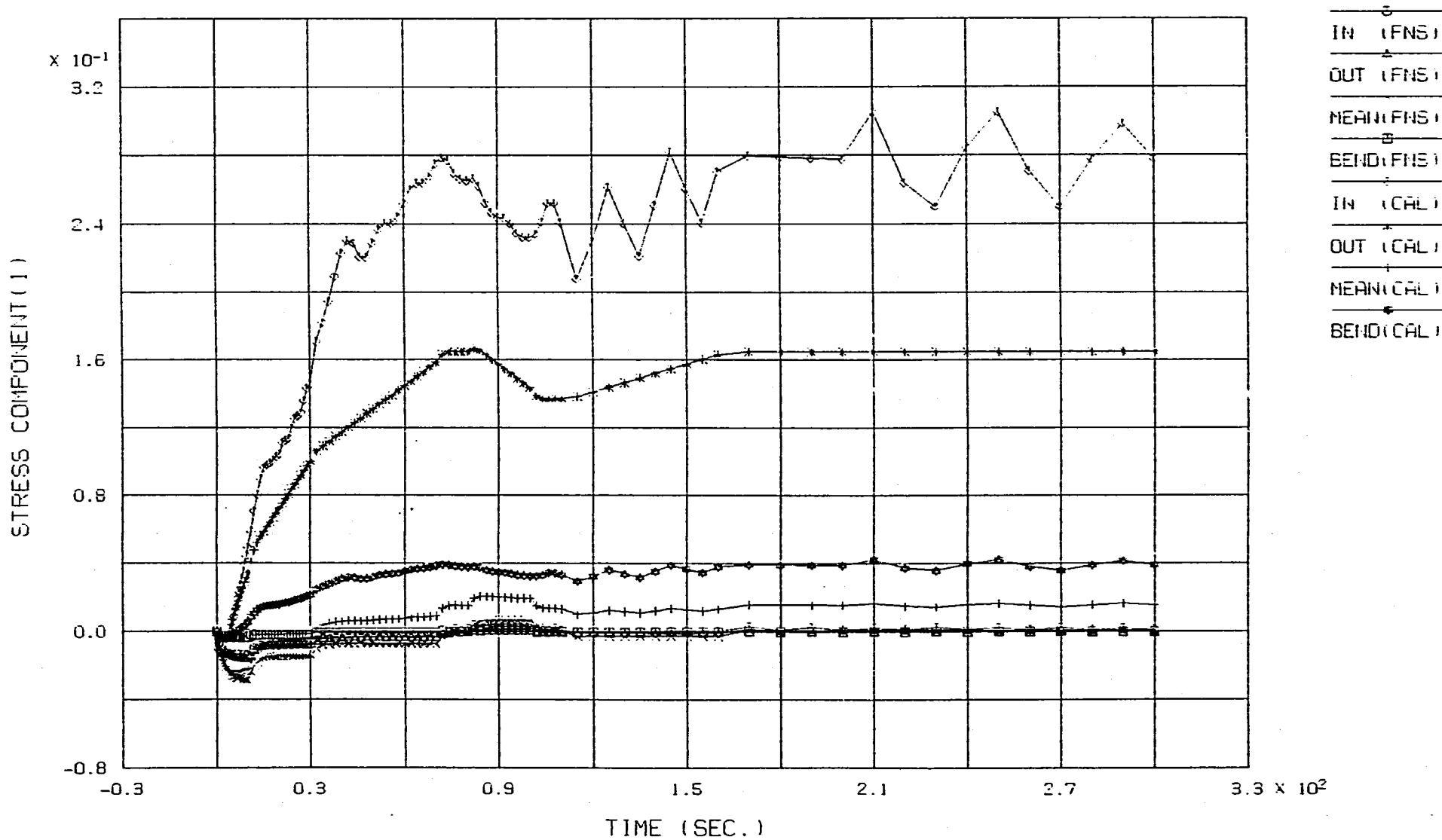


図16.6 評価断面6の温度



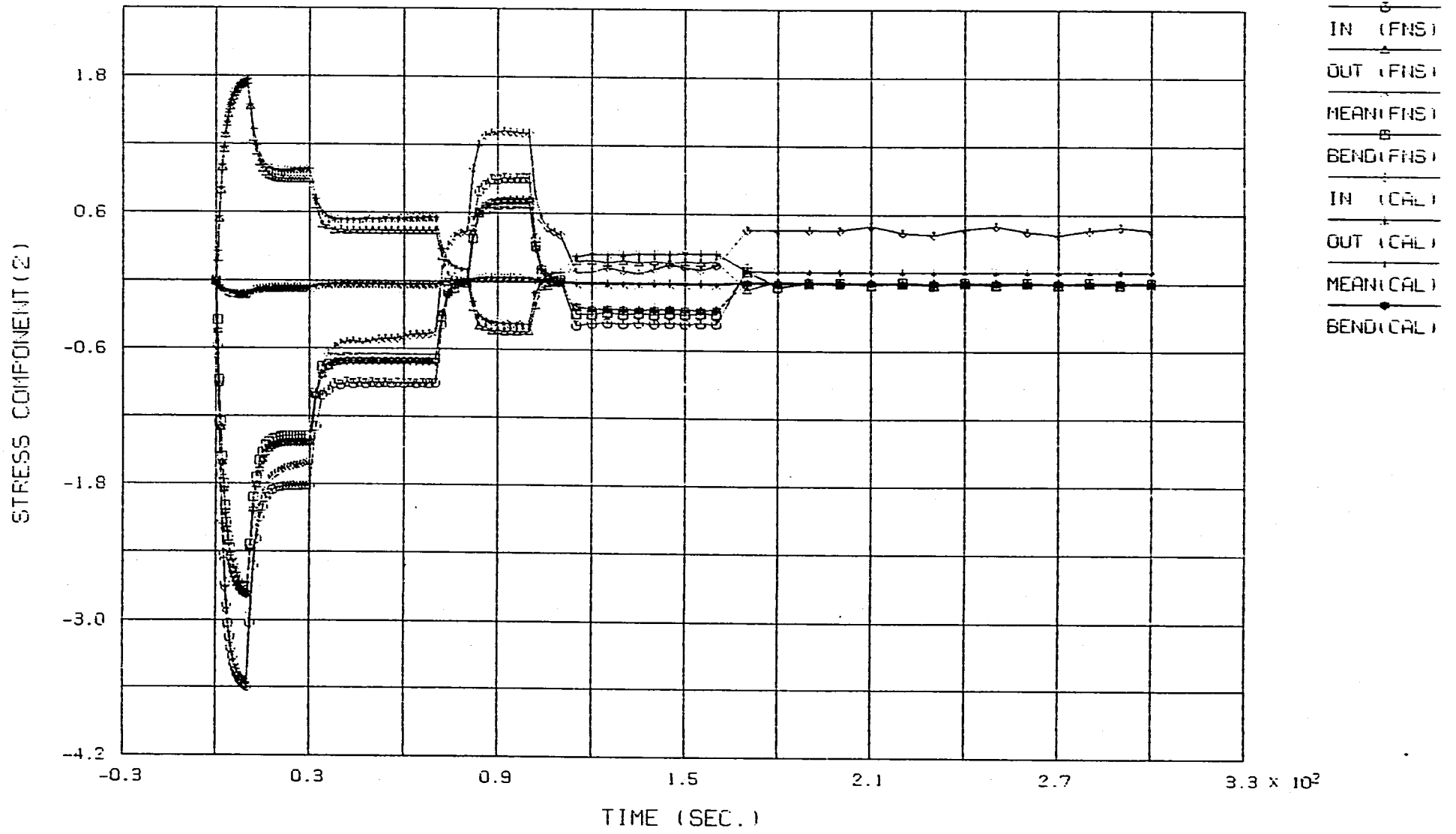
TEMPERATURE OF SECTION(7)

図16. 7 評価断面7の温度



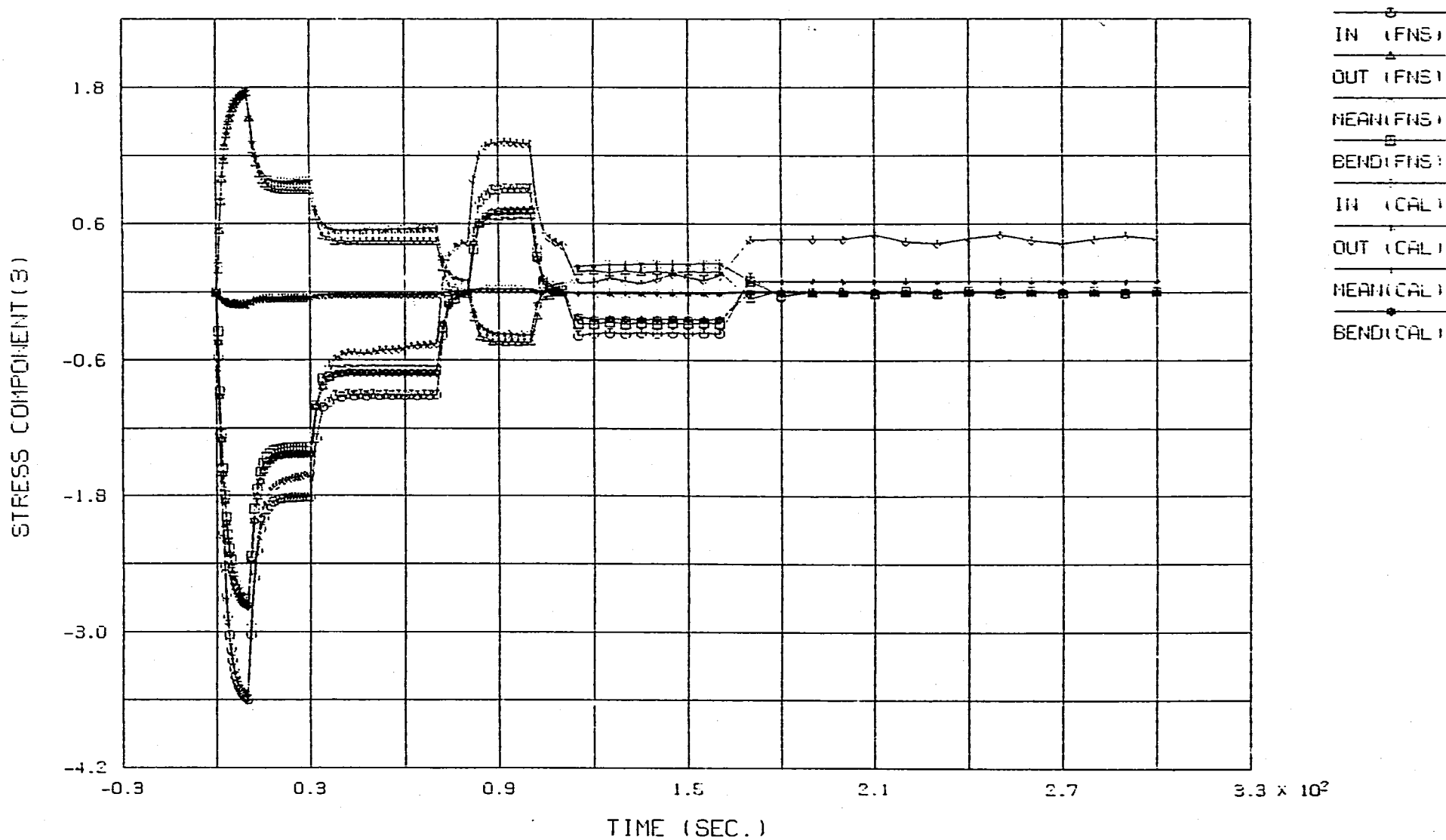
STRESS COMPONENT (1) OF SECTION (1)

図17. 1(1) 評価断面1の応力テンソル成分1



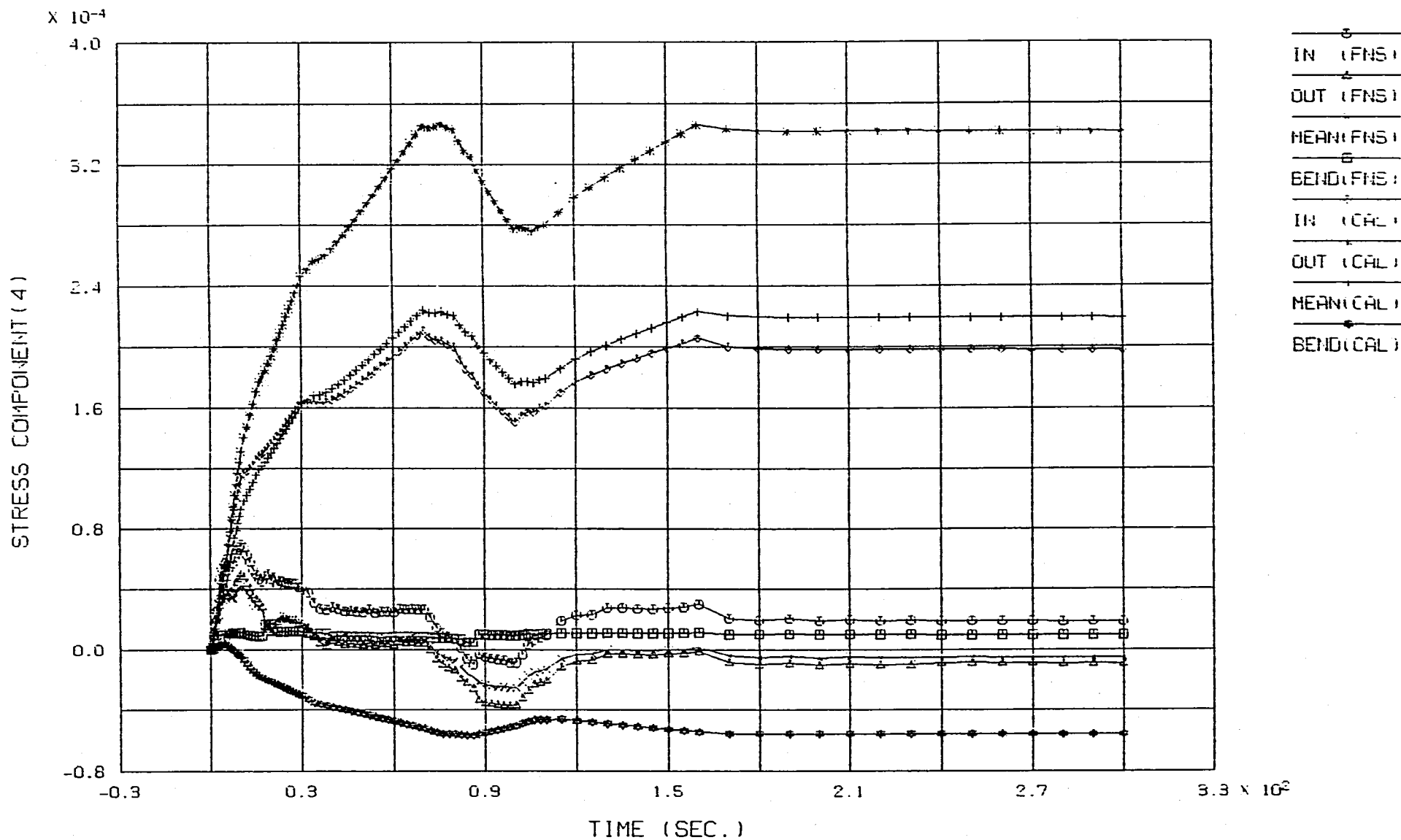
STRESS COMPONENT(2) OF SECTION(1)

図17. 1(2) 評価断面1の応力テンソル成分2



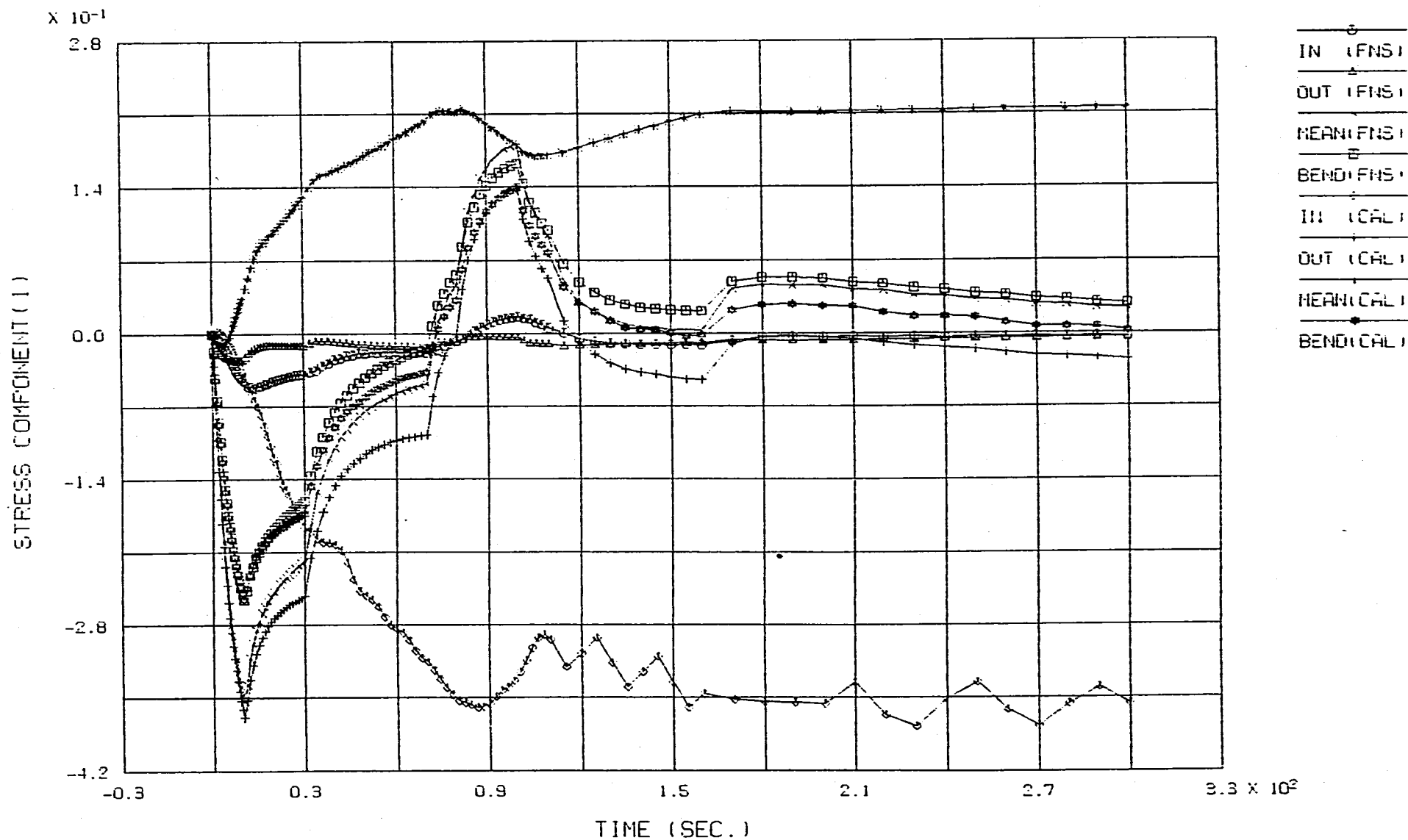
STRESS COMPONENT(3) OF SECTION(1)

図17. 1(3) 評価断面1の応力テンソル成分3



STRESS COMPONENT(4) OF SECTION(1)

図17. 1(4) 評価断面1の応力テンソル成分4

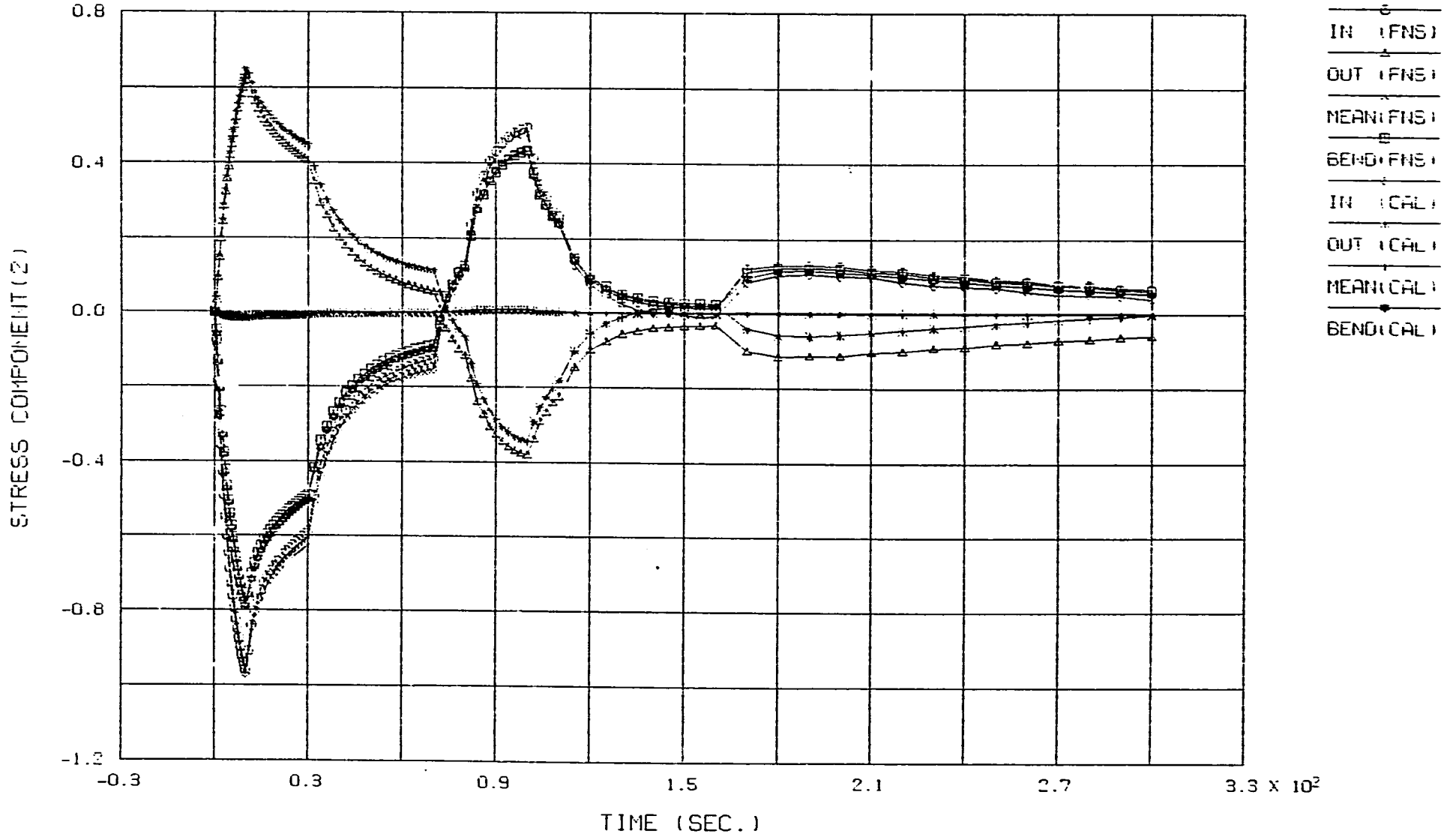


STRESS COMPONENT(1) OF SECTION(2)

図17. 2(1) 評価断面2の応力テンソル成分1

FINPS

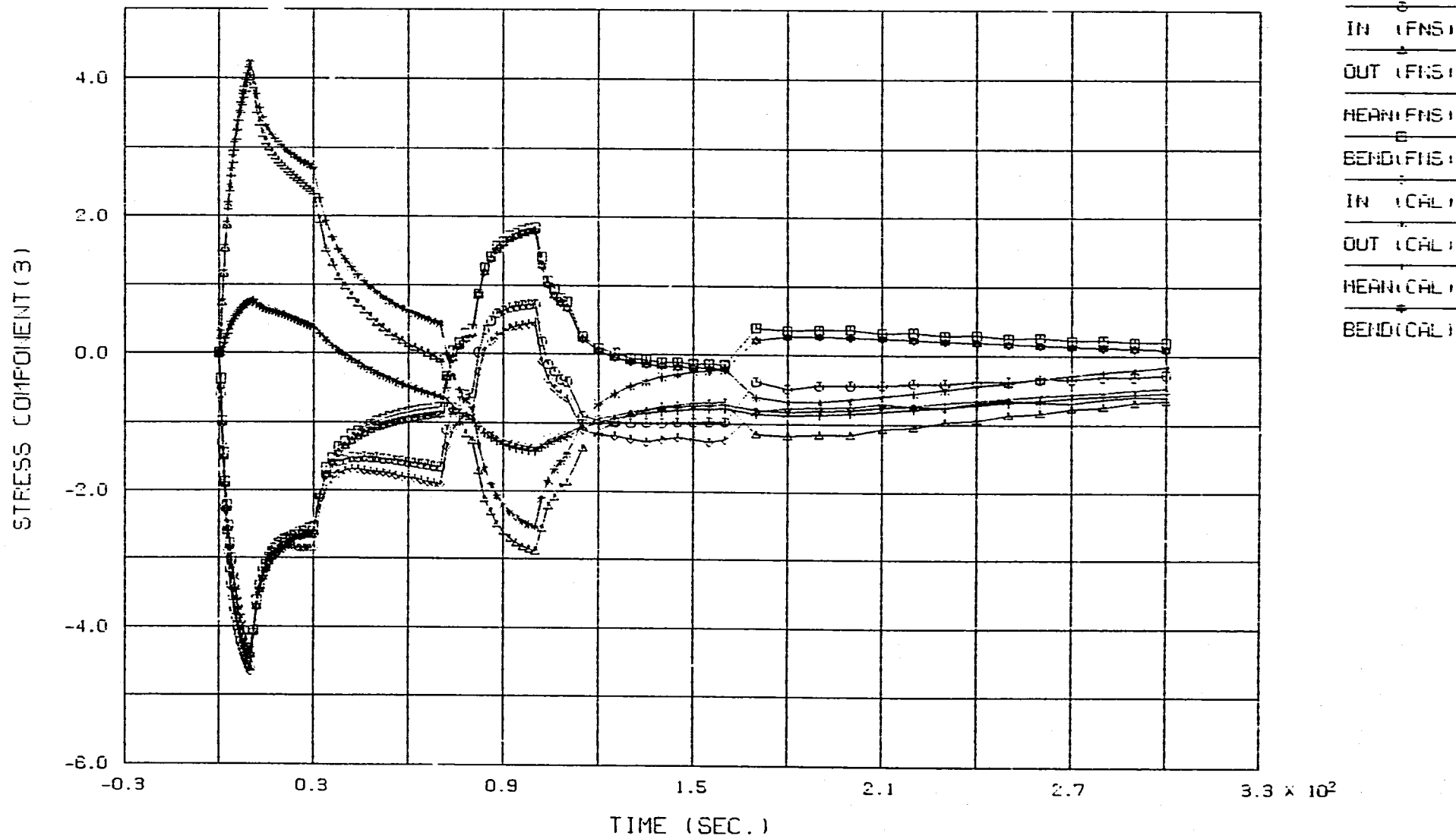
x 10¹



- 269 -

STRESS COMPONENT(2) OF SECTION(2)

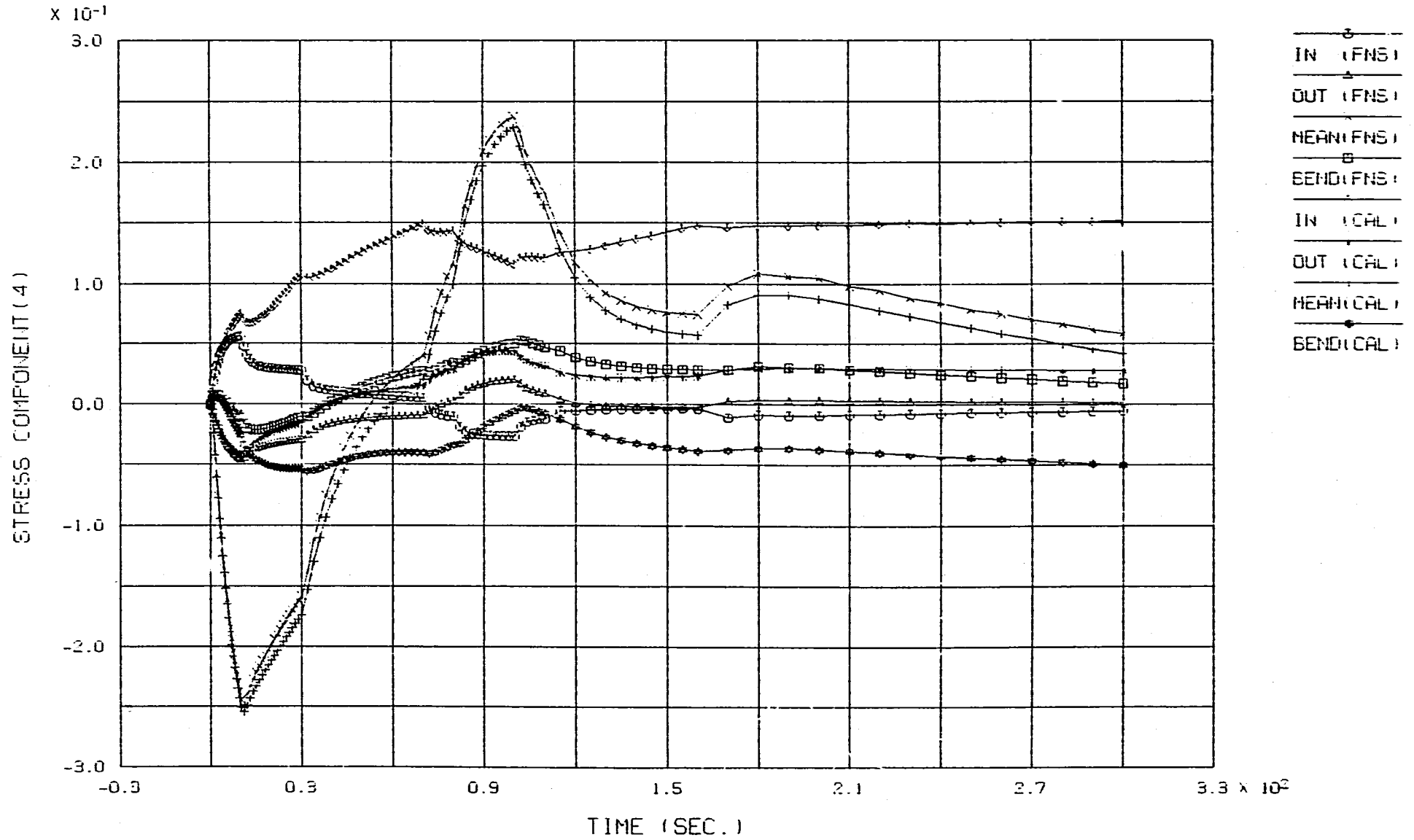
図17. 2(2) 評価断面2の応力テンソル成分2



STRESS COMPONENT(3) OF SECTION(2)

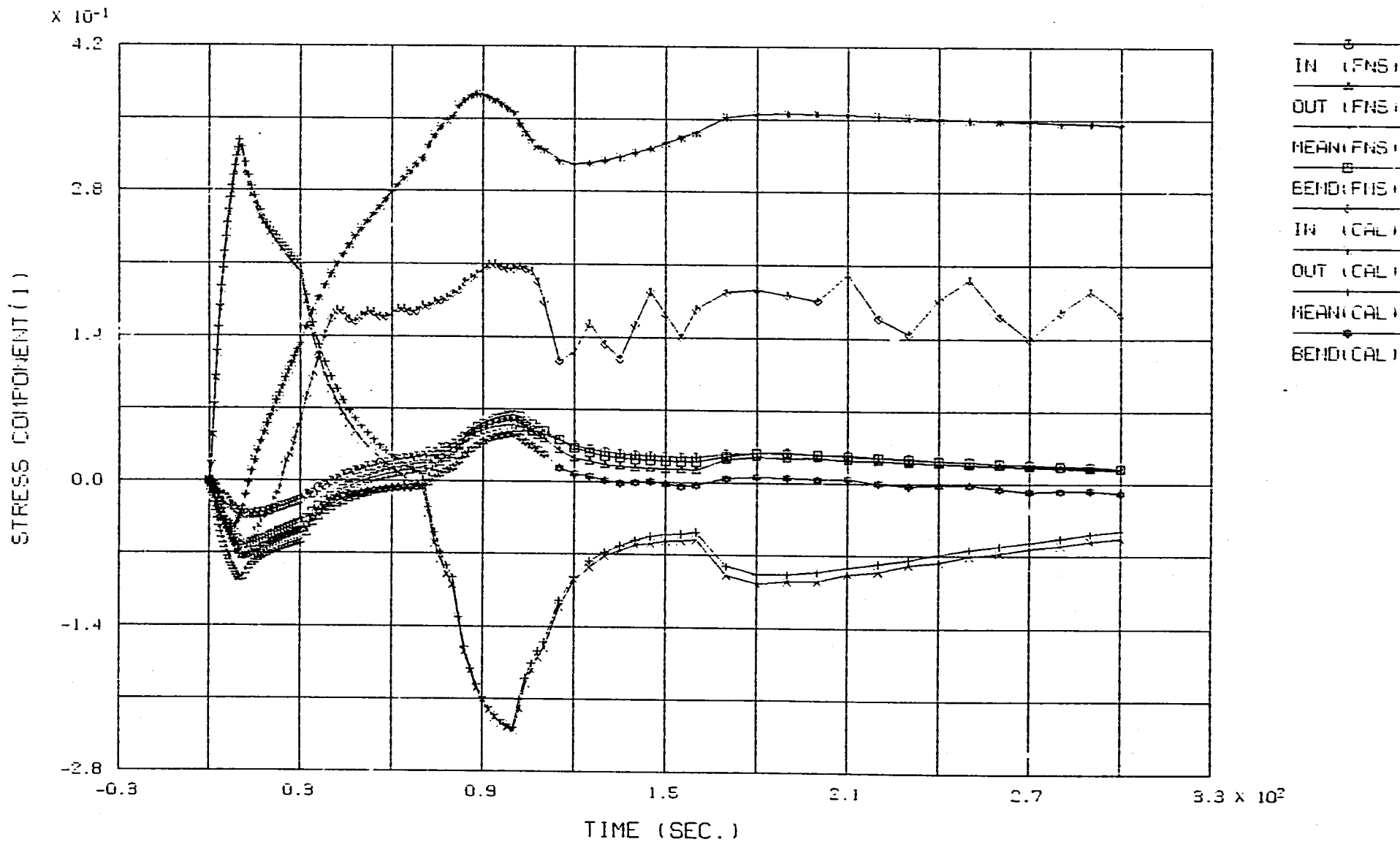
図17. 2(3) 評価断面2の応力テンソル成分3

FINAG



STRESS COMPONENT(4) OF SECTION(2)

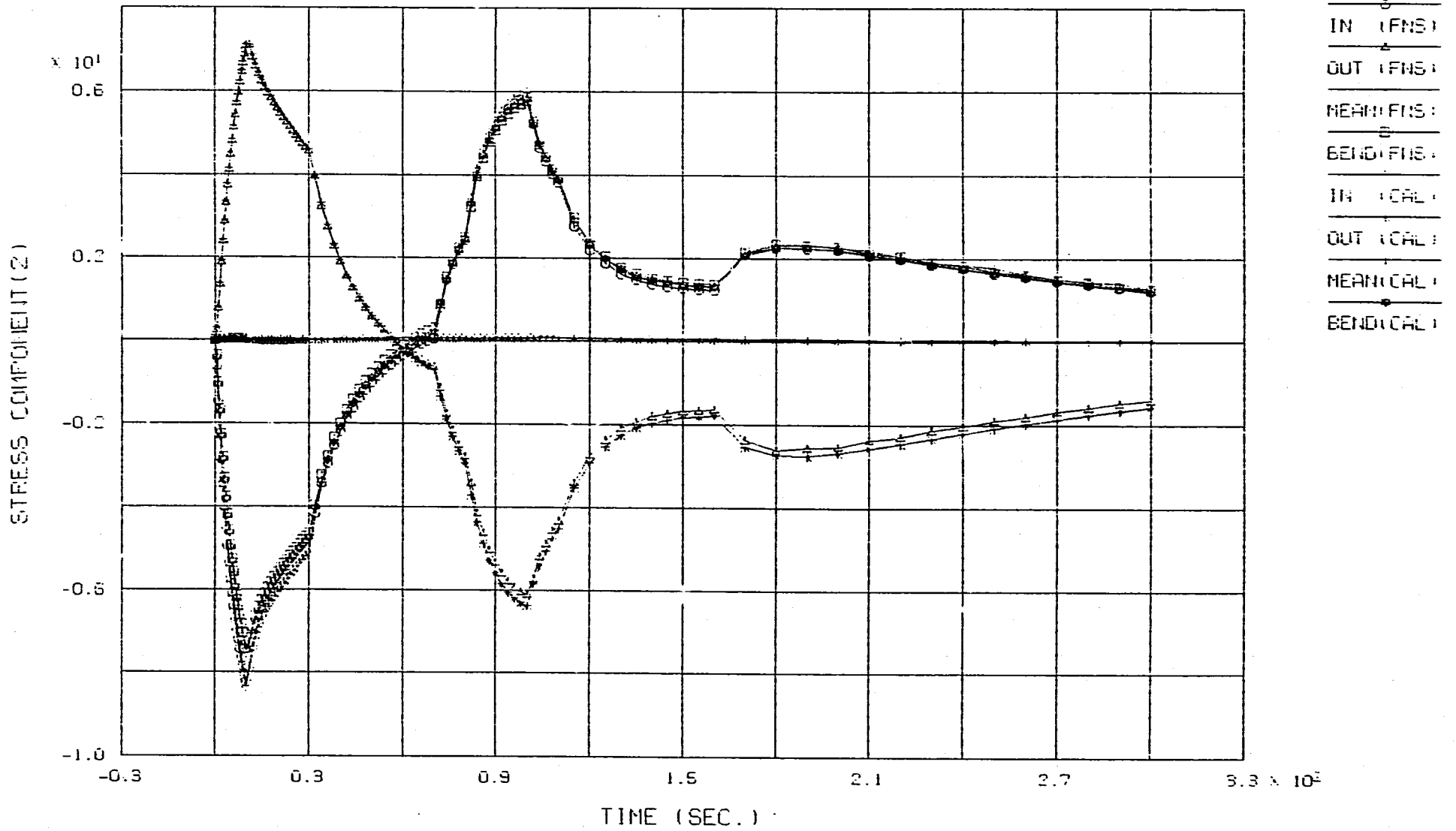
図17. 2(4) 評価断面2の応力テンソル成分4



- 272 -

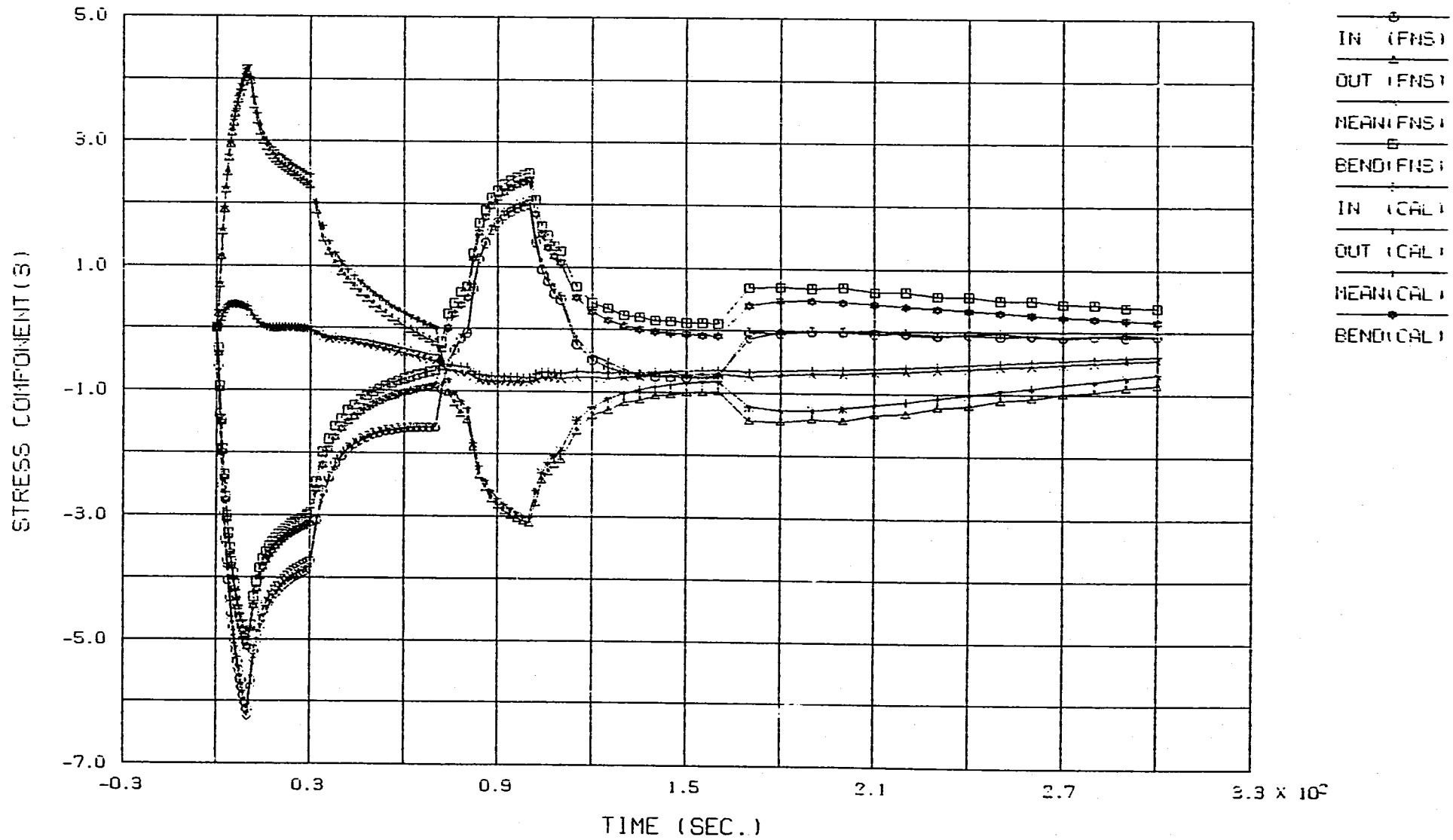
STRESS COMPONENT (1) OF SECTION (3)

図17. 3 (1) 評価断面3の応力テンソル成分1



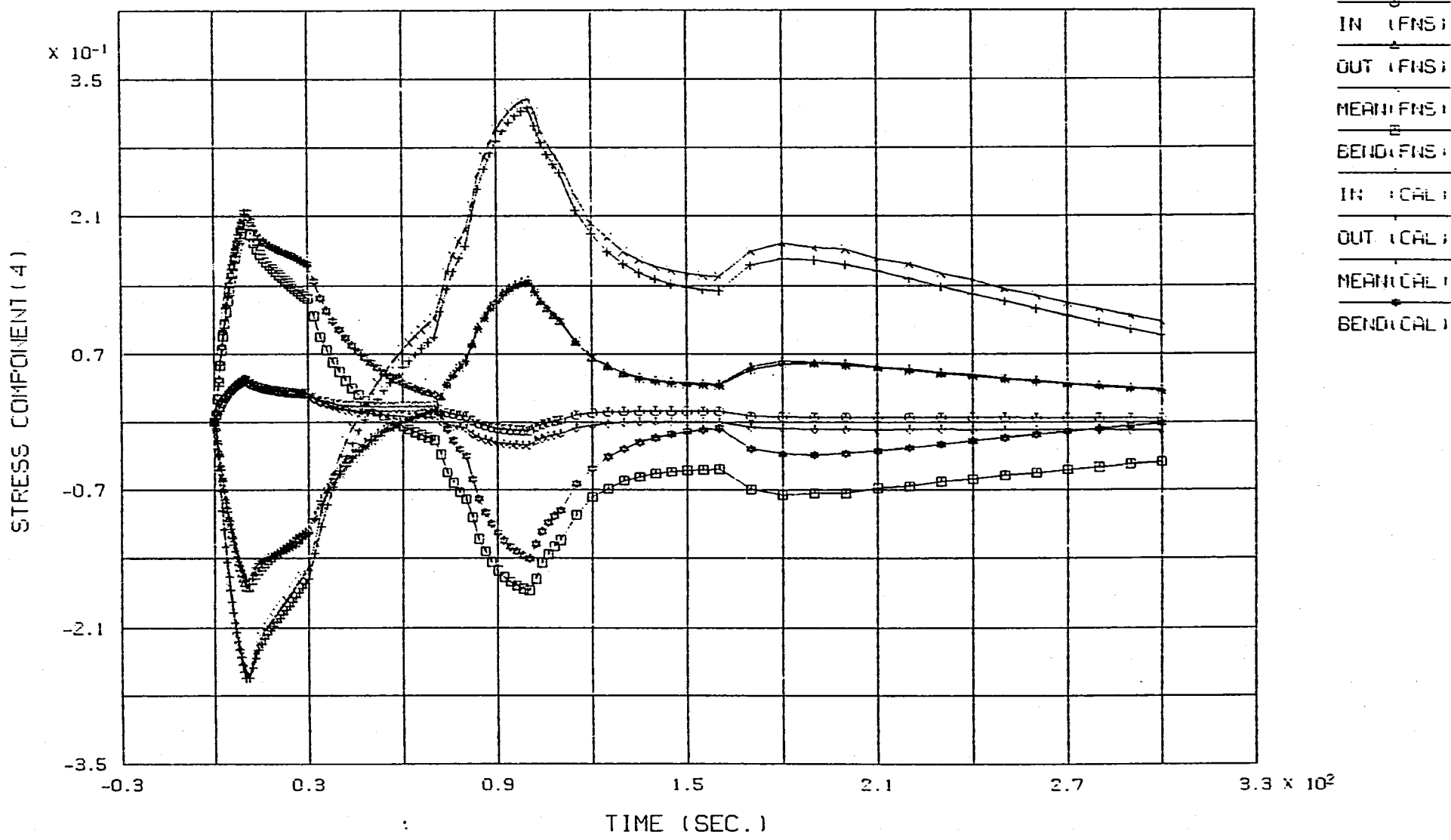
STRESS COMPONENT (2) OF SECTION (3)

図17. 3(2) 評価断面3の応力テンソル成分2



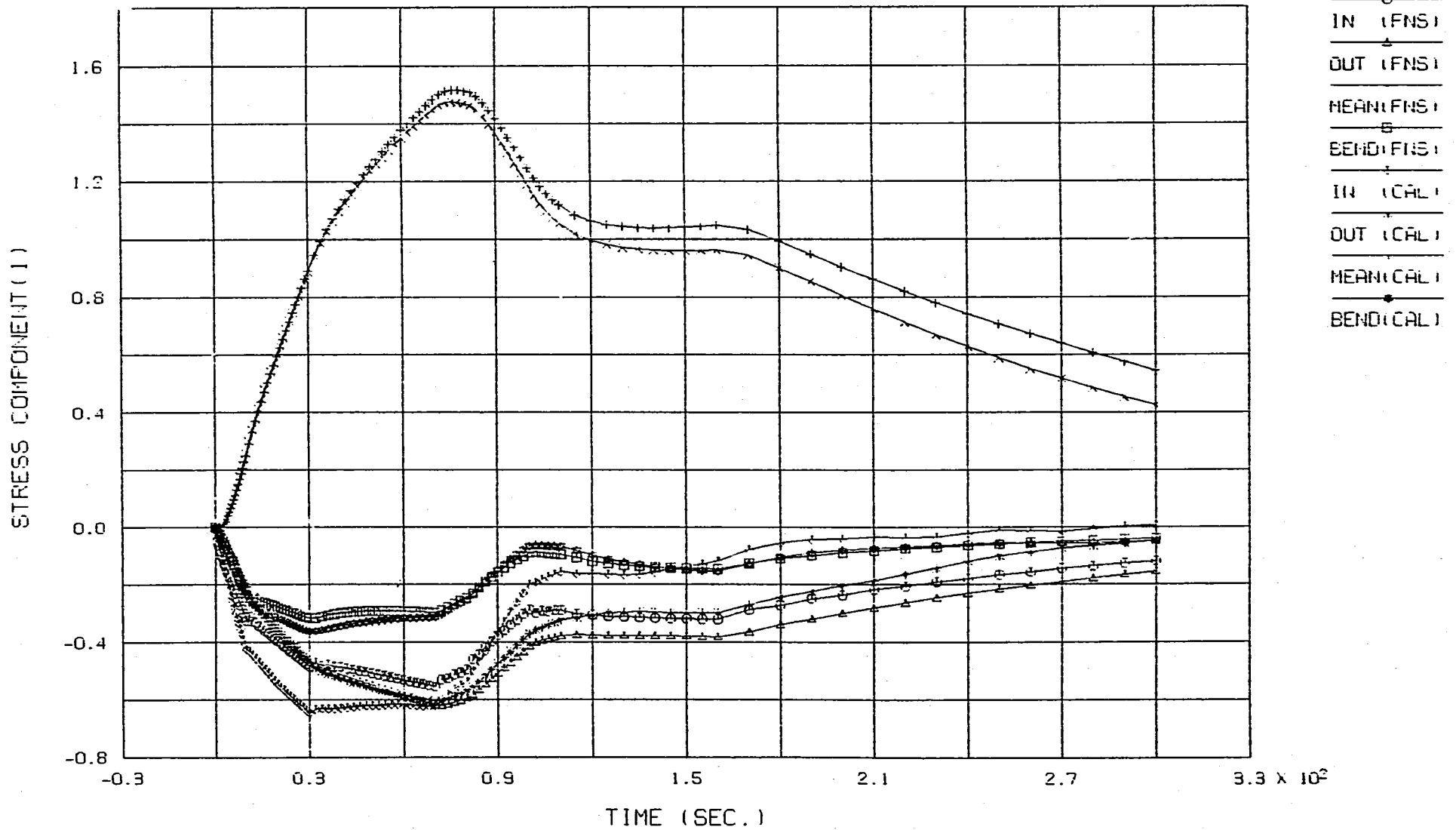
STRESS COMPONENT(3) OF SECTION(3)

図17. 3(3) 評価断面3の応力テンソル成分3



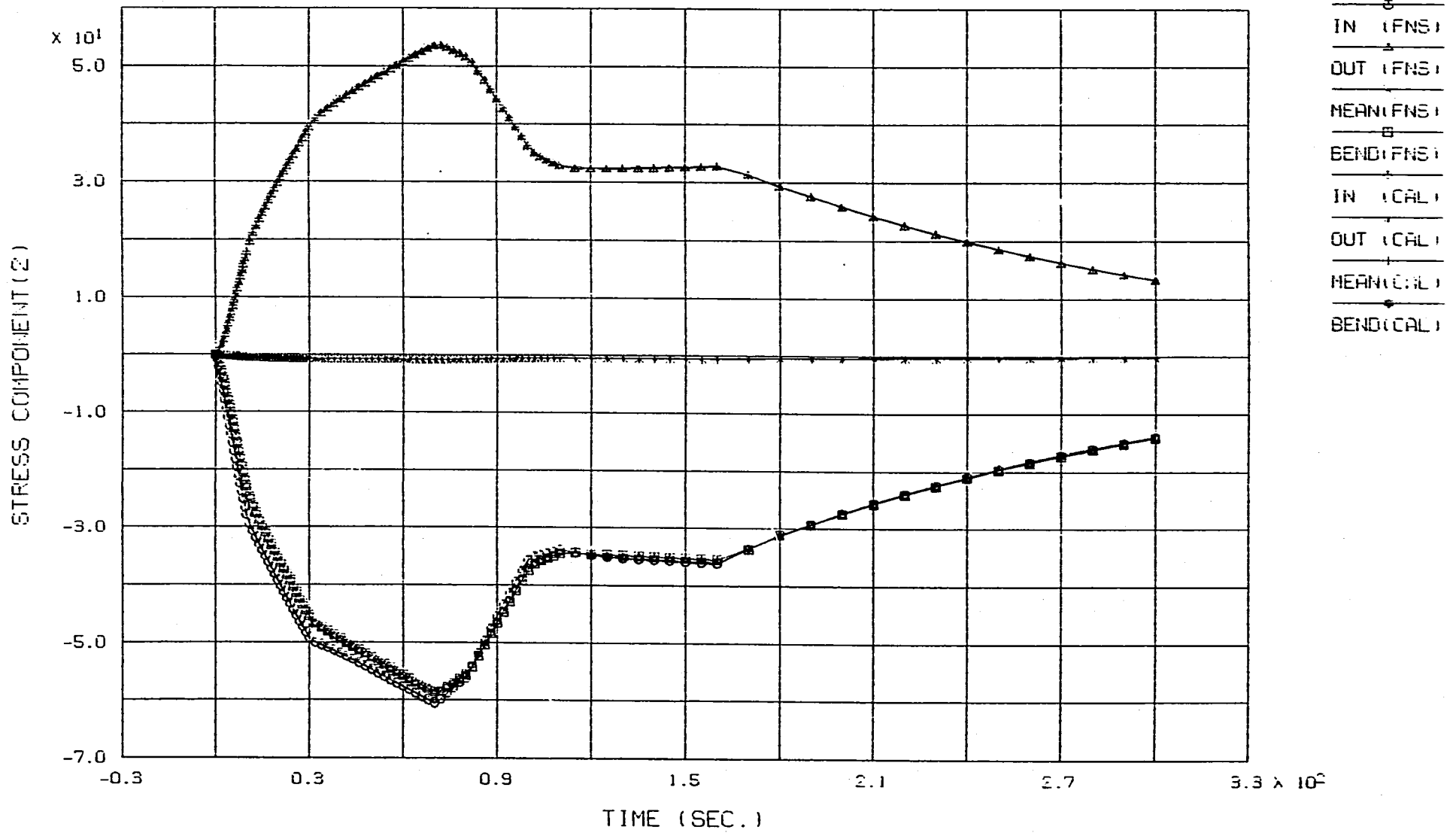
STRESS COMPONENT(4) OF SECTION(3)

図17. 3(4) 評価断面3の応力テンソル成分4



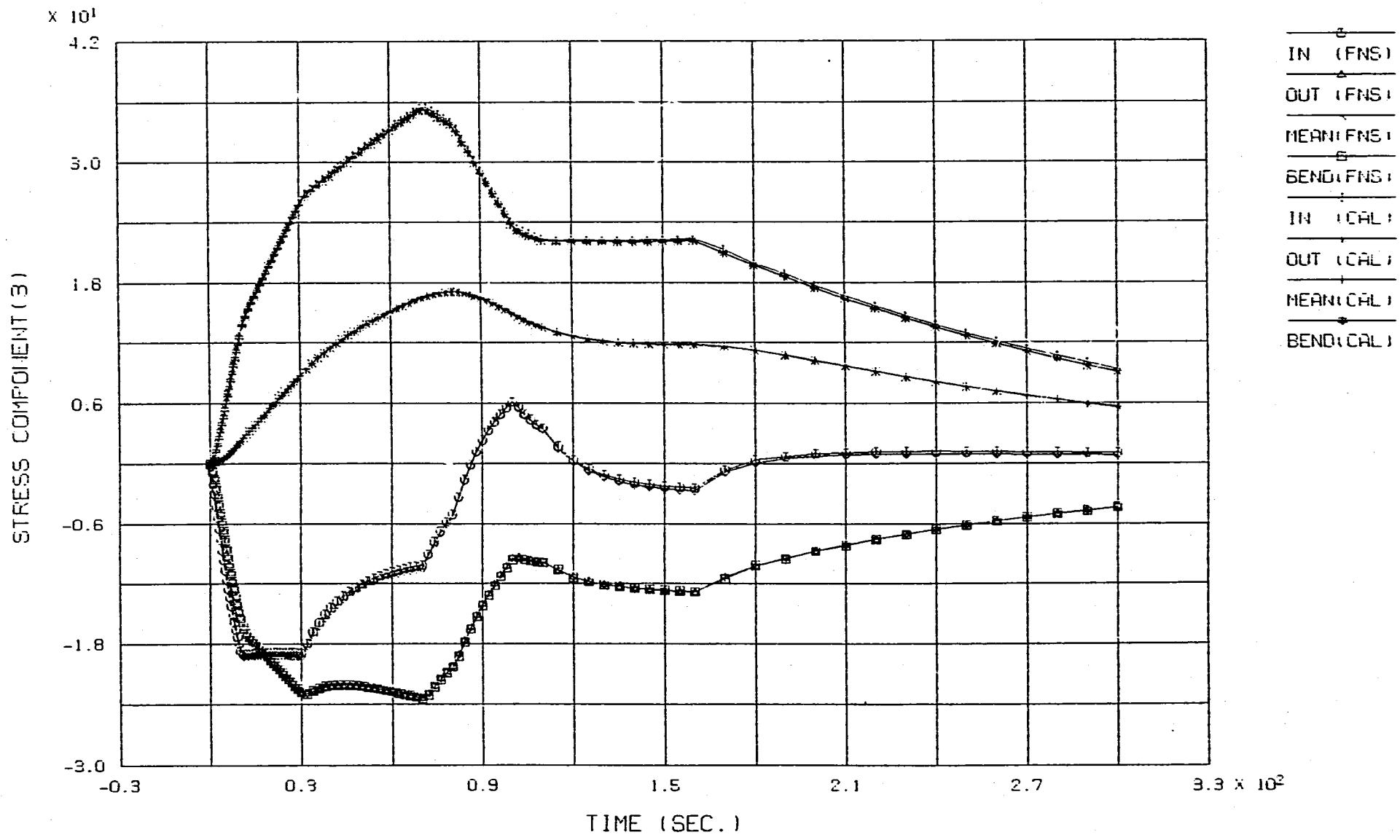
STRESS COMPONENT(1) OF SECTION(4)

図17. 4(1) 評価断面4の応力テンソル成分1



STRESS COMPONENT (2) OF SECTION (4)

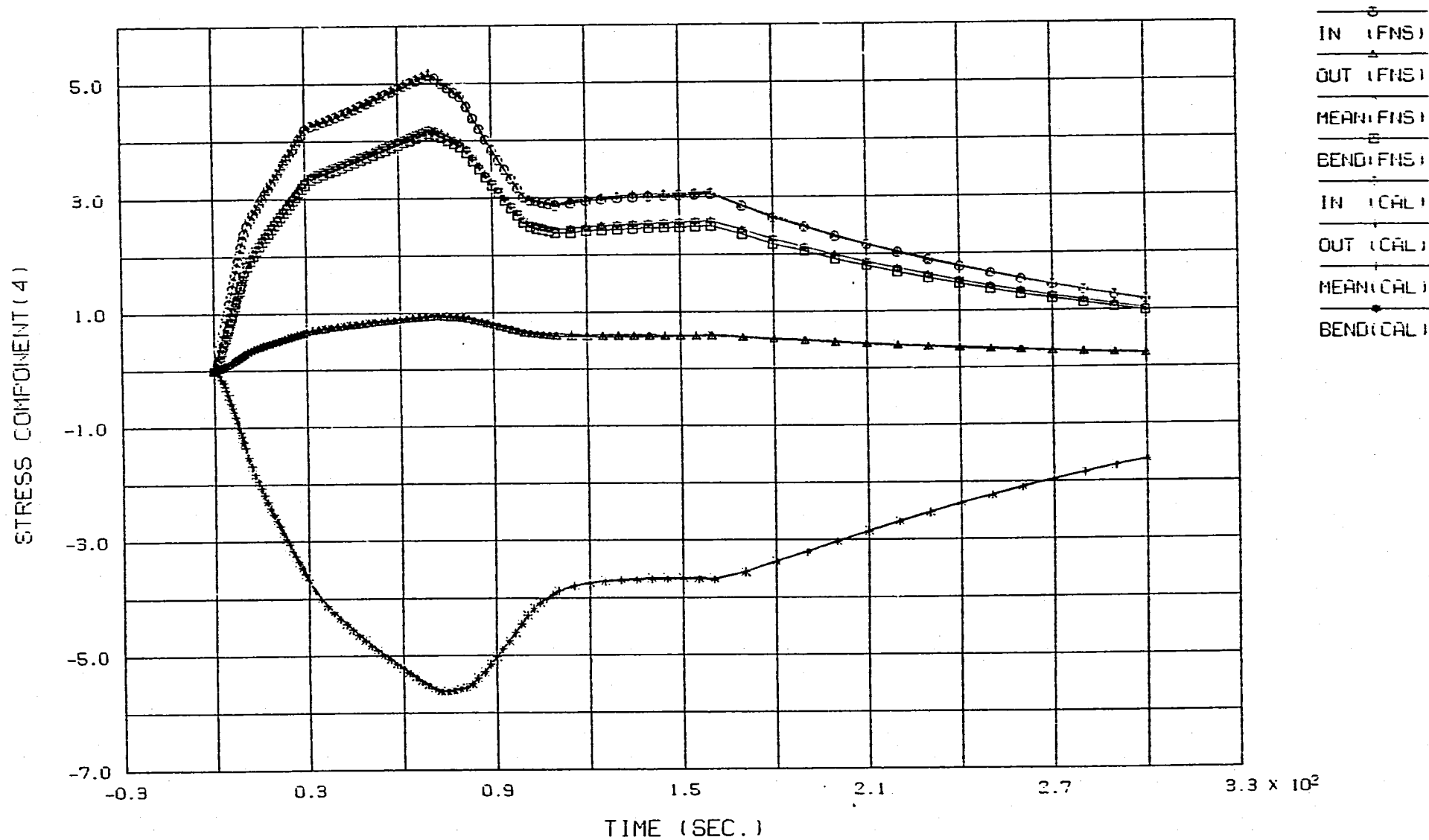
図17. 4 (2) 評価断面4の応力テンソル成分2



- 278 -

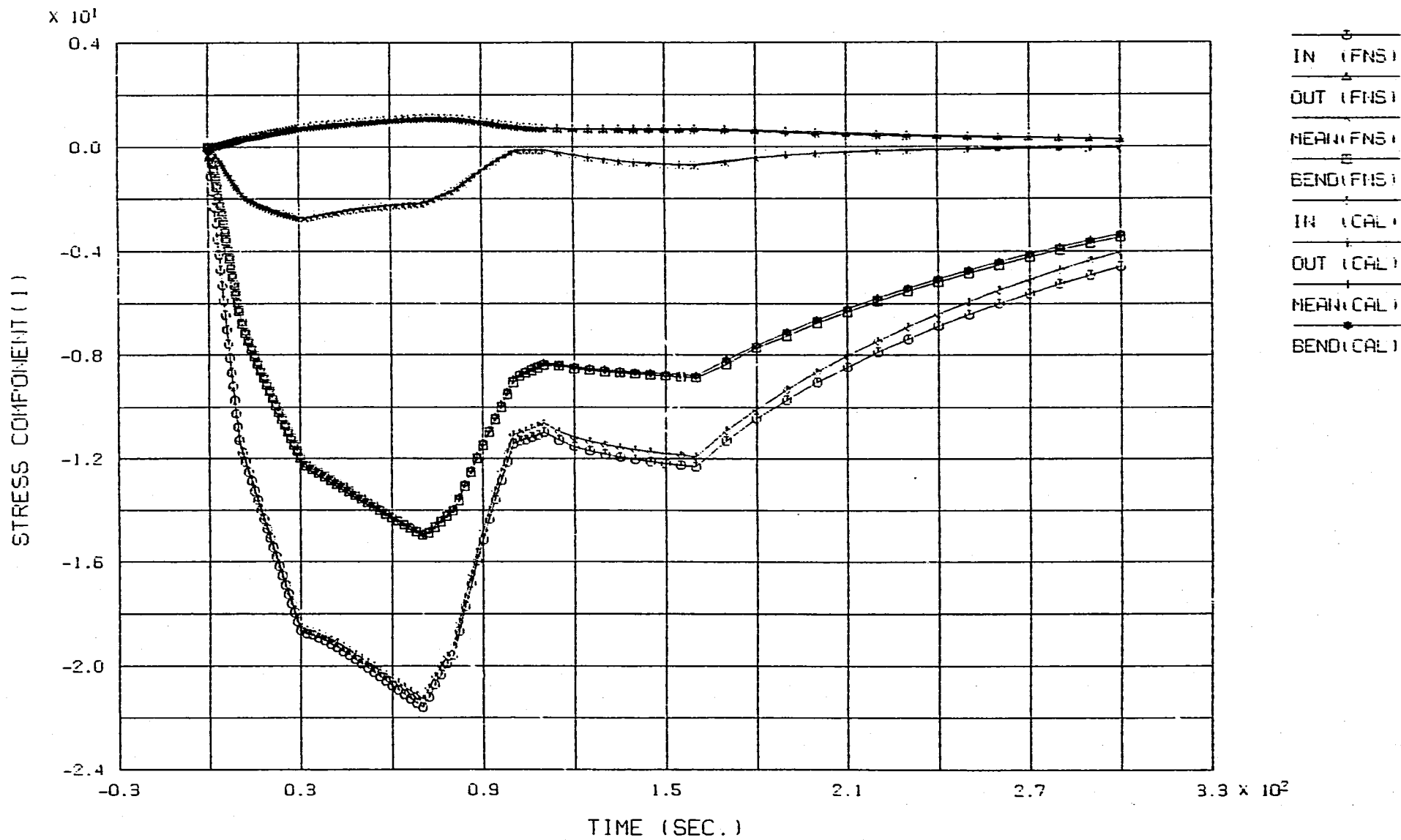
STRESS COMPONENT(3) OF SECTION(4)

図17. 4(3) 評価断面4の応力テンソル成分3



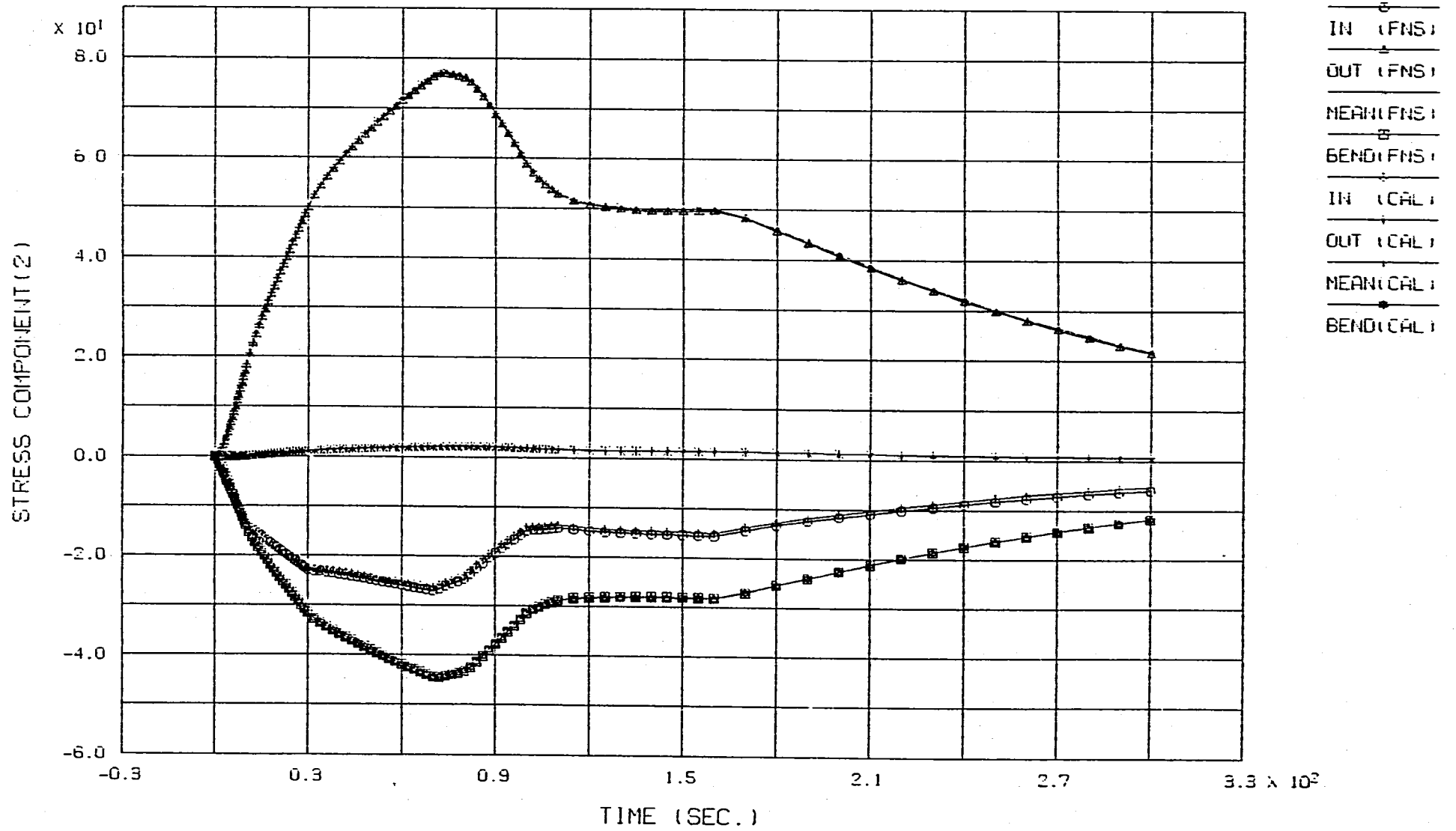
STRESS COMPONENT(4) OF SECTION(4)

図17. 4(4) 評価断面4の応力テンソル成分4



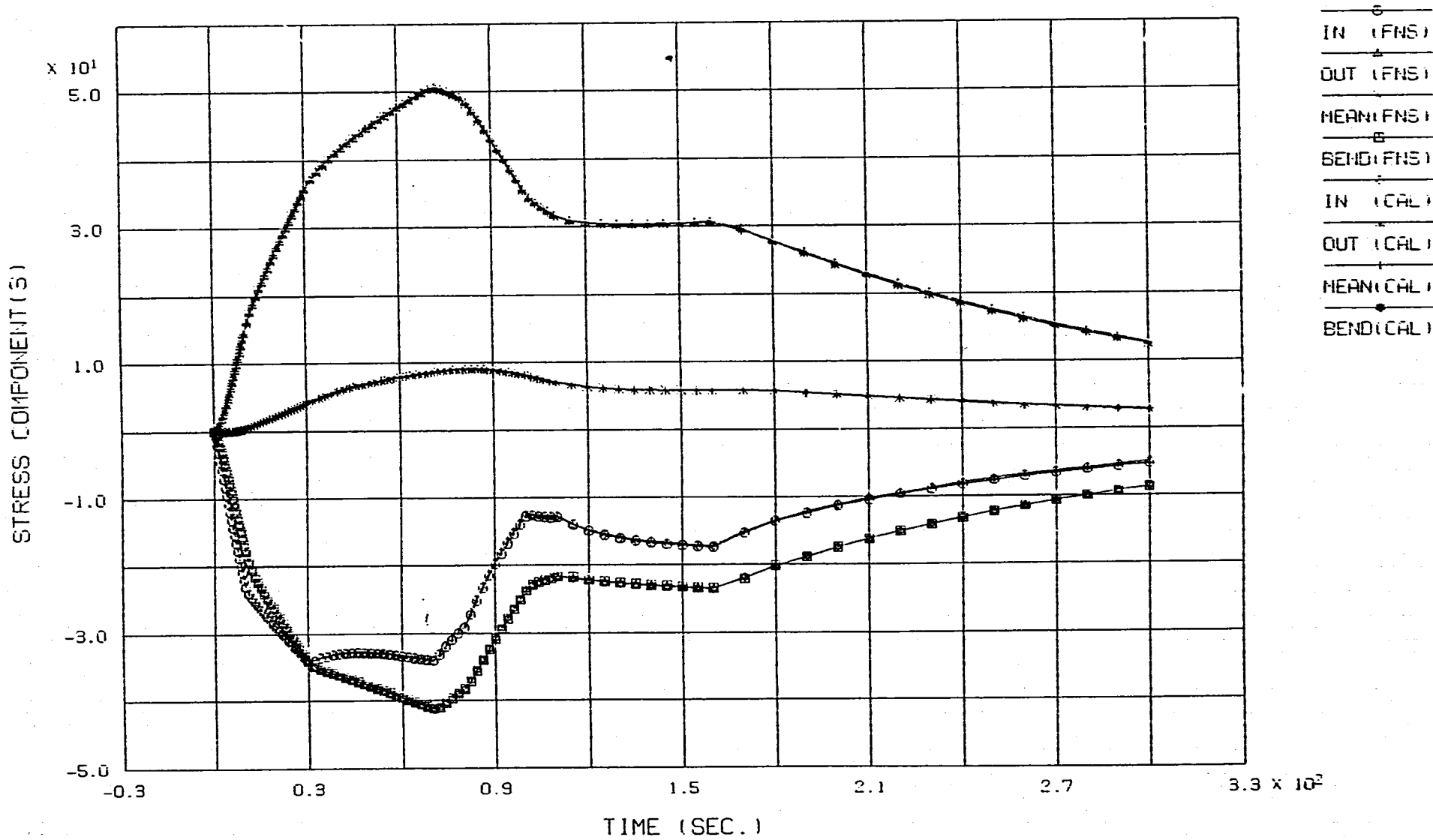
STRESS COMPONENT (1) OF SECTION (5)

図17. 5 (1) 評価断面5の応力テンソル成分1



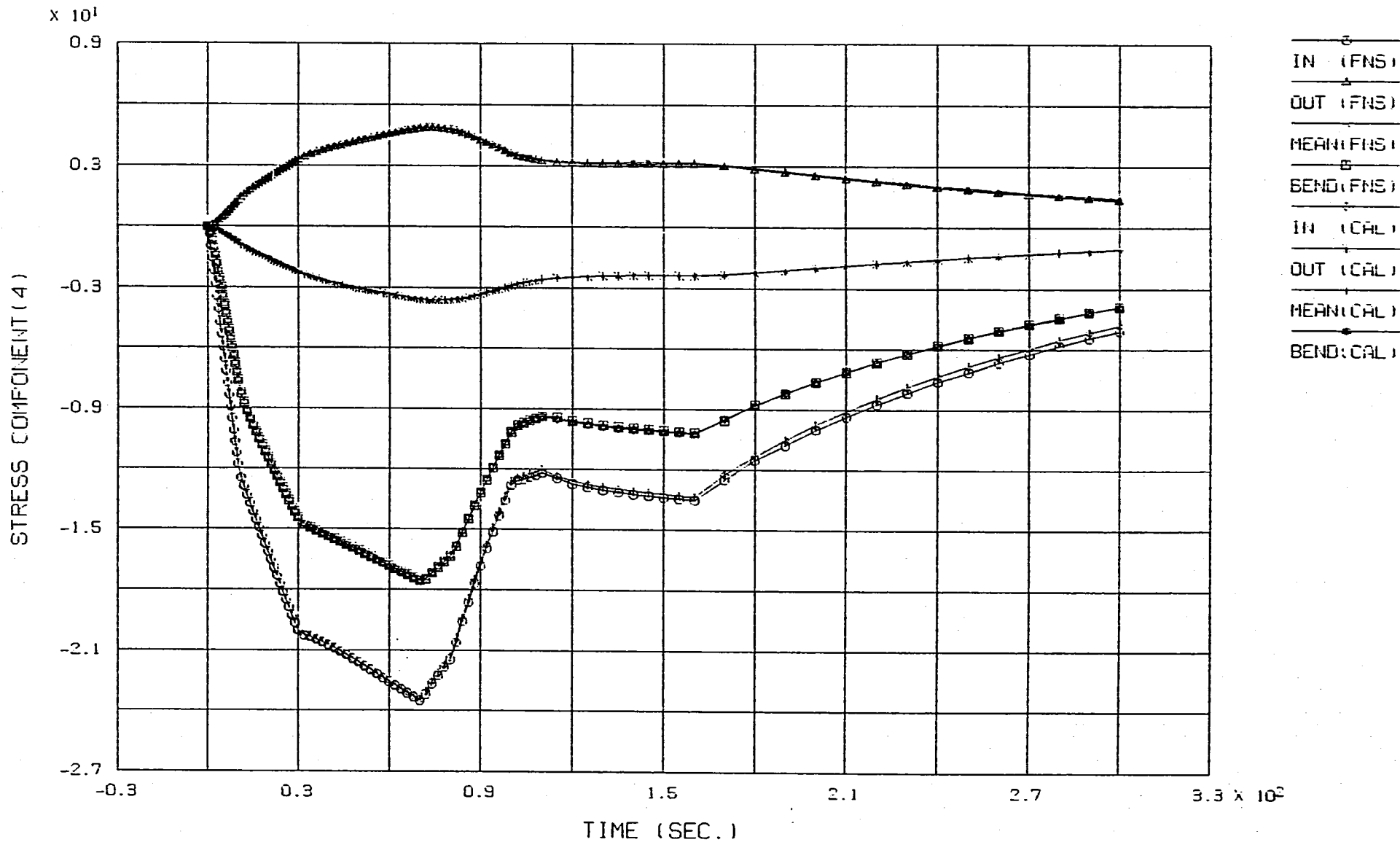
STRESS COMPONENT (2) OF SECTION (5)

図17.5(2) 評価断面5の応力テンソル成分2



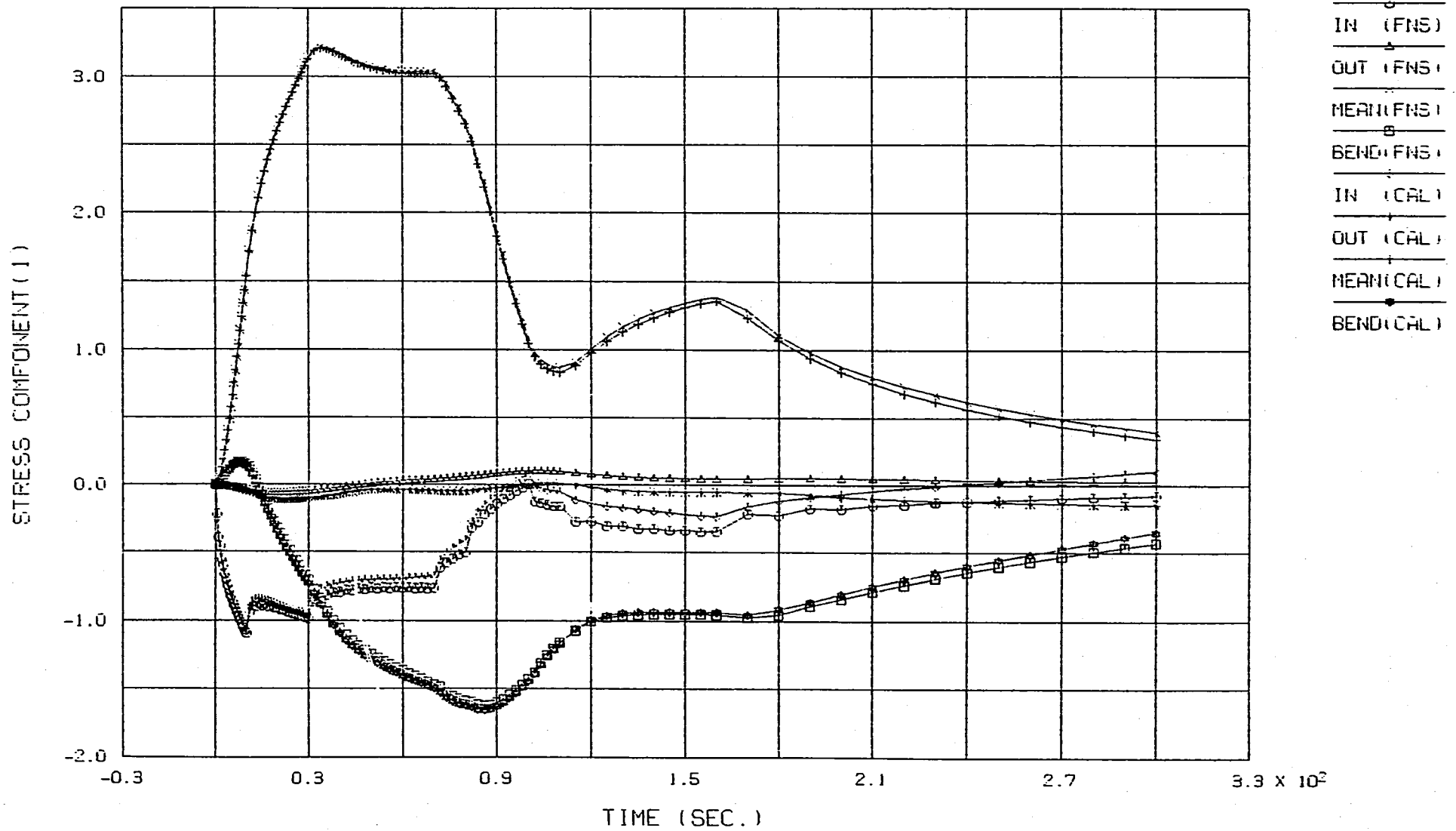
STRESS COMPONENT(3) OF SECTION(5)

図17. 5(3) 評価断面5の応力テンソル成分3



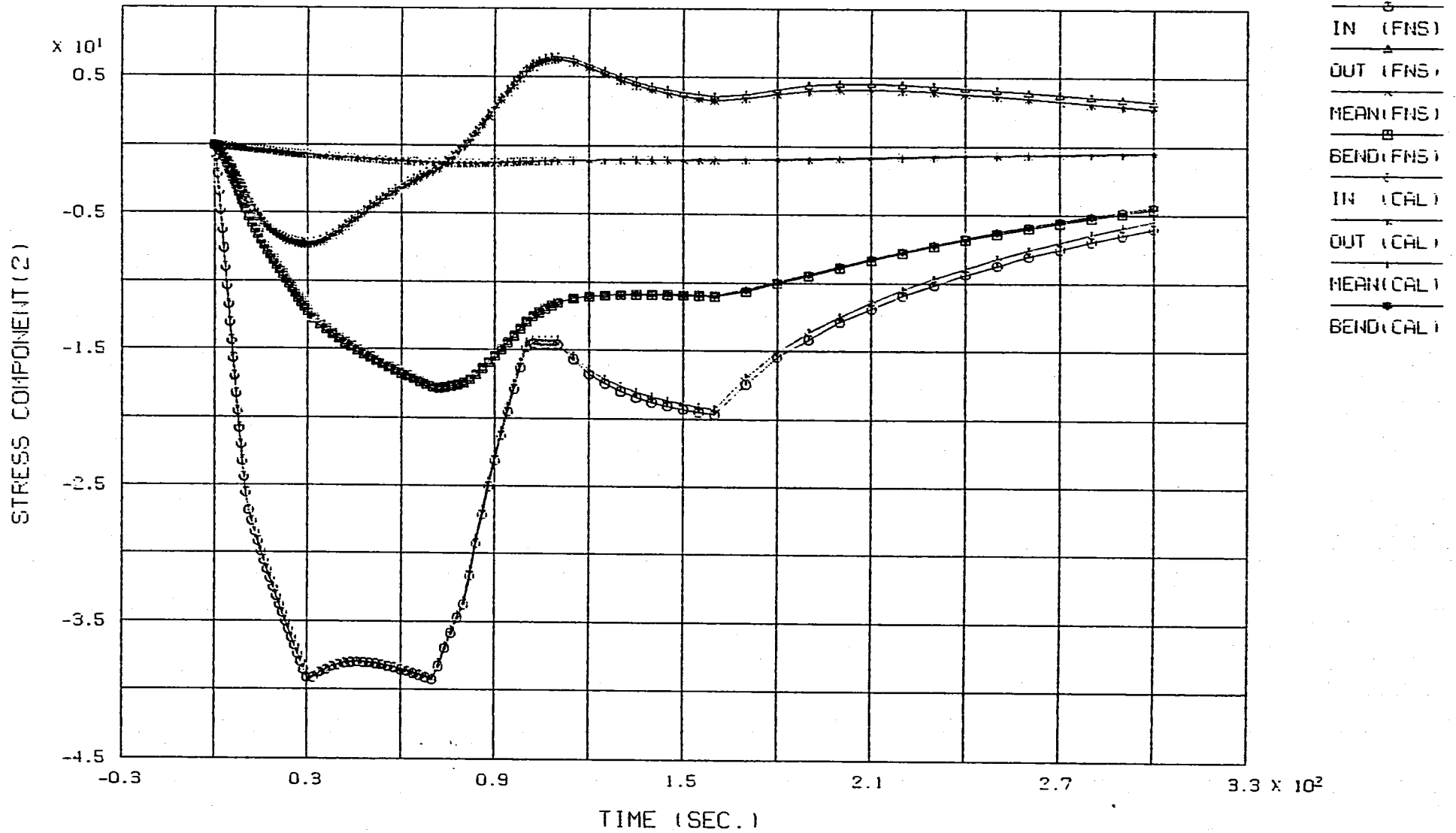
STRESS COMPONENT(4) OF SECTION(5)

図17. 5(4) 評価断面5の応力テンソル成分4



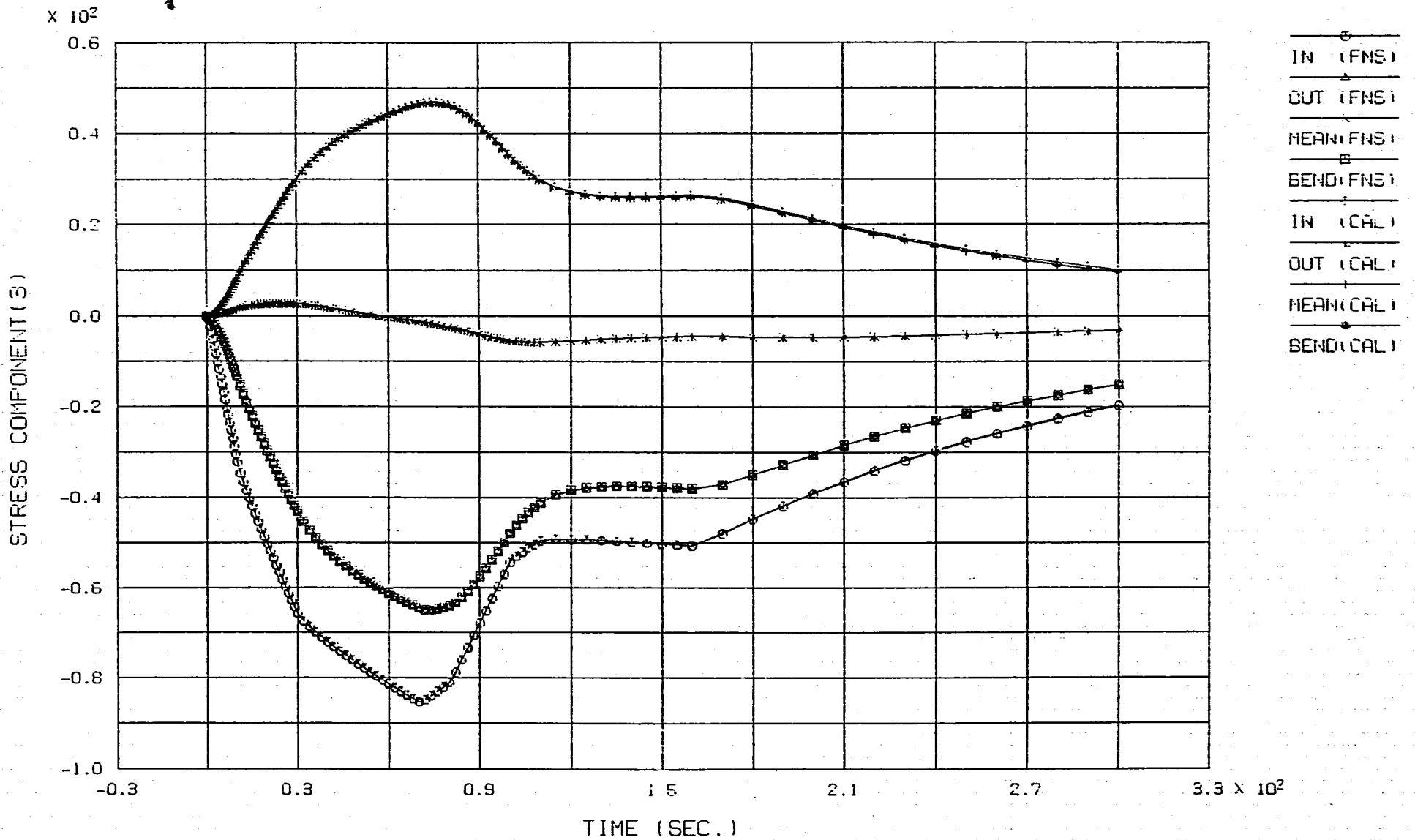
STRESS COMPONENT (1) OF SECTION (6)

図17. 6 (1) 評価断面6の応力テンソル成分1



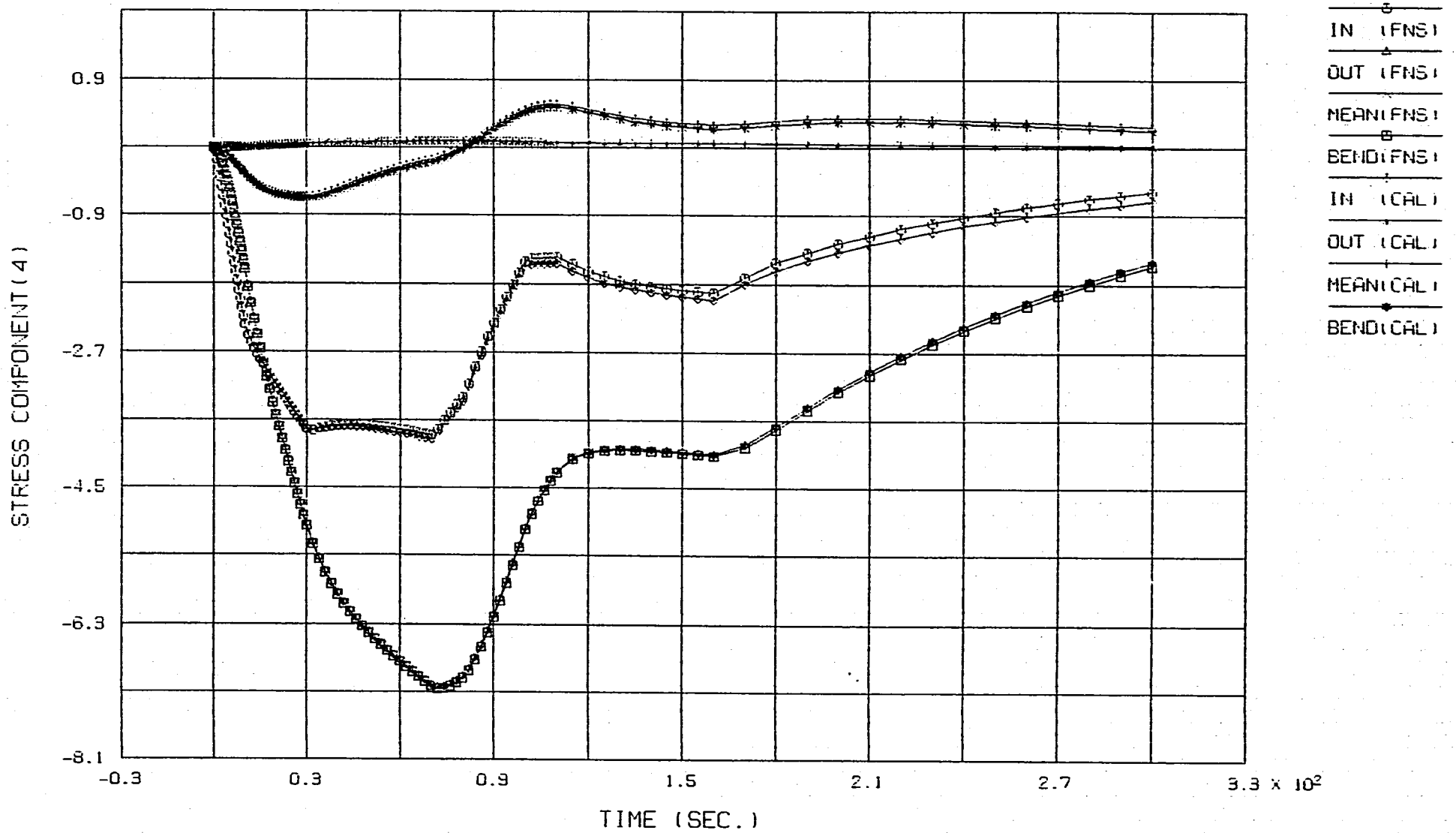
STRESS COMPONENT (2) OF SECTION (6)

図17.6(2) 評価断面6の応力テンソル成分2



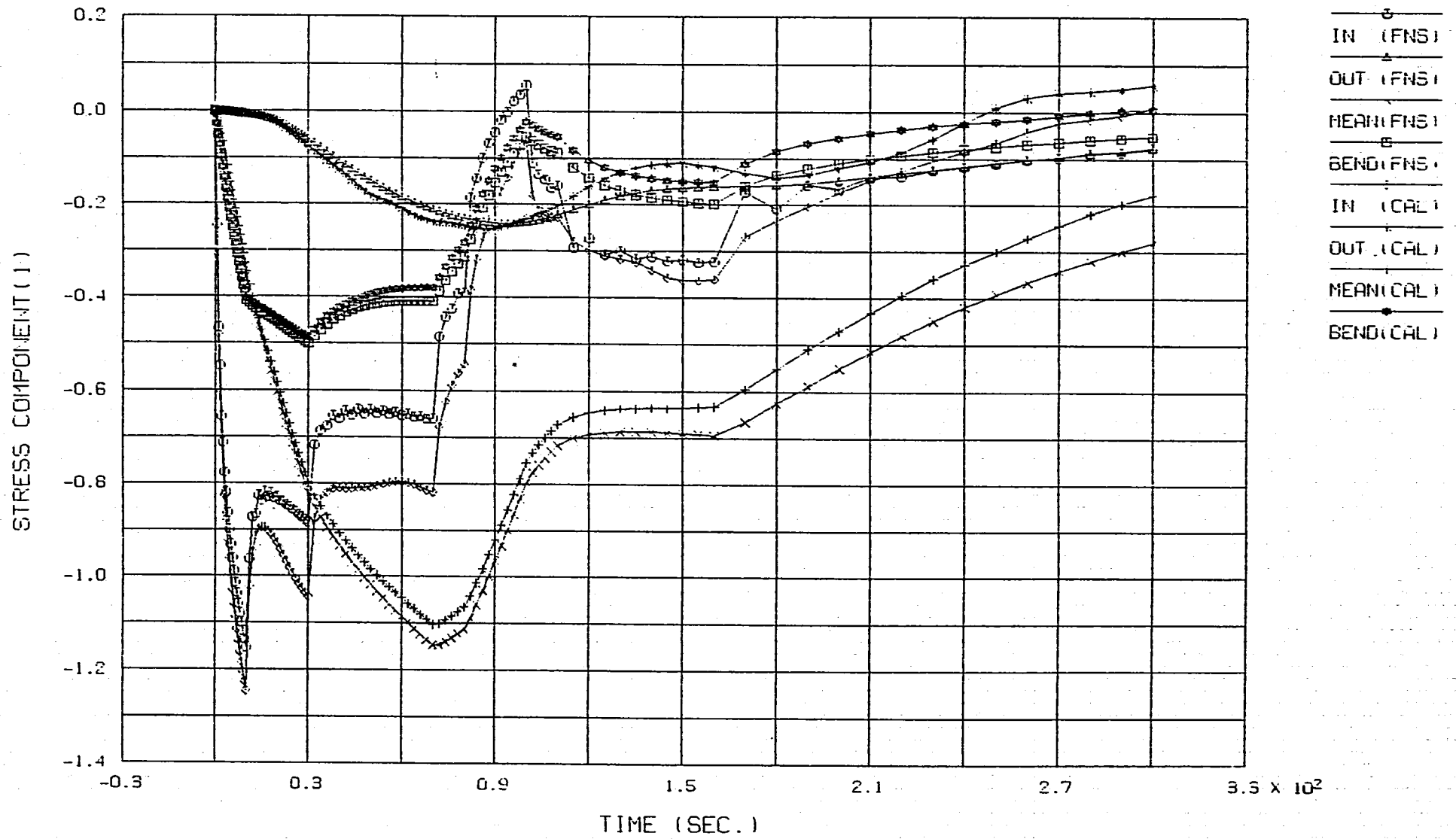
STRESS COMPONENT(3) OF SECTION(6)

図17. 6(3) 評価断面6の応力テンソル成分3



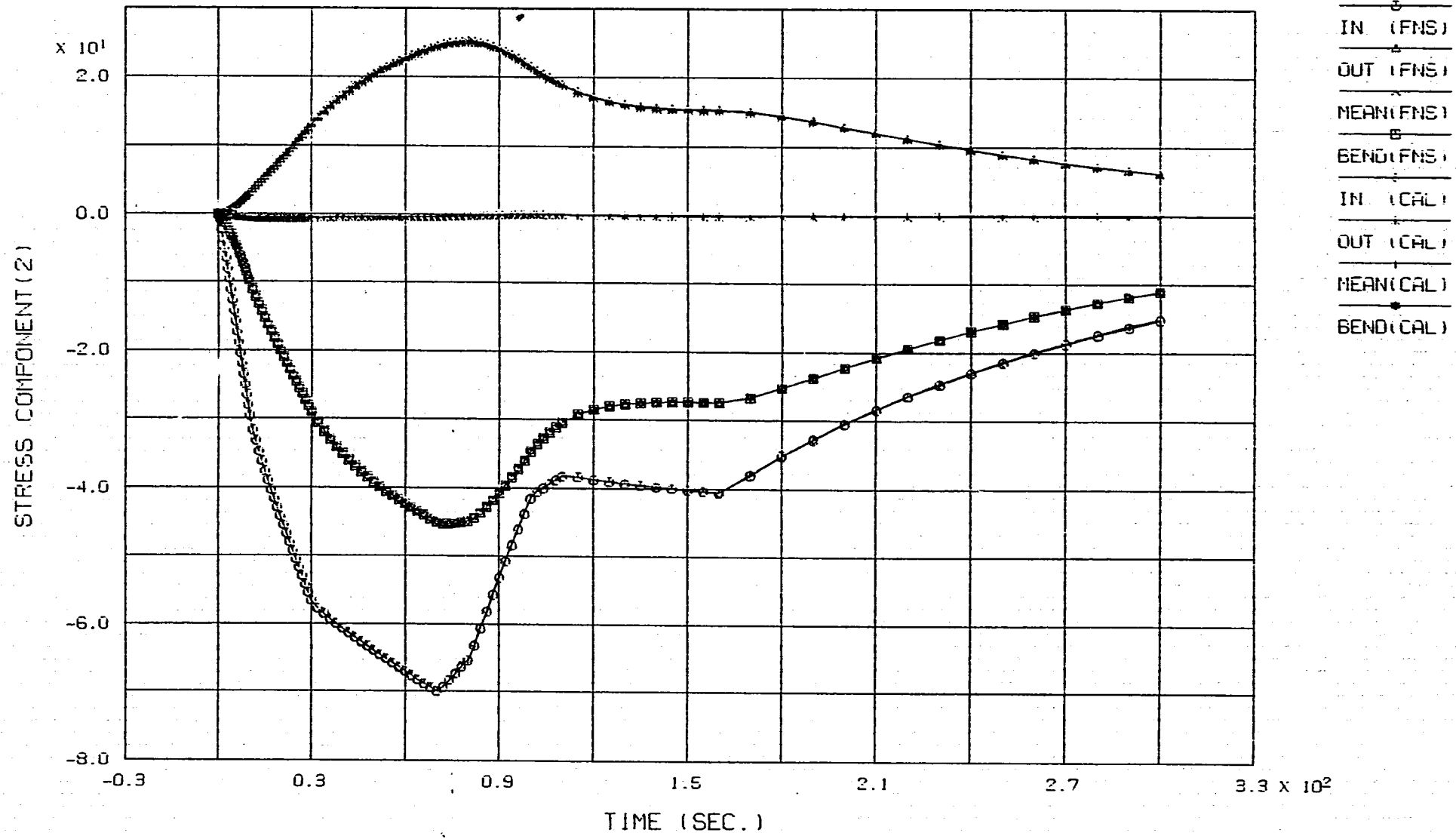
STRESS COMPONENT(4) OF SECTION(6)

図17. 6(4) 評価断面6の応力テンソル成分4



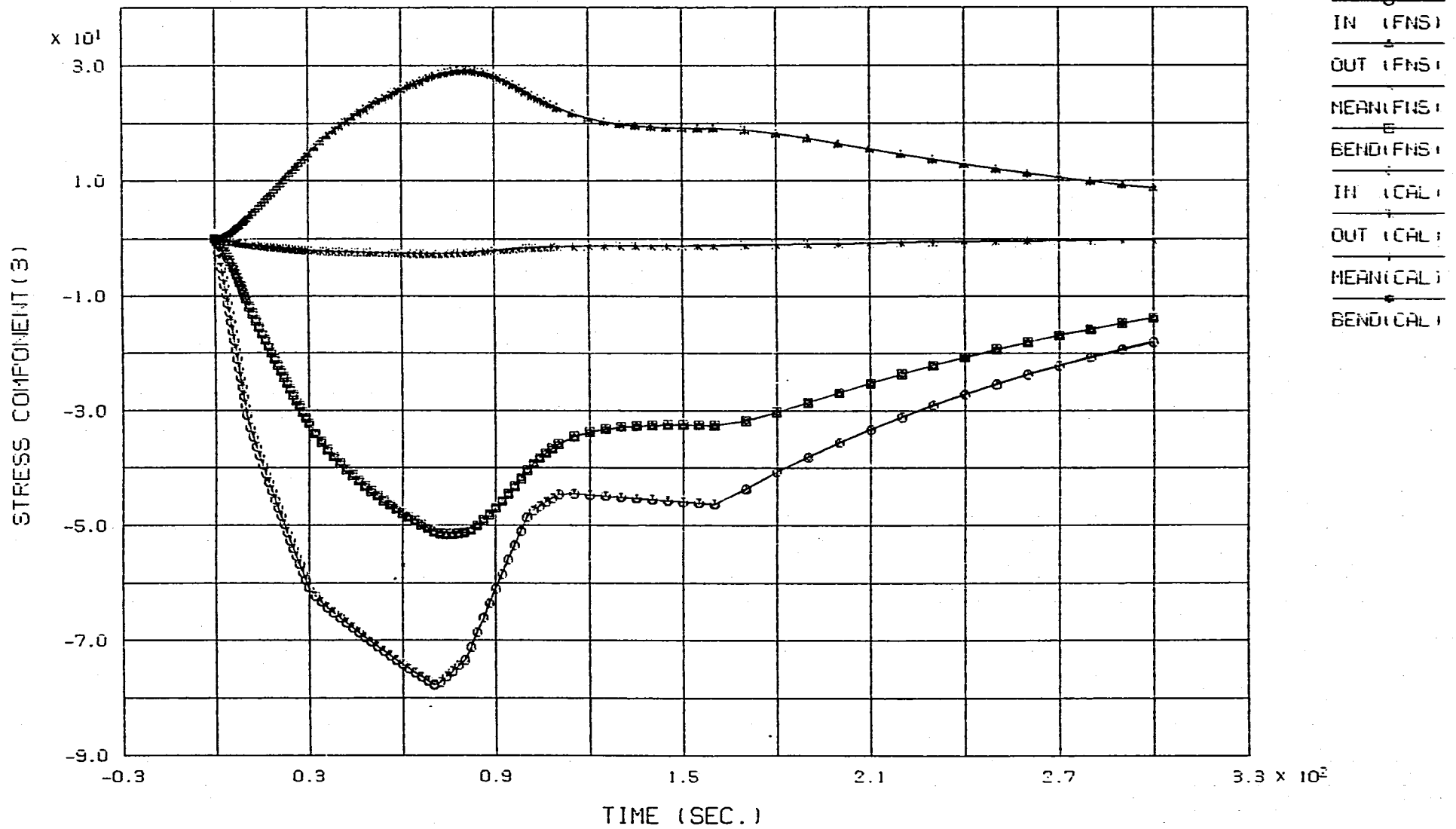
STRESS COMPONENT (1) OF SECTION (7)

図17. 7(1) 評価断面7の応力テンソル成分1



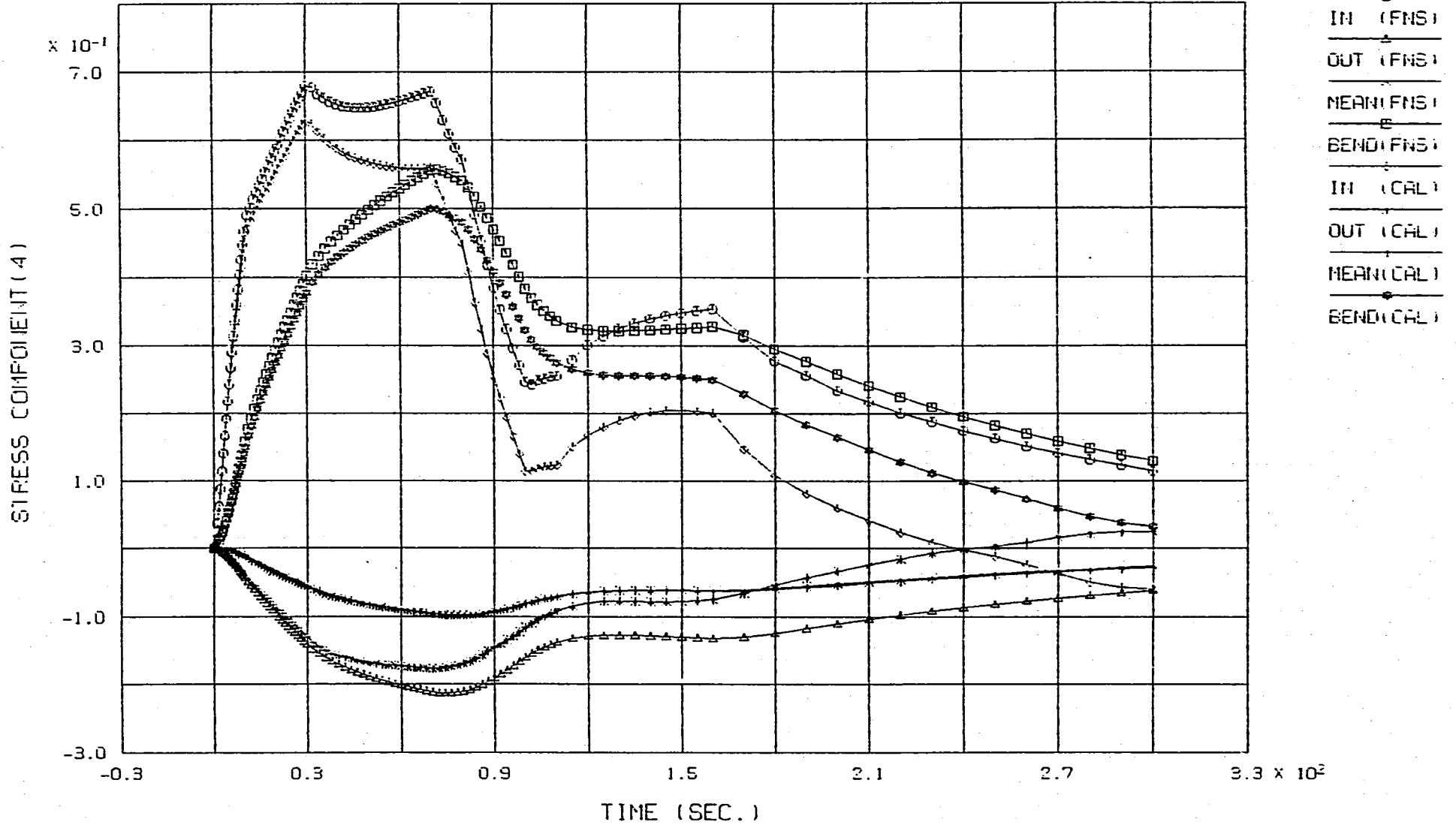
STRESS COMPONENT(2) OF SECTION(7)

図17. 7(2) 評価断面7の応力テンソル成分2



STRESS COMPONENT (3) OF SECTION (7)

図17. 7 (3) 評価断面7の応力テンソル成分3



STRESS COMPONENT (4) OF SECTION (7)

図17. 7(4) 評価断面7の応力テンソル成分4

表6. 1 評価断面1の温度

FINAS解と簡易計算値との比較 (ホットショック)

断面1の温度

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|--------|--------|------|--------|--------|--------|------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 300.00 | 300.00 | 300.00 | 0.00 | 300.00 | 300.00 | 300.00 | 0.00 |
| 2 | 0.5 | 301.83 | 300.17 | 300.63 | 0.75 | 302.09 | 300.07 | 300.68 | 0.97 |
| 3 | 1.0 | 304.85 | 300.97 | 302.23 | 1.91 | 304.97 | 300.95 | 302.27 | 2.00 |
| 4 | 1.5 | 308.10 | 302.66 | 304.51 | 2.72 | 308.29 | 302.65 | 304.55 | 2.84 |
| 5 | 2.0 | 311.81 | 305.04 | 307.36 | 3.39 | 311.94 | 305.03 | 307.39 | 3.50 |
| 6 | 2.5 | 315.71 | 307.95 | 310.64 | 3.92 | 315.86 | 307.94 | 310.68 | 4.03 |
| 7 | 3.0 | 319.89 | 311.29 | 314.28 | 4.34 | 320.01 | 311.29 | 314.31 | 4.45 |
| 8 | 3.5 | 324.20 | 314.97 | 318.19 | 4.67 | 324.33 | 314.97 | 318.22 | 4.78 |
| 9 | 4.0 | 328.68 | 318.92 | 322.33 | 4.94 | 328.78 | 318.92 | 322.35 | 5.05 |
| 10 | 4.5 | 333.24 | 323.08 | 326.64 | 5.15 | 333.34 | 323.09 | 326.67 | 5.26 |
| 11 | 5.0 | 337.91 | 327.42 | 331.10 | 5.32 | 338.00 | 327.44 | 331.12 | 5.43 |
| 12 | 5.5 | 342.64 | 331.89 | 335.66 | 5.45 | 342.72 | 331.91 | 335.68 | 5.57 |
| 13 | 6.0 | 347.43 | 336.47 | 340.32 | 5.56 | 347.49 | 336.49 | 340.34 | 5.68 |
| 14 | 6.5 | 352.25 | 341.14 | 345.04 | 5.64 | 352.30 | 341.15 | 345.06 | 5.76 |
| 15 | 7.0 | 357.12 | 345.87 | 349.82 | 5.71 | 357.15 | 345.88 | 349.84 | 5.83 |
| 16 | 7.5 | 362.01 | 350.66 | 354.65 | 5.76 | 362.03 | 350.67 | 354.67 | 5.89 |
| 17 | 8.0 | 366.93 | 355.49 | 359.51 | 5.80 | 366.94 | 355.50 | 359.53 | 5.94 |
| 18 | 8.5 | 371.85 | 360.36 | 364.40 | 5.84 | 371.86 | 360.37 | 364.42 | 5.97 |
| 19 | 9.0 | 376.80 | 365.25 | 369.32 | 5.86 | 376.79 | 365.26 | 369.33 | 6.00 |
| 20 | 9.5 | 381.76 | 370.17 | 374.25 | 5.88 | 381.74 | 370.18 | 374.26 | 6.03 |
| 21 | 10.0 | 386.73 | 375.10 | 379.19 | 5.90 | 386.69 | 375.11 | 379.21 | 6.04 |
| 22 | 11.0 | 394.40 | 384.49 | 388.05 | 5.09 | 394.25 | 384.49 | 388.03 | 5.16 |
| 23 | 12.0 | 400.72 | 392.52 | 395.43 | 4.17 | 400.72 | 392.41 | 395.44 | 4.43 |
| 24 | 13.0 | 406.75 | 399.31 | 401.94 | 3.80 | 406.64 | 399.26 | 401.96 | 3.96 |
| 25 | 14.0 | 412.28 | 405.47 | 407.88 | 3.46 | 412.22 | 405.42 | 407.92 | 3.66 |
| 26 | 15.0 | 417.68 | 411.19 | 413.48 | 3.30 | 417.59 | 411.16 | 413.54 | 3.47 |
| 27 | 16.0 | 422.89 | 416.65 | 418.85 | 3.17 | 422.82 | 416.63 | 418.93 | 3.35 |
| 28 | 17.0 | 428.05 | 421.93 | 424.09 | 3.11 | 427.97 | 421.93 | 424.18 | 3.27 |
| 29 | 18.0 | 433.13 | 427.11 | 429.23 | 3.06 | 433.06 | 427.12 | 429.33 | 3.22 |
| 30 | 19.0 | 438.20 | 432.23 | 434.33 | 3.03 | 438.11 | 432.23 | 434.42 | 3.19 |
| 31 | 20.0 | 443.22 | 437.29 | 439.38 | 3.01 | 443.13 | 437.30 | 439.48 | 3.17 |
| 32 | 21.0 | 448.25 | 442.34 | 444.42 | 3.00 | 448.14 | 442.35 | 444.52 | 3.16 |
| 33 | 22.0 | 453.26 | 447.36 | 449.44 | 3.00 | 453.14 | 447.37 | 449.54 | 3.15 |
| 34 | 23.0 | 458.27 | 452.38 | 454.46 | 2.99 | 458.14 | 452.38 | 454.55 | 3.15 |
| 35 | 24.0 | 463.27 | 457.39 | 459.46 | 2.99 | 463.12 | 457.39 | 459.55 | 3.14 |
| 36 | 25.0 | 468.28 | 462.40 | 464.47 | 2.99 | 468.10 | 462.38 | 464.55 | 3.14 |
| 37 | 26.0 | 473.28 | 467.40 | 469.47 | 2.99 | 473.09 | 467.38 | 469.55 | 3.14 |
| 38 | 27.0 | 478.28 | 472.41 | 474.48 | 2.99 | 478.08 | 472.38 | 474.55 | 3.15 |
| 39 | 28.0 | 483.28 | 477.41 | 479.48 | 2.98 | 483.06 | 477.37 | 479.54 | 3.15 |
| 40 | 29.0 | 488.28 | 482.41 | 484.48 | 2.98 | 488.04 | 482.37 | 484.54 | 3.15 |
| 41 | 30.0 | 493.28 | 487.41 | 489.48 | 2.98 | 493.03 | 487.37 | 489.54 | 3.15 |
| 42 | 32.0 | 500.50 | 496.26 | 497.79 | 2.18 | 500.01 | 496.19 | 497.74 | 2.24 |
| 43 | 34.0 | 506.12 | 502.85 | 503.99 | 1.66 | 505.78 | 502.73 | 504.02 | 1.84 |
| 44 | 36.0 | 511.50 | 508.34 | 509.46 | 1.62 | 511.06 | 508.35 | 509.53 | 1.68 |
| 45 | 38.0 | 516.54 | 513.59 | 514.62 | 1.49 | 516.15 | 513.59 | 514.73 | 1.62 |
| 46 | 40.0 | 521.63 | 518.64 | 519.69 | 1.52 | 521.17 | 518.68 | 519.81 | 1.59 |
| 47 | 42.0 | 526.60 | 523.68 | 524.71 | 1.48 | 526.16 | 523.71 | 524.83 | 1.58 |
| 48 | 44.0 | 531.64 | 528.68 | 529.72 | 1.50 | 531.16 | 528.72 | 529.84 | 1.58 |
| 49 | 46.0 | 536.61 | 533.69 | 534.72 | 1.48 | 536.18 | 533.72 | 534.84 | 1.58 |
| 50 | 48.0 | 541.64 | 538.69 | 539.73 | 1.50 | 541.17 | 538.72 | 539.84 | 1.58 |
| 51 | 50.0 | 546.62 | 543.69 | 544.73 | 1.49 | 546.15 | 543.71 | 544.84 | 1.58 |
| 52 | 52.0 | 551.64 | 548.69 | 549.73 | 1.49 | 551.13 | 548.71 | 549.84 | 1.58 |
| 53 | 54.0 | 556.62 | 553.69 | 554.73 | 1.49 | 556.11 | 553.71 | 554.83 | 1.58 |
| 54 | 56.0 | 561.63 | 558.69 | 559.73 | 1.49 | 561.11 | 558.70 | 559.83 | 1.58 |

| | | | | | | | | | |
|-----|-------|--------|--------|--------|-------|--------|--------|--------|-------|
| 55 | 58.0 | 566.62 | 563.69 | 564.73 | 1.49 | 566.10 | 563.70 | 564.83 | 1.58 |
| 56 | 60.0 | 571.63 | 568.69 | 569.73 | 1.49 | 571.07 | 568.70 | 569.83 | 1.58 |
| 57 | 62.0 | 576.62 | 573.69 | 574.72 | 1.49 | 576.05 | 573.69 | 574.82 | 1.58 |
| 58 | 64.0 | 581.63 | 578.69 | 579.72 | 1.49 | 581.04 | 578.69 | 579.82 | 1.58 |
| 59 | 66.0 | 586.62 | 583.69 | 584.72 | 1.49 | 586.04 | 583.69 | 584.82 | 1.59 |
| 60 | 68.0 | 591.63 | 588.69 | 589.72 | 1.49 | 591.02 | 588.68 | 589.82 | 1.59 |
| 61 | 70.0 | 596.62 | 593.69 | 594.72 | 1.49 | 596.00 | 593.68 | 594.81 | 1.59 |
| 62 | 72.0 | 598.84 | 597.54 | 598.03 | 0.69 | 597.89 | 597.37 | 597.85 | 0.66 |
| 63 | 74.0 | 599.46 | 599.13 | 599.24 | 0.16 | 598.64 | 598.84 | 599.07 | 0.28 |
| 64 | 76.0 | 599.85 | 599.62 | 599.71 | 0.13 | 598.95 | 599.43 | 599.55 | 0.13 |
| 65 | 78.0 | 599.88 | 599.87 | 599.87 | 0.00 | 599.08 | 599.66 | 599.75 | 0.07 |
| 66 | 80.0 | 599.98 | 599.92 | 599.94 | 0.03 | 599.13 | 599.75 | 599.82 | 0.04 |
| 67 | 82.0 | 597.16 | 598.81 | 598.27 | -0.82 | 596.04 | 598.48 | 597.89 | -0.90 |
| 68 | 84.0 | 592.83 | 595.41 | 594.49 | -1.31 | 591.81 | 594.97 | 594.12 | -1.27 |
| 69 | 86.0 | 588.18 | 590.90 | 589.96 | -1.37 | 587.13 | 590.56 | 589.60 | -1.43 |
| 70 | 88.0 | 583.24 | 586.15 | 585.13 | -1.48 | 582.26 | 585.80 | 584.80 | -1.49 |
| 71 | 90.0 | 578.31 | 581.20 | 580.19 | -1.46 | 577.32 | 580.89 | 579.88 | -1.51 |
| 72 | 92.0 | 573.31 | 576.25 | 575.21 | -1.50 | 572.34 | 575.93 | 574.91 | -1.53 |
| 73 | 94.0 | 568.33 | 571.25 | 570.23 | -1.48 | 567.35 | 570.94 | 569.92 | -1.53 |
| 74 | 96.0 | 563.32 | 566.26 | 565.23 | -1.50 | 562.37 | 565.94 | 564.92 | -1.53 |
| 75 | 98.0 | 558.33 | 561.26 | 560.23 | -1.49 | 557.38 | 560.95 | 559.92 | -1.53 |
| 76 | 100.0 | 553.32 | 556.26 | 555.23 | -1.49 | 552.38 | 555.95 | 554.92 | -1.53 |
| 77 | 102.0 | 551.11 | 552.41 | 551.92 | -0.68 | 550.49 | 552.26 | 551.88 | -0.60 |
| 78 | 104.0 | 550.48 | 550.82 | 550.71 | -0.17 | 549.72 | 550.79 | 550.67 | -0.23 |
| 79 | 106.0 | 550.10 | 550.33 | 550.24 | -0.13 | 549.40 | 550.20 | 550.18 | -0.08 |
| 80 | 108.0 | 550.07 | 550.08 | 550.08 | 0.00 | 549.28 | 549.97 | 549.99 | -0.02 |
| 81 | 110.0 | 549.97 | 550.03 | 550.01 | -0.03 | 549.26 | 549.88 | 549.92 | 0.01 |
| 82 | 115.0 | 553.53 | 552.31 | 552.73 | 0.62 | 553.36 | 552.97 | 553.35 | 0.50 |
| 83 | 120.0 | 558.65 | 557.45 | 557.88 | 0.61 | 558.21 | 557.78 | 558.19 | 0.55 |
| 84 | 125.0 | 563.62 | 562.47 | 562.87 | 0.58 | 563.13 | 562.77 | 563.17 | 0.54 |
| 85 | 130.0 | 568.64 | 567.44 | 567.87 | 0.61 | 568.17 | 567.76 | 568.17 | 0.55 |
| 86 | 135.0 | 573.63 | 572.47 | 572.87 | 0.58 | 573.21 | 572.76 | 573.17 | 0.56 |
| 87 | 140.0 | 578.64 | 577.44 | 577.87 | 0.61 | 578.14 | 577.75 | 578.17 | 0.55 |
| 88 | 145.0 | 583.63 | 582.46 | 582.87 | 0.59 | 583.07 | 582.75 | 583.16 | 0.55 |
| 89 | 150.0 | 588.63 | 587.45 | 587.87 | 0.61 | 588.11 | 587.75 | 588.16 | 0.55 |
| 90 | 155.0 | 593.63 | 592.46 | 592.87 | 0.59 | 593.14 | 592.74 | 593.16 | 0.56 |
| 91 | 160.0 | 598.63 | 597.45 | 597.87 | 0.60 | 598.08 | 597.74 | 598.16 | 0.55 |
| 92 | 170.0 | 600.51 | 600.94 | 600.80 | -0.21 | 599.11 | 599.78 | 599.84 | 0.03 |
| 93 | 180.0 | 599.74 | 599.60 | 599.65 | 0.06 | 599.11 | 599.80 | 599.85 | 0.03 |
| 94 | 190.0 | 600.08 | 600.10 | 600.10 | 0.00 | 599.11 | 599.80 | 599.85 | 0.03 |
| 95 | 200.0 | 599.91 | 599.93 | 599.92 | -0.02 | 599.12 | 599.80 | 599.85 | 0.03 |
| 96 | 210.0 | 600.01 | 599.97 | 599.99 | 0.02 | 599.06 | 599.80 | 599.85 | 0.02 |
| 97 | 220.0 | 599.94 | 599.98 | 599.96 | -0.03 | 599.14 | 599.80 | 599.86 | 0.03 |
| 98 | 230.0 | 600.00 | 599.95 | 599.98 | 0.03 | 599.17 | 599.80 | 599.86 | 0.03 |
| 99 | 240.0 | 599.94 | 599.98 | 599.97 | -0.02 | 599.10 | 599.80 | 599.85 | 0.03 |
| 100 | 250.0 | 599.99 | 599.95 | 599.97 | 0.02 | 599.06 | 599.80 | 599.85 | 0.02 |
| 101 | 260.0 | 599.95 | 599.98 | 599.97 | -0.02 | 599.13 | 599.80 | 599.85 | 0.03 |
| 102 | 270.0 | 599.99 | 599.96 | 599.97 | 0.02 | 599.17 | 599.80 | 599.86 | 0.03 |
| 103 | 280.0 | 599.95 | 599.98 | 599.97 | -0.02 | 599.12 | 599.80 | 599.85 | 0.03 |
| 104 | 290.0 | 599.99 | 599.96 | 599.97 | 0.02 | 599.07 | 599.80 | 599.85 | 0.02 |
| 105 | 300.0 | 599.95 | 599.98 | 599.97 | -0.02 | 599.12 | 599.80 | 599.85 | 0.03 |

表6. 2 評価断面2の温度

F I N A S解と簡易計算値との比較 (ホットショック)

断面2の温度

| ステップ | 時間(S) | F I N A S解 | | | | 簡易計算値 | | | |
|------|-------|------------|--------|--------|------|--------|--------|--------|------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 300.00 | 300.00 | 300.00 | 0.00 | 300.00 | 300.00 | 300.00 | 0.00 |
| 2 | 0.5 | 301.76 | 300.17 | 300.58 | 0.70 | 302.01 | 300.07 | 300.63 | 0.91 |
| 3 | 1.0 | 304.65 | 300.93 | 302.08 | 1.80 | 304.75 | 300.90 | 302.11 | 1.89 |
| 4 | 1.5 | 307.77 | 302.53 | 304.21 | 2.58 | 307.94 | 302.49 | 304.25 | 2.70 |
| 5 | 2.0 | 311.33 | 304.76 | 306.89 | 3.25 | 311.46 | 304.71 | 306.92 | 3.36 |
| 6 | 2.5 | 315.10 | 307.50 | 309.99 | 3.78 | 315.25 | 307.45 | 310.02 | 3.89 |
| 7 | 3.0 | 319.14 | 310.67 | 313.45 | 4.22 | 319.27 | 310.60 | 313.48 | 4.33 |
| 8 | 3.5 | 323.33 | 314.17 | 317.20 | 4.57 | 323.47 | 314.09 | 317.22 | 4.69 |
| 9 | 4.0 | 327.69 | 317.95 | 321.17 | 4.87 | 327.81 | 317.86 | 321.19 | 4.98 |
| 10 | 4.5 | 332.14 | 321.95 | 325.33 | 5.10 | 332.28 | 321.85 | 325.35 | 5.21 |
| 11 | 5.0 | 336.72 | 326.13 | 329.65 | 5.29 | 336.84 | 326.02 | 329.67 | 5.41 |
| 12 | 5.5 | 341.35 | 330.46 | 334.08 | 5.45 | 341.48 | 330.34 | 334.10 | 5.57 |
| 13 | 6.0 | 346.06 | 334.91 | 338.62 | 5.58 | 346.19 | 334.78 | 338.64 | 5.70 |
| 14 | 6.5 | 350.81 | 339.46 | 343.24 | 5.69 | 350.94 | 339.31 | 343.26 | 5.80 |
| 15 | 7.0 | 355.62 | 344.09 | 347.93 | 5.77 | 355.74 | 343.93 | 347.95 | 5.89 |
| 16 | 7.5 | 360.45 | 348.78 | 352.67 | 5.85 | 360.58 | 348.61 | 352.70 | 5.96 |
| 17 | 8.0 | 365.32 | 353.53 | 357.46 | 5.91 | 365.44 | 353.35 | 357.48 | 6.01 |
| 18 | 8.5 | 370.20 | 358.31 | 362.28 | 5.95 | 370.33 | 358.13 | 362.31 | 6.06 |
| 19 | 9.0 | 375.11 | 363.14 | 367.13 | 6.00 | 375.24 | 362.95 | 367.16 | 6.09 |
| 20 | 9.5 | 380.03 | 367.99 | 372.01 | 6.03 | 380.17 | 367.79 | 372.04 | 6.12 |
| 21 | 10.0 | 384.97 | 372.87 | 376.91 | 6.06 | 385.11 | 372.66 | 376.94 | 6.15 |
| 22 | 11.0 | 392.68 | 382.19 | 385.76 | 5.31 | 392.74 | 381.96 | 385.77 | 5.33 |
| 23 | 12.0 | 399.11 | 390.24 | 393.23 | 4.44 | 399.34 | 389.91 | 393.27 | 4.62 |
| 24 | 13.0 | 405.23 | 397.15 | 399.87 | 4.06 | 405.39 | 396.85 | 399.92 | 4.15 |
| 25 | 14.0 | 410.86 | 403.44 | 405.94 | 3.71 | 411.10 | 403.13 | 406.02 | 3.84 |
| 26 | 15.0 | 416.35 | 409.29 | 411.66 | 3.53 | 416.57 | 408.98 | 411.74 | 3.63 |
| 27 | 16.0 | 421.62 | 414.84 | 417.12 | 3.39 | 421.89 | 414.55 | 417.23 | 3.49 |
| 28 | 17.0 | 426.84 | 420.22 | 422.44 | 3.31 | 427.11 | 419.92 | 422.55 | 3.40 |
| 29 | 18.0 | 431.96 | 425.46 | 427.64 | 3.25 | 432.27 | 425.17 | 427.77 | 3.33 |
| 30 | 19.0 | 437.06 | 430.64 | 432.79 | 3.21 | 437.37 | 430.34 | 432.92 | 3.29 |
| 31 | 20.0 | 442.11 | 435.75 | 437.88 | 3.18 | 442.44 | 435.45 | 438.03 | 3.27 |
| 32 | 21.0 | 447.16 | 440.83 | 442.95 | 3.16 | 447.48 | 440.52 | 443.09 | 3.25 |
| 33 | 22.0 | 452.18 | 445.88 | 447.99 | 3.15 | 452.52 | 445.56 | 448.14 | 3.24 |
| 34 | 23.0 | 457.21 | 450.92 | 453.02 | 3.14 | 457.54 | 450.58 | 453.17 | 3.24 |
| 35 | 24.0 | 462.21 | 455.94 | 458.04 | 3.14 | 462.55 | 455.59 | 458.19 | 3.24 |
| 36 | 25.0 | 467.23 | 460.96 | 463.06 | 3.13 | 467.55 | 460.59 | 463.20 | 3.24 |
| 37 | 26.0 | 472.23 | 465.97 | 468.07 | 3.13 | 472.57 | 465.59 | 468.21 | 3.24 |
| 38 | 27.0 | 477.24 | 470.98 | 473.08 | 3.13 | 477.58 | 470.58 | 473.22 | 3.25 |
| 39 | 28.0 | 482.24 | 475.99 | 478.08 | 3.13 | 482.58 | 475.56 | 478.22 | 3.25 |
| 40 | 29.0 | 487.25 | 480.99 | 483.09 | 3.12 | 487.58 | 480.54 | 483.22 | 3.26 |
| 41 | 30.0 | 492.24 | 486.00 | 488.09 | 3.12 | 492.59 | 485.52 | 488.22 | 3.27 |
| 42 | 32.0 | 499.57 | 494.91 | 496.51 | 2.35 | 499.72 | 494.38 | 496.54 | 2.41 |
| 43 | 34.0 | 505.34 | 501.67 | 502.90 | 1.82 | 505.64 | 501.08 | 502.98 | 2.01 |
| 44 | 36.0 | 510.81 | 507.33 | 508.51 | 1.75 | 511.04 | 506.82 | 508.62 | 1.83 |
| 45 | 38.0 | 515.91 | 512.69 | 513.77 | 1.61 | 516.20 | 512.14 | 513.91 | 1.76 |
| 46 | 40.0 | 521.04 | 517.80 | 518.89 | 1.62 | 521.27 | 517.28 | 519.04 | 1.73 |
| 47 | 42.0 | 526.04 | 522.89 | 523.95 | 1.57 | 526.30 | 522.33 | 524.10 | 1.72 |
| 48 | 44.0 | 531.09 | 527.92 | 528.98 | 1.59 | 531.34 | 527.35 | 529.13 | 1.72 |
| 49 | 46.0 | 536.08 | 532.95 | 534.00 | 1.56 | 536.37 | 532.35 | 534.14 | 1.72 |
| 50 | 48.0 | 541.11 | 537.96 | 539.01 | 1.57 | 541.39 | 537.34 | 539.14 | 1.73 |
| 51 | 50.0 | 546.09 | 542.97 | 544.01 | 1.56 | 546.39 | 542.32 | 544.14 | 1.74 |
| 52 | 52.0 | 551.11 | 547.97 | 549.02 | 1.57 | 551.38 | 547.30 | 549.14 | 1.74 |
| 53 | 54.0 | 556.10 | 552.98 | 554.02 | 1.56 | 556.39 | 552.28 | 554.13 | 1.75 |
| 54 | 56.0 | 561.11 | 557.98 | 559.03 | 1.57 | 561.40 | 557.26 | 559.13 | 1.75 |

| | | | | | | | | | |
|-----|-------|--------|--------|--------|-------|--------|--------|--------|-------|
| 55 | 58.0 | 566.10 | 562.98 | 564.03 | 1.56 | 566.40 | 562.24 | 564.13 | 1.75 |
| 56 | 60.0 | 571.11 | 567.98 | 569.03 | 1.56 | 571.40 | 567.22 | 569.12 | 1.76 |
| 57 | 62.0 | 576.10 | 572.98 | 574.03 | 1.56 | 576.39 | 572.20 | 574.12 | 1.76 |
| 58 | 64.0 | 581.11 | 577.99 | 579.03 | 1.56 | 581.39 | 577.18 | 579.12 | 1.76 |
| 59 | 66.0 | 586.11 | 582.99 | 584.03 | 1.56 | 586.40 | 582.17 | 584.11 | 1.77 |
| 60 | 68.0 | 591.12 | 587.99 | 589.03 | 1.56 | 591.41 | 587.15 | 589.11 | 1.77 |
| 61 | 70.0 | 596.11 | 592.99 | 594.03 | 1.56 | 596.40 | 592.13 | 594.11 | 1.78 |
| 62 | 72.0 | 598.43 | 596.90 | 597.45 | 0.79 | 598.43 | 595.88 | 597.28 | 0.88 |
| 63 | 74.0 | 599.20 | 598.66 | 598.84 | 0.26 | 599.33 | 597.53 | 598.67 | 0.49 |
| 64 | 76.0 | 599.68 | 599.32 | 599.45 | 0.19 | 599.74 | 598.27 | 599.28 | 0.32 |
| 65 | 78.0 | 599.77 | 599.67 | 599.70 | 0.05 | 599.93 | 598.60 | 599.56 | 0.25 |
| 66 | 80.0 | 599.91 | 599.79 | 599.83 | 0.06 | 600.02 | 598.75 | 599.69 | 0.22 |
| 67 | 82.0 | 597.22 | 598.78 | 598.30 | -0.76 | 597.08 | 597.59 | 597.92 | -0.69 |
| 68 | 84.0 | 593.05 | 595.57 | 594.72 | -1.27 | 592.98 | 594.29 | 594.34 | -1.09 |
| 69 | 86.0 | 588.50 | 591.25 | 590.35 | -1.37 | 588.40 | 590.06 | 589.98 | -1.26 |
| 70 | 88.0 | 583.63 | 586.61 | 585.61 | -1.50 | 583.58 | 585.41 | 585.26 | -1.34 |
| 71 | 90.0 | 578.74 | 581.74 | 580.74 | -1.50 | 578.66 | 580.58 | 580.40 | -1.37 |
| 72 | 92.0 | 573.76 | 576.83 | 575.80 | -1.54 | 573.69 | 575.67 | 575.46 | -1.38 |
| 73 | 94.0 | 568.80 | 571.86 | 570.84 | -1.53 | 568.70 | 570.72 | 570.49 | -1.39 |
| 74 | 96.0 | 563.80 | 566.90 | 565.86 | -1.55 | 563.71 | 565.76 | 565.51 | -1.39 |
| 75 | 98.0 | 558.81 | 561.91 | 560.87 | -1.54 | 558.71 | 560.78 | 560.52 | -1.39 |
| 76 | 100.0 | 553.82 | 556.92 | 555.88 | -1.55 | 553.70 | 555.80 | 555.53 | -1.39 |
| 77 | 102.0 | 551.50 | 553.02 | 552.48 | -0.78 | 551.66 | 552.04 | 552.36 | -0.50 |
| 78 | 104.0 | 550.73 | 551.26 | 551.09 | -0.25 | 550.75 | 550.39 | 550.97 | -0.11 |
| 79 | 106.0 | 550.26 | 550.61 | 550.48 | -0.18 | 550.33 | 549.66 | 550.35 | 0.06 |
| 80 | 108.0 | 550.17 | 550.26 | 550.23 | -0.04 | 550.15 | 549.33 | 550.07 | 0.14 |
| 81 | 110.0 | 550.04 | 550.15 | 550.11 | -0.06 | 550.09 | 549.18 | 549.95 | 0.17 |
| 82 | 115.0 | 553.45 | 552.25 | 552.64 | 0.59 | 554.03 | 552.02 | 553.14 | 0.67 |
| 83 | 120.0 | 558.47 | 557.23 | 557.65 | 0.63 | 558.82 | 556.72 | 557.89 | 0.72 |
| 84 | 125.0 | 563.44 | 562.22 | 562.62 | 0.60 | 563.74 | 561.66 | 562.85 | 0.73 |
| 85 | 130.0 | 568.45 | 567.19 | 567.62 | 0.63 | 568.80 | 566.64 | 567.85 | 0.73 |
| 86 | 135.0 | 573.43 | 572.20 | 572.60 | 0.61 | 573.85 | 571.62 | 572.84 | 0.73 |
| 87 | 140.0 | 578.44 | 577.18 | 577.60 | 0.63 | 578.79 | 576.60 | 577.84 | 0.74 |
| 88 | 145.0 | 583.43 | 582.19 | 582.60 | 0.61 | 583.74 | 581.58 | 582.83 | 0.74 |
| 89 | 150.0 | 588.43 | 587.18 | 587.60 | 0.63 | 588.79 | 586.56 | 587.83 | 0.74 |
| 90 | 155.0 | 593.43 | 592.19 | 592.60 | 0.62 | 593.85 | 591.55 | 592.83 | 0.75 |
| 91 | 160.0 | 598.43 | 597.17 | 597.60 | 0.63 | 598.79 | 596.53 | 597.82 | 0.75 |
| 92 | 170.0 | 600.49 | 600.86 | 600.74 | -0.18 | 600.02 | 598.82 | 599.76 | 0.21 |
| 93 | 180.0 | 599.76 | 599.65 | 599.68 | 0.05 | 600.05 | 598.87 | 599.80 | 0.21 |
| 94 | 190.0 | 600.06 | 600.07 | 600.08 | 0.01 | 600.05 | 598.87 | 599.80 | 0.21 |
| 95 | 200.0 | 599.92 | 599.94 | 599.93 | -0.02 | 600.05 | 598.87 | 599.80 | 0.21 |
| 96 | 210.0 | 600.01 | 599.97 | 599.99 | 0.02 | 599.99 | 598.87 | 599.80 | 0.21 |
| 97 | 220.0 | 599.94 | 599.98 | 599.96 | -0.02 | 600.08 | 598.87 | 599.80 | 0.21 |
| 98 | 230.0 | 600.00 | 599.96 | 599.98 | 0.02 | 600.11 | 598.87 | 599.80 | 0.21 |
| 99 | 240.0 | 599.95 | 599.98 | 599.97 | -0.02 | 600.03 | 598.87 | 599.80 | 0.21 |
| 100 | 250.0 | 599.99 | 599.96 | 599.97 | 0.02 | 599.99 | 598.87 | 599.80 | 0.21 |
| 101 | 260.0 | 599.95 | 599.98 | 599.97 | -0.02 | 600.07 | 598.87 | 599.80 | 0.21 |
| 102 | 270.0 | 599.99 | 599.96 | 599.97 | 0.02 | 600.11 | 598.87 | 599.80 | 0.21 |
| 103 | 280.0 | 599.95 | 599.98 | 599.97 | -0.02 | 600.05 | 598.87 | 599.80 | 0.21 |
| 104 | 290.0 | 599.99 | 599.96 | 599.97 | 0.02 | 600.00 | 598.87 | 599.80 | 0.21 |
| 105 | 300.0 | 599.95 | 599.98 | 599.97 | -0.01 | 600.05 | 598.87 | 599.80 | 0.21 |

表 6. 3 評価断面 3 の温度

FINAS解と簡易計算値との比較 (ホットショック)

断面 3 の温度

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|--------|--------|------|--------|--------|--------|------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 300.00 | 300.00 | 300.00 | 0.00 | 300.00 | 300.00 | 300.00 | 0.00 |
| 2 | 0.5 | 301.86 | 300.09 | 300.49 | 0.71 | 302.13 | 300.02 | 300.51 | 0.90 |
| 3 | 1.0 | 304.93 | 300.58 | 301.80 | 1.98 | 305.07 | 300.54 | 301.82 | 2.09 |
| 4 | 1.5 | 308.20 | 301.76 | 303.73 | 3.05 | 308.41 | 301.75 | 303.75 | 3.15 |
| 5 | 2.0 | 311.85 | 303.59 | 306.16 | 3.95 | 312.02 | 303.57 | 306.18 | 4.05 |
| 6 | 2.5 | 315.66 | 305.92 | 309.01 | 4.70 | 315.85 | 305.89 | 309.03 | 4.81 |
| 7 | 3.0 | 319.70 | 308.68 | 312.20 | 5.34 | 319.88 | 308.64 | 312.21 | 5.45 |
| 8 | 3.5 | 323.86 | 311.78 | 315.67 | 5.87 | 324.07 | 311.74 | 315.68 | 6.00 |
| 9 | 4.0 | 328.17 | 315.17 | 319.37 | 6.33 | 328.38 | 315.12 | 319.38 | 6.46 |
| 10 | 4.5 | 332.57 | 318.81 | 323.28 | 6.72 | 332.79 | 318.75 | 323.28 | 6.85 |
| 11 | 5.0 | 337.08 | 322.65 | 327.34 | 7.05 | 337.30 | 322.59 | 327.34 | 7.19 |
| 12 | 5.5 | 341.64 | 326.66 | 331.54 | 7.34 | 341.87 | 326.58 | 331.53 | 7.48 |
| 13 | 6.0 | 346.28 | 330.81 | 335.85 | 7.58 | 346.51 | 330.72 | 335.84 | 7.74 |
| 14 | 6.5 | 350.96 | 335.07 | 340.27 | 7.79 | 351.19 | 334.98 | 340.25 | 7.95 |
| 15 | 7.0 | 355.69 | 339.44 | 344.76 | 7.97 | 355.92 | 339.34 | 344.73 | 8.14 |
| 16 | 7.5 | 360.45 | 343.89 | 349.32 | 8.13 | 360.69 | 343.78 | 349.29 | 8.31 |
| 17 | 8.0 | 365.25 | 348.41 | 353.93 | 8.27 | 365.49 | 348.30 | 353.90 | 8.45 |
| 18 | 8.5 | 370.07 | 353.00 | 358.60 | 8.39 | 370.31 | 352.88 | 358.56 | 8.58 |
| 19 | 9.0 | 374.92 | 357.63 | 363.30 | 8.50 | 375.15 | 357.51 | 363.26 | 8.69 |
| 20 | 9.5 | 379.78 | 362.31 | 368.05 | 8.59 | 380.02 | 362.18 | 368.00 | 8.79 |
| 21 | 10.0 | 384.66 | 367.03 | 372.82 | 8.67 | 384.90 | 366.89 | 372.77 | 8.88 |
| 22 | 11.0 | 392.16 | 376.22 | 381.58 | 7.95 | 392.29 | 376.07 | 381.50 | 8.10 |
| 23 | 12.0 | 398.35 | 384.45 | 389.09 | 6.89 | 398.67 | 384.18 | 389.02 | 7.25 |
| 24 | 13.0 | 404.38 | 391.58 | 395.83 | 6.34 | 404.62 | 391.33 | 395.76 | 6.65 |
| 25 | 14.0 | 409.99 | 398.07 | 402.04 | 5.90 | 410.27 | 397.83 | 401.97 | 6.23 |
| 26 | 15.0 | 415.48 | 404.13 | 407.89 | 5.61 | 415.73 | 403.88 | 407.83 | 5.94 |
| 27 | 16.0 | 420.77 | 409.86 | 413.48 | 5.40 | 421.07 | 409.64 | 413.43 | 5.73 |
| 28 | 17.0 | 426.02 | 415.40 | 418.91 | 5.25 | 426.32 | 415.17 | 418.87 | 5.58 |
| 29 | 18.0 | 431.17 | 420.77 | 424.22 | 5.14 | 431.50 | 420.56 | 424.18 | 5.47 |
| 30 | 19.0 | 436.31 | 426.05 | 429.44 | 5.06 | 436.64 | 425.84 | 429.40 | 5.40 |
| 31 | 20.0 | 441.38 | 431.26 | 434.60 | 5.00 | 441.75 | 431.04 | 434.57 | 5.35 |
| 32 | 21.0 | 446.46 | 436.41 | 439.72 | 4.96 | 446.81 | 436.19 | 439.69 | 5.31 |
| 33 | 22.0 | 451.50 | 441.52 | 444.81 | 4.92 | 451.88 | 441.30 | 444.78 | 5.28 |
| 34 | 23.0 | 456.54 | 446.61 | 449.88 | 4.90 | 456.93 | 446.38 | 449.85 | 5.26 |
| 35 | 24.0 | 461.56 | 451.67 | 454.94 | 4.88 | 461.96 | 451.45 | 454.90 | 5.24 |
| 36 | 25.0 | 466.59 | 456.72 | 459.98 | 4.87 | 466.99 | 456.49 | 459.94 | 5.24 |
| 37 | 26.0 | 471.60 | 461.76 | 465.01 | 4.85 | 472.02 | 461.52 | 464.96 | 5.23 |
| 38 | 27.0 | 476.62 | 466.80 | 470.03 | 4.84 | 477.05 | 466.55 | 469.99 | 5.23 |
| 39 | 28.0 | 481.62 | 471.82 | 475.05 | 4.84 | 482.06 | 471.57 | 475.01 | 5.23 |
| 40 | 29.0 | 486.64 | 476.84 | 480.07 | 4.83 | 487.07 | 476.58 | 480.02 | 5.24 |
| 41 | 30.0 | 491.64 | 481.86 | 485.08 | 4.82 | 492.08 | 481.59 | 485.04 | 5.24 |
| 42 | 32.0 | 498.86 | 491.03 | 493.68 | 3.92 | 499.10 | 490.76 | 493.56 | 4.24 |
| 43 | 34.0 | 504.60 | 498.27 | 500.36 | 3.12 | 505.02 | 497.91 | 500.29 | 3.64 |
| 44 | 36.0 | 510.17 | 504.27 | 506.23 | 2.93 | 510.47 | 504.03 | 506.18 | 3.32 |
| 45 | 38.0 | 515.34 | 509.88 | 511.69 | 2.70 | 515.70 | 509.63 | 511.66 | 3.15 |
| 46 | 40.0 | 520.54 | 515.20 | 516.96 | 2.64 | 520.82 | 514.97 | 516.93 | 3.06 |
| 47 | 42.0 | 525.58 | 520.41 | 522.12 | 2.56 | 525.89 | 520.17 | 522.08 | 3.01 |
| 48 | 44.0 | 530.67 | 525.54 | 527.23 | 2.53 | 530.94 | 525.29 | 527.18 | 2.99 |
| 49 | 46.0 | 535.68 | 530.64 | 532.31 | 2.49 | 536.00 | 530.36 | 532.24 | 2.97 |
| 50 | 48.0 | 540.73 | 535.71 | 537.36 | 2.48 | 541.02 | 535.41 | 537.27 | 2.97 |
| 51 | 50.0 | 545.74 | 540.76 | 542.40 | 2.46 | 546.02 | 540.44 | 542.29 | 2.96 |
| 52 | 52.0 | 550.77 | 545.80 | 547.43 | 2.45 | 551.01 | 545.45 | 547.31 | 2.97 |
| 53 | 54.0 | 555.76 | 550.83 | 552.46 | 2.44 | 556.01 | 550.46 | 552.31 | 2.97 |
| 54 | 56.0 | 560.79 | 555.86 | 557.48 | 2.43 | 561.02 | 555.46 | 557.31 | 2.98 |

| | | | | | | | | | |
|-----|-------|--------|--------|--------|-------|--------|--------|--------|-------|
| 55 | 58.0 | 565.78 | 560.87 | 562.49 | 2.42 | 566.01 | 560.46 | 562.31 | 2.99 |
| 56 | 60.0 | 570.80 | 565.89 | 567.51 | 2.42 | 571.00 | 565.45 | 567.30 | 3.00 |
| 57 | 62.0 | 575.80 | 570.90 | 572.52 | 2.42 | 575.98 | 570.44 | 572.29 | 3.01 |
| 58 | 64.0 | 580.81 | 575.91 | 577.53 | 2.41 | 580.98 | 575.43 | 577.28 | 3.02 |
| 59 | 66.0 | 585.80 | 580.92 | 582.53 | 2.41 | 585.98 | 580.41 | 582.27 | 3.03 |
| 60 | 68.0 | 590.82 | 585.93 | 587.54 | 2.41 | 590.98 | 585.40 | 587.26 | 3.04 |
| 61 | 70.0 | 595.81 | 590.93 | 592.54 | 2.41 | 595.96 | 590.39 | 592.25 | 3.05 |
| 62 | 72.0 | 598.03 | 595.09 | 596.13 | 1.50 | 597.81 | 594.50 | 595.60 | 1.92 |
| 63 | 74.0 | 598.75 | 597.31 | 597.79 | 0.71 | 598.71 | 596.56 | 597.25 | 1.34 |
| 64 | 76.0 | 599.33 | 598.30 | 598.65 | 0.53 | 599.18 | 597.62 | 598.11 | 1.04 |
| 65 | 78.0 | 599.49 | 598.91 | 599.11 | 0.29 | 599.43 | 598.21 | 598.58 | 0.87 |
| 66 | 80.0 | 599.69 | 599.22 | 599.38 | 0.24 | 599.57 | 598.54 | 598.84 | 0.78 |
| 67 | 82.0 | 596.94 | 598.58 | 598.11 | -0.75 | 596.50 | 597.87 | 597.37 | -0.42 |
| 68 | 84.0 | 592.76 | 595.93 | 594.89 | -1.56 | 592.45 | 595.07 | 594.14 | -1.04 |
| 69 | 86.0 | 588.34 | 592.00 | 590.82 | -1.78 | 587.95 | 591.24 | 590.07 | -1.38 |
| 70 | 88.0 | 583.56 | 587.68 | 586.32 | -2.03 | 583.22 | 586.89 | 585.60 | -1.57 |
| 71 | 90.0 | 578.75 | 583.03 | 581.63 | -2.10 | 578.37 | 582.28 | 580.91 | -1.69 |
| 72 | 92.0 | 573.83 | 578.28 | 576.82 | -2.19 | 573.45 | 577.52 | 576.10 | -1.76 |
| 73 | 94.0 | 568.91 | 573.44 | 571.95 | -2.23 | 568.51 | 572.69 | 571.23 | -1.82 |
| 74 | 96.0 | 563.95 | 568.56 | 567.04 | -2.27 | 563.54 | 567.81 | 566.32 | -1.86 |
| 75 | 98.0 | 558.99 | 563.64 | 562.11 | -2.29 | 558.56 | 562.89 | 561.39 | -1.89 |
| 76 | 100.0 | 554.01 | 558.71 | 557.16 | -2.31 | 553.56 | 557.96 | 556.43 | -1.91 |
| 77 | 102.0 | 551.83 | 554.61 | 553.62 | -1.43 | 551.71 | 553.87 | 553.11 | -0.79 |
| 78 | 104.0 | 551.11 | 552.43 | 551.99 | -0.65 | 550.80 | 551.84 | 551.47 | -0.22 |
| 79 | 106.0 | 550.55 | 551.48 | 551.16 | -0.48 | 550.32 | 550.79 | 550.62 | 0.08 |
| 80 | 108.0 | 550.40 | 550.90 | 550.73 | -0.25 | 550.07 | 550.22 | 550.17 | 0.25 |
| 81 | 110.0 | 550.21 | 550.61 | 550.48 | -0.20 | 549.95 | 549.90 | 549.90 | 0.34 |
| 82 | 115.0 | 553.59 | 552.19 | 552.62 | 0.67 | 553.80 | 552.06 | 552.63 | 1.15 |
| 83 | 120.0 | 558.50 | 556.73 | 557.33 | 0.88 | 558.50 | 556.41 | 557.11 | 1.34 |
| 84 | 125.0 | 563.38 | 561.61 | 562.18 | 0.86 | 563.37 | 561.19 | 561.93 | 1.41 |
| 85 | 130.0 | 568.38 | 566.48 | 567.11 | 0.95 | 568.40 | 566.09 | 566.86 | 1.44 |
| 86 | 135.0 | 573.33 | 571.47 | 572.07 | 0.91 | 573.45 | 571.05 | 571.83 | 1.46 |
| 87 | 140.0 | 578.34 | 576.40 | 577.05 | 0.96 | 578.40 | 576.03 | 576.81 | 1.47 |
| 88 | 145.0 | 583.32 | 581.41 | 582.03 | 0.93 | 583.34 | 581.01 | 581.80 | 1.47 |
| 89 | 150.0 | 588.32 | 586.38 | 587.02 | 0.97 | 588.40 | 586.00 | 586.79 | 1.49 |
| 90 | 155.0 | 593.31 | 591.39 | 592.02 | 0.94 | 593.44 | 590.98 | 591.78 | 1.50 |
| 91 | 160.0 | 598.32 | 596.37 | 597.01 | 0.96 | 598.39 | 595.97 | 596.77 | 1.51 |
| 92 | 170.0 | 600.34 | 600.61 | 600.54 | -0.12 | 599.65 | 598.91 | 599.13 | 0.68 |
| 93 | 180.0 | 599.77 | 599.68 | 599.69 | 0.03 | 599.73 | 599.11 | 599.29 | 0.62 |
| 94 | 190.0 | 600.05 | 600.01 | 600.03 | 0.04 | 599.73 | 599.15 | 599.32 | 0.61 |
| 95 | 200.0 | 599.91 | 599.96 | 599.93 | -0.04 | 599.73 | 599.15 | 599.32 | 0.61 |
| 96 | 210.0 | 600.02 | 599.95 | 599.98 | 0.04 | 599.67 | 599.15 | 599.32 | 0.61 |
| 97 | 220.0 | 599.93 | 599.99 | 599.96 | -0.04 | 599.75 | 599.15 | 599.32 | 0.61 |
| 98 | 230.0 | 600.01 | 599.95 | 599.97 | 0.04 | 599.78 | 599.15 | 599.32 | 0.62 |
| 99 | 240.0 | 599.94 | 599.99 | 599.96 | -0.03 | 599.71 | 599.15 | 599.32 | 0.61 |
| 100 | 250.0 | 600.00 | 599.95 | 599.97 | 0.03 | 599.67 | 599.15 | 599.32 | 0.61 |
| 101 | 260.0 | 599.94 | 599.99 | 599.97 | -0.03 | 599.74 | 599.15 | 599.32 | 0.61 |
| 102 | 270.0 | 600.00 | 599.96 | 599.97 | 0.02 | 599.78 | 599.15 | 599.32 | 0.62 |
| 103 | 280.0 | 599.95 | 599.99 | 599.97 | -0.02 | 599.72 | 599.15 | 599.32 | 0.61 |
| 104 | 290.0 | 599.99 | 599.96 | 599.97 | 0.02 | 599.68 | 599.15 | 599.32 | 0.61 |
| 105 | 300.0 | 599.95 | 599.98 | 599.97 | -0.02 | 599.72 | 599.15 | 599.32 | 0.61 |

表6. 4 評価断面4の温度

FINAS解と簡易計算値との比較 (ホットショック)

断面4の温度

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|--------|--------|-------|--------|--------|--------|-------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 300.00 | 300.00 | 300.00 | 0.00 | 300.00 | 300.00 | 300.00 | 0.00 |
| 2 | 0.5 | 301.81 | 300.00 | 300.21 | 0.49 | 302.08 | 300.00 | 300.23 | 0.55 |
| 3 | 1.0 | 304.79 | 300.01 | 300.76 | 1.61 | 304.93 | 300.00 | 300.77 | 1.67 |
| 4 | 1.5 | 307.92 | 300.03 | 301.56 | 3.01 | 308.12 | 300.02 | 301.57 | 3.07 |
| 5 | 2.0 | 311.36 | 300.12 | 302.58 | 4.58 | 311.52 | 300.09 | 302.58 | 4.63 |
| 6 | 2.5 | 314.88 | 300.30 | 303.79 | 6.21 | 315.07 | 300.28 | 303.79 | 6.26 |
| 7 | 3.0 | 318.56 | 300.61 | 305.17 | 7.86 | 318.73 | 300.59 | 305.17 | 7.91 |
| 8 | 3.5 | 322.28 | 301.07 | 306.72 | 9.50 | 322.49 | 301.05 | 306.71 | 9.54 |
| 9 | 4.0 | 326.11 | 301.69 | 308.42 | 11.11 | 326.32 | 301.67 | 308.41 | 11.15 |
| 10 | 4.5 | 329.98 | 302.47 | 310.26 | 12.68 | 330.21 | 302.46 | 310.24 | 12.71 |
| 11 | 5.0 | 333.93 | 303.40 | 312.23 | 14.21 | 334.16 | 303.41 | 312.21 | 14.23 |
| 12 | 5.5 | 337.91 | 304.50 | 314.33 | 15.68 | 338.16 | 304.51 | 314.31 | 15.70 |
| 13 | 6.0 | 341.95 | 305.74 | 316.54 | 17.10 | 342.21 | 305.76 | 316.52 | 17.11 |
| 14 | 6.5 | 346.01 | 307.13 | 318.87 | 18.47 | 346.29 | 307.16 | 318.84 | 18.48 |
| 15 | 7.0 | 350.13 | 308.65 | 321.30 | 19.79 | 350.42 | 308.69 | 321.27 | 19.80 |
| 16 | 7.5 | 354.27 | 310.31 | 323.84 | 21.06 | 354.58 | 310.36 | 323.80 | 21.07 |
| 17 | 8.0 | 358.46 | 312.10 | 326.47 | 22.29 | 358.77 | 312.16 | 326.43 | 22.29 |
| 18 | 8.5 | 362.67 | 314.01 | 329.19 | 23.47 | 363.00 | 314.08 | 329.15 | 23.47 |
| 19 | 9.0 | 366.92 | 316.03 | 332.00 | 24.61 | 367.25 | 316.11 | 331.96 | 24.60 |
| 20 | 9.5 | 371.19 | 318.17 | 334.89 | 25.70 | 371.54 | 318.26 | 334.85 | 25.70 |
| 21 | 10.0 | 375.50 | 320.41 | 337.86 | 26.76 | 375.85 | 320.51 | 337.81 | 26.75 |
| 22 | 11.0 | 381.95 | 325.18 | 343.66 | 28.02 | 382.21 | 325.32 | 343.60 | 27.97 |
| 23 | 12.0 | 387.25 | 330.25 | 349.17 | 28.36 | 387.72 | 330.44 | 349.13 | 28.36 |
| 24 | 13.0 | 392.59 | 335.49 | 354.55 | 28.46 | 393.00 | 335.70 | 354.52 | 28.46 |
| 25 | 14.0 | 397.69 | 340.74 | 359.84 | 28.44 | 398.18 | 340.97 | 359.81 | 28.46 |
| 26 | 15.0 | 402.83 | 345.95 | 365.05 | 28.41 | 403.30 | 346.19 | 365.02 | 28.44 |
| 27 | 16.0 | 407.88 | 351.10 | 370.19 | 28.38 | 408.38 | 351.36 | 370.17 | 28.41 |
| 28 | 17.0 | 412.95 | 356.19 | 375.29 | 28.37 | 413.44 | 356.48 | 375.26 | 28.40 |
| 29 | 18.0 | 417.96 | 361.22 | 380.34 | 28.37 | 418.48 | 361.53 | 380.31 | 28.41 |
| 30 | 19.0 | 422.99 | 366.21 | 385.35 | 28.39 | 423.51 | 366.54 | 385.33 | 28.43 |
| 31 | 20.0 | 427.98 | 371.16 | 390.33 | 28.43 | 428.52 | 371.50 | 390.30 | 28.46 |
| 32 | 21.0 | 432.98 | 376.06 | 395.28 | 28.48 | 433.52 | 376.42 | 395.25 | 28.51 |
| 33 | 22.0 | 437.96 | 380.94 | 400.20 | 28.54 | 438.52 | 381.31 | 400.18 | 28.57 |
| 34 | 23.0 | 442.94 | 385.78 | 405.11 | 28.61 | 443.50 | 386.17 | 405.08 | 28.64 |
| 35 | 24.0 | 447.91 | 390.61 | 409.99 | 28.69 | 448.48 | 391.01 | 409.97 | 28.72 |
| 36 | 25.0 | 452.88 | 395.41 | 414.86 | 28.78 | 453.45 | 395.83 | 414.84 | 28.81 |
| 37 | 26.0 | 457.83 | 400.20 | 419.72 | 28.88 | 458.42 | 400.63 | 419.70 | 28.91 |
| 38 | 27.0 | 462.79 | 404.97 | 424.57 | 28.98 | 463.39 | 405.42 | 424.54 | 29.01 |
| 39 | 28.0 | 467.74 | 409.72 | 429.41 | 29.08 | 468.35 | 410.20 | 429.38 | 29.11 |
| 40 | 29.0 | 472.69 | 414.47 | 434.24 | 29.19 | 473.31 | 414.97 | 434.21 | 29.22 |
| 41 | 30.0 | 477.64 | 419.21 | 439.06 | 29.30 | 478.27 | 419.73 | 439.03 | 29.33 |
| 42 | 32.0 | 484.87 | 428.60 | 448.08 | 28.52 | 485.33 | 429.19 | 448.03 | 28.45 |
| 43 | 34.0 | 490.83 | 437.66 | 456.21 | 26.99 | 491.52 | 438.28 | 456.19 | 27.06 |
| 44 | 36.0 | 496.85 | 446.11 | 463.78 | 25.74 | 497.44 | 446.72 | 463.76 | 25.80 |
| 45 | 38.0 | 502.52 | 453.94 | 470.89 | 24.66 | 503.16 | 454.57 | 470.87 | 24.74 |
| 46 | 40.0 | 508.19 | 461.27 | 477.64 | 23.80 | 508.76 | 461.92 | 477.61 | 23.85 |
| 47 | 42.0 | 513.65 | 468.20 | 484.08 | 23.07 | 514.26 | 468.87 | 484.05 | 23.12 |
| 48 | 44.0 | 519.10 | 474.80 | 490.27 | 22.47 | 519.67 | 475.48 | 490.24 | 22.52 |
| 49 | 46.0 | 524.42 | 481.13 | 496.26 | 21.98 | 525.01 | 481.82 | 496.23 | 22.01 |
| 50 | 48.0 | 529.74 | 487.23 | 502.08 | 21.57 | 530.30 | 487.94 | 502.05 | 21.59 |
| 51 | 50.0 | 534.96 | 493.14 | 507.77 | 21.22 | 535.54 | 493.87 | 507.74 | 21.25 |
| 52 | 52.0 | 540.17 | 498.90 | 513.33 | 20.94 | 540.74 | 499.65 | 513.31 | 20.95 |
| 53 | 54.0 | 545.32 | 504.52 | 518.80 | 20.71 | 545.91 | 505.29 | 518.78 | 20.71 |
| 54 | 56.0 | 550.47 | 510.04 | 524.19 | 20.51 | 551.05 | 510.83 | 524.17 | 20.50 |

| | | | | | | | | | |
|-----|-------|--------|--------|--------|-------|--------|--------|--------|-------|
| 55 | 58.0 | 555.58 | 515.47 | 529.51 | 20.35 | 556.17 | 516.27 | 529.49 | 20.33 |
| 56 | 60.0 | 560.68 | 520.82 | 534.77 | 20.22 | 561.26 | 521.63 | 534.75 | 20.19 |
| 57 | 62.0 | 565.75 | 526.11 | 539.99 | 20.12 | 566.34 | 526.92 | 539.96 | 20.07 |
| 58 | 64.0 | 570.82 | 531.34 | 545.17 | 20.03 | 571.41 | 532.16 | 545.13 | 19.98 |
| 59 | 66.0 | 575.86 | 536.53 | 550.31 | 19.96 | 576.48 | 537.36 | 550.27 | 19.90 |
| 60 | 68.0 | 580.91 | 541.68 | 555.42 | 19.91 | 581.54 | 542.53 | 555.38 | 19.84 |
| 61 | 70.0 | 585.93 | 546.79 | 560.51 | 19.86 | 586.59 | 547.66 | 560.47 | 19.80 |
| 62 | 72.0 | 588.31 | 551.82 | 564.97 | 18.82 | 588.59 | 552.76 | 564.87 | 18.47 |
| 63 | 74.0 | 589.41 | 556.51 | 568.55 | 17.04 | 589.92 | 557.46 | 568.46 | 16.80 |
| 64 | 76.0 | 590.57 | 560.59 | 571.56 | 15.52 | 590.97 | 561.49 | 571.46 | 15.28 |
| 65 | 78.0 | 591.37 | 564.03 | 574.10 | 14.20 | 591.85 | 564.94 | 574.01 | 13.97 |
| 66 | 80.0 | 592.17 | 566.97 | 576.27 | 13.08 | 592.60 | 567.88 | 576.17 | 12.85 |
| 67 | 82.0 | 590.10 | 569.43 | 577.51 | 11.10 | 590.20 | 570.40 | 577.35 | 10.59 |
| 68 | 84.0 | 586.78 | 571.23 | 577.64 | 8.51 | 587.04 | 572.19 | 577.49 | 8.11 |
| 69 | 86.0 | 583.36 | 572.15 | 577.00 | 6.28 | 583.55 | 573.05 | 576.84 | 5.89 |
| 70 | 88.0 | 579.60 | 572.21 | 575.72 | 4.33 | 579.82 | 573.10 | 575.56 | 3.95 |
| 71 | 90.0 | 575.72 | 571.59 | 573.93 | 2.65 | 575.91 | 572.46 | 573.77 | 2.27 |
| 72 | 92.0 | 571.66 | 570.39 | 571.72 | 1.19 | 571.85 | 571.25 | 571.56 | 0.80 |
| 73 | 94.0 | 567.50 | 568.70 | 569.14 | -0.09 | 567.66 | 569.56 | 568.99 | -0.48 |
| 74 | 96.0 | 563.21 | 566.62 | 566.27 | -1.22 | 563.38 | 567.47 | 566.12 | -1.62 |
| 75 | 98.0 | 558.85 | 564.20 | 563.16 | -2.22 | 559.01 | 565.04 | 563.00 | -2.62 |
| 76 | 100.0 | 554.41 | 561.50 | 559.82 | -3.12 | 554.56 | 562.33 | 559.67 | -3.52 |
| 77 | 102.0 | 552.58 | 558.62 | 556.92 | -2.91 | 553.09 | 559.38 | 556.85 | -3.04 |
| 78 | 104.0 | 551.93 | 555.84 | 554.74 | -1.87 | 552.24 | 556.60 | 554.65 | -2.12 |
| 79 | 106.0 | 551.20 | 553.49 | 552.98 | -1.03 | 551.62 | 554.29 | 552.90 | -1.28 |
| 80 | 108.0 | 550.77 | 551.60 | 551.56 | -0.31 | 551.12 | 552.40 | 551.48 | -0.59 |
| 81 | 110.0 | 550.31 | 550.07 | 550.41 | 0.25 | 550.72 | 550.87 | 550.34 | -0.02 |
| 82 | 115.0 | 552.84 | 547.74 | 549.51 | 2.51 | 553.64 | 548.44 | 549.63 | 2.60 |
| 83 | 120.0 | 556.77 | 547.73 | 550.93 | 4.60 | 557.43 | 548.62 | 551.05 | 4.42 |
| 84 | 125.0 | 560.86 | 549.62 | 553.59 | 5.69 | 561.67 | 550.47 | 553.71 | 5.63 |
| 85 | 130.0 | 565.39 | 552.56 | 557.06 | 6.52 | 566.19 | 553.40 | 557.17 | 6.43 |
| 86 | 135.0 | 570.00 | 556.15 | 561.03 | 7.03 | 570.87 | 557.02 | 561.13 | 6.98 |
| 87 | 140.0 | 574.78 | 560.20 | 565.32 | 7.40 | 575.64 | 561.08 | 565.41 | 7.36 |
| 88 | 145.0 | 579.59 | 564.52 | 569.83 | 7.65 | 580.48 | 565.42 | 569.91 | 7.63 |
| 89 | 150.0 | 584.48 | 569.04 | 574.48 | 7.85 | 585.37 | 569.95 | 574.55 | 7.83 |
| 90 | 155.0 | 589.39 | 573.69 | 579.22 | 7.98 | 590.30 | 574.60 | 579.28 | 7.99 |
| 91 | 160.0 | 594.33 | 578.42 | 584.02 | 8.09 | 595.23 | 579.34 | 584.09 | 8.10 |
| 92 | 170.0 | 597.01 | 586.17 | 590.30 | 5.72 | 597.37 | 587.00 | 589.95 | 5.37 |
| 93 | 180.0 | 597.51 | 590.03 | 592.80 | 3.87 | 598.30 | 590.65 | 592.63 | 3.97 |
| 94 | 190.0 | 598.24 | 591.72 | 594.21 | 3.45 | 598.80 | 592.62 | 594.06 | 3.21 |
| 95 | 200.0 | 598.31 | 592.99 | 595.02 | 2.78 | 599.10 | 593.83 | 594.95 | 2.75 |
| 96 | 210.0 | 598.66 | 593.77 | 595.64 | 2.58 | 599.30 | 594.67 | 595.57 | 2.43 |
| 97 | 220.0 | 598.69 | 594.45 | 596.08 | 2.23 | 599.48 | 595.31 | 596.04 | 2.18 |
| 98 | 230.0 | 598.91 | 594.98 | 596.47 | 2.06 | 599.63 | 595.83 | 596.44 | 1.97 |
| 99 | 240.0 | 598.93 | 595.44 | 596.79 | 1.83 | 599.74 | 596.30 | 596.78 | 1.79 |
| 100 | 250.0 | 599.09 | 595.86 | 597.08 | 1.70 | 599.83 | 596.71 | 597.07 | 1.65 |
| 101 | 260.0 | 599.11 | 596.21 | 597.33 | 1.53 | 599.93 | 597.07 | 597.32 | 1.53 |
| 102 | 270.0 | 599.24 | 596.53 | 597.56 | 1.42 | 600.01 | 597.40 | 597.55 | 1.42 |
| 103 | 280.0 | 599.25 | 596.81 | 597.76 | 1.29 | 600.07 | 597.70 | 597.76 | 1.31 |
| 104 | 290.0 | 599.35 | 597.08 | 597.94 | 1.19 | 600.11 | 597.97 | 597.94 | 1.21 |
| 105 | 300.0 | 599.36 | 597.31 | 598.10 | 1.09 | 600.13 | 598.21 | 598.11 | 1.11 |

表6. 5 評価断面5の温度

FINAS解と簡易計算値との比較 (ホットショック)

断面5の温度

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|--------|--------|-------|--------|--------|--------|-------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 300.00 | 300.00 | 300.00 | 0.00 | 300.00 | 300.00 | 300.00 | 0.00 |
| 2 | 0.5 | 301.67 | 300.00 | 300.18 | 0.44 | 302.01 | 300.00 | 300.20 | 0.49 |
| 3 | 1.0 | 304.64 | 300.00 | 300.65 | 1.46 | 304.81 | 300.00 | 300.66 | 1.51 |
| 4 | 1.5 | 307.71 | 300.01 | 301.33 | 2.76 | 307.95 | 300.00 | 301.34 | 2.82 |
| 5 | 2.0 | 311.11 | 300.03 | 302.19 | 4.26 | 311.30 | 300.02 | 302.20 | 4.32 |
| 6 | 2.5 | 314.59 | 300.09 | 303.21 | 5.88 | 314.80 | 300.07 | 303.21 | 5.95 |
| 7 | 3.0 | 318.23 | 300.20 | 304.37 | 7.57 | 318.42 | 300.18 | 304.38 | 7.64 |
| 8 | 3.5 | 321.93 | 300.38 | 305.67 | 9.30 | 322.13 | 300.37 | 305.67 | 9.37 |
| 9 | 4.0 | 325.71 | 300.65 | 307.09 | 11.05 | 325.91 | 300.64 | 307.09 | 11.12 |
| 10 | 4.5 | 329.55 | 301.01 | 308.63 | 12.79 | 329.75 | 301.01 | 308.63 | 12.86 |
| 11 | 5.0 | 333.45 | 301.47 | 310.27 | 14.53 | 333.64 | 301.48 | 310.27 | 14.60 |
| 12 | 5.5 | 337.39 | 302.03 | 312.00 | 16.24 | 337.58 | 302.04 | 312.00 | 16.32 |
| 13 | 6.0 | 341.37 | 302.69 | 313.83 | 17.94 | 341.56 | 302.71 | 313.84 | 18.01 |
| 14 | 6.5 | 345.39 | 303.45 | 315.75 | 19.60 | 345.57 | 303.48 | 315.75 | 19.68 |
| 15 | 7.0 | 349.44 | 304.30 | 317.75 | 21.24 | 349.62 | 304.35 | 317.75 | 21.32 |
| 16 | 7.5 | 353.51 | 305.25 | 319.82 | 22.85 | 353.69 | 305.31 | 319.83 | 22.92 |
| 17 | 8.0 | 357.62 | 306.30 | 321.97 | 24.42 | 357.80 | 306.36 | 321.98 | 24.50 |
| 18 | 8.5 | 361.75 | 307.43 | 324.19 | 25.97 | 361.92 | 307.51 | 324.20 | 26.04 |
| 19 | 9.0 | 365.90 | 308.65 | 326.47 | 27.48 | 366.07 | 308.74 | 326.49 | 27.55 |
| 20 | 9.5 | 370.08 | 309.95 | 328.82 | 28.96 | 370.24 | 310.05 | 328.84 | 29.03 |
| 21 | 10.0 | 374.27 | 311.34 | 331.23 | 30.42 | 374.43 | 311.45 | 331.25 | 30.48 |
| 22 | 11.0 | 380.58 | 314.34 | 335.91 | 32.56 | 380.58 | 314.48 | 335.92 | 32.58 |
| 23 | 12.0 | 385.63 | 317.61 | 340.33 | 33.82 | 385.85 | 317.78 | 340.36 | 33.88 |
| 24 | 13.0 | 390.74 | 321.09 | 344.64 | 34.76 | 390.85 | 321.29 | 344.68 | 34.82 |
| 25 | 14.0 | 395.55 | 324.69 | 348.86 | 35.50 | 395.73 | 324.89 | 348.90 | 35.57 |
| 26 | 15.0 | 400.40 | 328.34 | 353.02 | 36.15 | 400.53 | 328.55 | 353.07 | 36.22 |
| 27 | 16.0 | 405.13 | 332.01 | 357.14 | 36.75 | 405.29 | 332.23 | 357.19 | 36.82 |
| 28 | 17.0 | 409.89 | 335.69 | 361.23 | 37.31 | 410.01 | 335.91 | 361.29 | 37.39 |
| 29 | 18.0 | 414.58 | 339.36 | 365.30 | 37.86 | 414.72 | 339.60 | 365.36 | 37.94 |
| 30 | 19.0 | 419.30 | 343.04 | 369.35 | 38.41 | 419.42 | 343.28 | 369.42 | 38.48 |
| 31 | 20.0 | 423.99 | 346.71 | 373.40 | 38.94 | 424.11 | 346.96 | 373.47 | 39.02 |
| 32 | 21.0 | 428.69 | 350.39 | 377.45 | 39.47 | 428.79 | 350.64 | 377.52 | 39.55 |
| 33 | 22.0 | 433.37 | 354.07 | 381.49 | 39.99 | 433.47 | 354.32 | 381.56 | 40.07 |
| 34 | 23.0 | 438.06 | 357.75 | 385.54 | 40.52 | 438.15 | 358.01 | 385.61 | 40.60 |
| 35 | 24.0 | 442.75 | 361.43 | 389.58 | 41.04 | 442.83 | 361.71 | 389.65 | 41.12 |
| 36 | 25.0 | 447.45 | 365.13 | 393.64 | 41.56 | 447.52 | 365.41 | 393.71 | 41.64 |
| 37 | 26.0 | 452.13 | 368.83 | 397.69 | 42.07 | 452.21 | 369.11 | 397.76 | 42.16 |
| 38 | 27.0 | 456.83 | 372.54 | 401.76 | 42.58 | 456.91 | 372.83 | 401.83 | 42.67 |
| 39 | 28.0 | 461.53 | 376.25 | 405.83 | 43.09 | 461.61 | 376.56 | 405.90 | 43.18 |
| 40 | 29.0 | 466.23 | 379.98 | 409.91 | 43.59 | 466.31 | 380.30 | 409.98 | 43.69 |
| 41 | 30.0 | 470.93 | 383.72 | 413.99 | 44.09 | 471.02 | 384.05 | 414.06 | 44.19 |
| 42 | 32.0 | 477.76 | 391.22 | 421.68 | 44.12 | 477.67 | 391.58 | 421.73 | 44.15 |
| 43 | 34.0 | 483.30 | 398.62 | 428.68 | 43.29 | 483.46 | 399.00 | 428.75 | 43.43 |
| 44 | 36.0 | 488.95 | 405.76 | 435.28 | 42.51 | 488.99 | 406.12 | 435.35 | 42.66 |
| 45 | 38.0 | 494.25 | 412.54 | 441.55 | 41.79 | 494.38 | 412.90 | 441.64 | 41.96 |
| 46 | 40.0 | 499.62 | 419.01 | 447.59 | 41.20 | 499.68 | 419.36 | 447.69 | 41.37 |
| 47 | 42.0 | 504.81 | 425.22 | 453.44 | 40.70 | 504.93 | 425.57 | 453.54 | 40.88 |
| 48 | 44.0 | 510.05 | 431.20 | 459.13 | 40.30 | 510.13 | 431.55 | 459.23 | 40.47 |
| 49 | 46.0 | 515.17 | 437.00 | 464.69 | 39.96 | 515.29 | 437.36 | 464.79 | 40.14 |
| 50 | 48.0 | 520.33 | 442.64 | 470.14 | 39.70 | 520.42 | 443.00 | 470.24 | 39.87 |
| 51 | 50.0 | 525.40 | 448.16 | 475.50 | 39.48 | 525.53 | 448.52 | 475.61 | 39.66 |
| 52 | 52.0 | 530.50 | 453.56 | 480.78 | 39.31 | 530.62 | 453.23 | 480.90 | 39.50 |
| 53 | 54.0 | 535.55 | 458.88 | 486.00 | 39.18 | 535.68 | 459.25 | 486.13 | 39.37 |
| 54 | 56.0 | 540.61 | 464.11 | 491.17 | 39.09 | 540.73 | 464.48 | 491.31 | 39.28 |

| | | | | | | | | | |
|-----|-------|--------|--------|--------|-------|--------|--------|--------|-------|
| 55 | 58.0 | 545.62 | 469.28 | 496.28 | 39.02 | 545.76 | 469.65 | 496.44 | 39.21 |
| 56 | 60.0 | 550.66 | 474.39 | 501.36 | 38.97 | 550.78 | 474.77 | 501.52 | 39.17 |
| 57 | 62.0 | 555.66 | 479.45 | 506.41 | 38.95 | 555.79 | 479.84 | 506.58 | 39.14 |
| 58 | 64.0 | 560.67 | 484.47 | 511.42 | 38.94 | 560.79 | 484.87 | 511.60 | 39.14 |
| 59 | 66.0 | 565.65 | 489.45 | 516.41 | 38.94 | 565.79 | 489.87 | 516.60 | 39.14 |
| 60 | 68.0 | 570.65 | 494.40 | 521.38 | 38.96 | 570.77 | 494.83 | 521.57 | 39.16 |
| 61 | 70.0 | 575.62 | 499.33 | 526.32 | 38.99 | 575.75 | 499.78 | 526.52 | 39.19 |
| 62 | 72.0 | 578.02 | 504.21 | 530.74 | 38.08 | 577.73 | 504.70 | 530.89 | 38.04 |
| 63 | 74.0 | 579.09 | 508.93 | 534.42 | 36.34 | 579.04 | 509.45 | 534.58 | 36.38 |
| 64 | 76.0 | 580.27 | 513.31 | 537.64 | 34.67 | 580.10 | 513.83 | 537.81 | 34.70 |
| 65 | 78.0 | 581.08 | 517.28 | 540.50 | 33.08 | 581.01 | 517.79 | 540.67 | 33.14 |
| 66 | 80.0 | 581.94 | 520.86 | 543.07 | 31.65 | 581.81 | 521.38 | 543.25 | 31.71 |
| 67 | 82.0 | 580.02 | 524.09 | 544.89 | 29.38 | 579.54 | 524.65 | 545.01 | 29.22 |
| 68 | 84.0 | 576.83 | 526.90 | 545.77 | 26.40 | 576.54 | 527.50 | 545.91 | 26.31 |
| 69 | 86.0 | 573.60 | 529.15 | 546.05 | 23.57 | 573.23 | 529.73 | 546.18 | 23.48 |
| 70 | 88.0 | 570.04 | 530.78 | 545.81 | 20.91 | 569.73 | 531.36 | 545.94 | 20.84 |
| 71 | 90.0 | 566.44 | 531.86 | 545.17 | 18.48 | 566.09 | 532.45 | 545.30 | 18.40 |
| 72 | 92.0 | 562.66 | 532.45 | 544.18 | 16.22 | 562.35 | 533.06 | 544.31 | 16.15 |
| 73 | 94.0 | 558.84 | 532.63 | 542.89 | 14.14 | 558.51 | 533.25 | 543.02 | 14.06 |
| 74 | 96.0 | 554.90 | 532.45 | 541.35 | 12.20 | 554.61 | 533.08 | 541.48 | 12.12 |
| 75 | 98.0 | 550.93 | 531.95 | 539.58 | 10.40 | 550.64 | 532.58 | 539.71 | 10.32 |
| 76 | 100.0 | 546.87 | 531.17 | 537.00 | 8.71 | 546.61 | 531.80 | 537.74 | 8.63 |
| 77 | 102.0 | 545.36 | 530.16 | 535.97 | 8.07 | 545.52 | 530.77 | 536.17 | 8.22 |
| 78 | 104.0 | 545.10 | 529.06 | 534.91 | 8.36 | 545.06 | 529.66 | 535.10 | 8.43 |
| 79 | 106.0 | 544.71 | 528.09 | 534.14 | 8.67 | 544.80 | 528.71 | 534.34 | 8.75 |
| 80 | 108.0 | 544.63 | 527.34 | 533.60 | 8.97 | 544.65 | 527.99 | 533.81 | 9.02 |
| 81 | 110.0 | 544.47 | 526.80 | 533.22 | 9.18 | 544.55 | 527.46 | 533.43 | 9.24 |
| 82 | 115.0 | 547.57 | 526.29 | 533.70 | 10.79 | 548.04 | 526.87 | 534.08 | 11.20 |
| 83 | 120.0 | 551.90 | 527.13 | 535.84 | 12.65 | 552.19 | 527.85 | 536.21 | 12.83 |
| 84 | 125.0 | 556.19 | 529.23 | 538.79 | 13.77 | 556.58 | 529.96 | 539.16 | 14.02 |
| 85 | 130.0 | 560.80 | 532.14 | 542.30 | 14.65 | 561.13 | 532.88 | 542.67 | 14.87 |
| 86 | 135.0 | 565.42 | 535.56 | 546.17 | 15.28 | 565.78 | 536.32 | 546.53 | 15.51 |
| 87 | 140.0 | 570.17 | 539.35 | 550.30 | 15.77 | 570.51 | 540.12 | 550.65 | 16.00 |
| 88 | 145.0 | 574.94 | 543.39 | 554.61 | 16.15 | 575.29 | 544.18 | 554.95 | 16.39 |
| 89 | 150.0 | 579.78 | 547.62 | 559.06 | 16.46 | 580.13 | 548.43 | 559.39 | 16.69 |
| 90 | 155.0 | 584.62 | 551.99 | 563.60 | 16.71 | 585.00 | 552.80 | 563.94 | 16.94 |
| 91 | 160.0 | 589.51 | 556.47 | 568.22 | 16.92 | 589.90 | 557.27 | 568.56 | 17.14 |
| 92 | 170.0 | 592.22 | 564.54 | 574.77 | 14.46 | 592.06 | 565.34 | 574.76 | 14.22 |
| 93 | 180.0 | 592.92 | 570.05 | 578.35 | 11.82 | 593.20 | 570.60 | 578.53 | 12.09 |
| 94 | 190.0 | 594.04 | 573.64 | 581.08 | 10.61 | 594.01 | 574.41 | 581.24 | 10.57 |
| 95 | 200.0 | 594.51 | 576.59 | 583.14 | 9.29 | 594.66 | 577.42 | 583.36 | 9.39 |
| 96 | 210.0 | 595.21 | 578.96 | 584.87 | 8.44 | 595.23 | 579.91 | 585.10 | 8.42 |
| 97 | 220.0 | 595.55 | 580.98 | 586.32 | 7.57 | 595.73 | 582.01 | 586.58 | 7.61 |
| 98 | 230.0 | 596.06 | 582.74 | 587.59 | 6.91 | 596.15 | 583.80 | 587.85 | 6.91 |
| 99 | 240.0 | 596.33 | 584.28 | 588.70 | 6.26 | 596.48 | 585.34 | 588.97 | 6.31 |
| 100 | 250.0 | 596.72 | 585.65 | 589.69 | 5.74 | 596.79 | 586.70 | 589.96 | 5.77 |
| 101 | 260.0 | 596.93 | 586.87 | 590.56 | 5.23 | 597.07 | 587.90 | 590.84 | 5.29 |
| 102 | 270.0 | 597.25 | 587.97 | 591.35 | 4.81 | 597.33 | 588.96 | 591.64 | 4.86 |
| 103 | 280.0 | 597.42 | 588.96 | 592.06 | 4.40 | 597.55 | 589.89 | 592.35 | 4.48 |
| 104 | 290.0 | 597.67 | 589.85 | 592.71 | 4.05 | 597.75 | 590.74 | 592.99 | 4.13 |
| 105 | 300.0 | 597.81 | 590.66 | 593.29 | 3.72 | 597.92 | 591.53 | 593.57 | 3.82 |

表 6. 6 評価断面6の温度

FINAS解と簡易計算値との比較 (ホットショック)

断面6の温度

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|--------|--------|-------|--------|--------|--------|-------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 300.00 | 300.00 | 300.00 | 0.00 | 300.00 | 300.00 | 300.00 | 0.00 |
| 2 | 0.5 | 301.67 | 300.00 | 300.06 | 0.16 | 301.99 | 300.00 | 300.06 | 0.18 |
| 3 | 1.0 | 304.63 | 300.00 | 300.20 | 0.56 | 304.78 | 300.00 | 300.21 | 0.58 |
| 4 | 1.5 | 307.72 | 300.00 | 300.42 | 1.13 | 307.94 | 300.00 | 300.42 | 1.15 |
| 5 | 2.0 | 311.16 | 300.00 | 300.69 | 1.84 | 311.33 | 300.00 | 300.69 | 1.85 |
| 6 | 2.5 | 314.68 | 300.00 | 301.01 | 2.66 | 314.88 | 300.00 | 301.01 | 2.67 |
| 7 | 3.0 | 318.39 | 300.00 | 301.38 | 3.58 | 318.56 | 300.00 | 301.38 | 3.59 |
| 8 | 3.5 | 322.15 | 300.00 | 301.79 | 4.59 | 322.33 | 300.00 | 301.79 | 4.60 |
| 9 | 4.0 | 326.01 | 300.00 | 302.24 | 5.69 | 326.18 | 300.00 | 302.23 | 5.69 |
| 10 | 4.5 | 329.92 | 300.00 | 302.73 | 6.86 | 330.10 | 300.00 | 302.72 | 6.86 |
| 11 | 5.0 | 333.90 | 300.00 | 303.26 | 8.10 | 334.07 | 300.00 | 303.25 | 8.10 |
| 12 | 5.5 | 337.93 | 300.01 | 303.83 | 9.40 | 338.10 | 300.00 | 303.81 | 9.41 |
| 13 | 6.0 | 342.00 | 300.02 | 304.43 | 10.77 | 342.16 | 300.00 | 304.41 | 10.78 |
| 14 | 6.5 | 346.10 | 300.03 | 305.07 | 12.18 | 346.27 | 300.01 | 305.05 | 12.20 |
| 15 | 7.0 | 350.24 | 300.05 | 305.75 | 13.65 | 350.41 | 300.03 | 305.72 | 13.67 |
| 16 | 7.5 | 354.41 | 300.08 | 306.47 | 15.17 | 354.58 | 300.05 | 306.44 | 15.19 |
| 17 | 8.0 | 358.61 | 300.11 | 307.22 | 16.72 | 358.78 | 300.08 | 307.19 | 16.75 |
| 18 | 8.5 | 362.84 | 300.15 | 308.01 | 18.32 | 363.00 | 300.13 | 307.97 | 18.34 |
| 19 | 9.0 | 367.09 | 300.21 | 308.84 | 19.95 | 367.25 | 300.18 | 308.80 | 19.98 |
| 20 | 9.5 | 371.36 | 300.28 | 309.70 | 21.61 | 371.52 | 300.24 | 309.66 | 21.65 |
| 21 | 10.0 | 375.65 | 300.36 | 310.60 | 23.30 | 375.81 | 300.32 | 310.56 | 23.34 |
| 22 | 11.0 | 382.16 | 300.58 | 312.42 | 26.50 | 382.17 | 300.52 | 312.36 | 26.53 |
| 23 | 12.0 | 387.39 | 300.86 | 314.22 | 29.40 | 387.62 | 300.80 | 314.16 | 29.46 |
| 24 | 13.0 | 392.63 | 301.21 | 316.07 | 32.15 | 392.77 | 301.14 | 316.01 | 32.22 |
| 25 | 14.0 | 397.56 | 301.65 | 317.97 | 34.77 | 397.78 | 301.57 | 317.91 | 34.85 |
| 26 | 15.0 | 402.53 | 302.17 | 319.93 | 37.28 | 402.71 | 302.08 | 319.86 | 37.36 |
| 27 | 16.0 | 407.36 | 302.78 | 321.95 | 39.69 | 407.58 | 302.68 | 321.88 | 39.79 |
| 28 | 17.0 | 412.21 | 303.47 | 324.02 | 42.02 | 412.41 | 303.36 | 323.94 | 42.12 |
| 29 | 18.0 | 416.99 | 304.25 | 326.15 | 44.27 | 417.22 | 304.13 | 326.07 | 44.38 |
| 30 | 19.0 | 421.79 | 305.10 | 328.33 | 46.44 | 422.00 | 304.98 | 328.24 | 46.56 |
| 31 | 20.0 | 426.54 | 306.04 | 330.55 | 48.56 | 426.77 | 305.91 | 330.46 | 48.68 |
| 32 | 21.0 | 431.32 | 307.04 | 332.82 | 50.61 | 431.52 | 306.91 | 332.72 | 50.74 |
| 33 | 22.0 | 436.06 | 308.11 | 335.14 | 52.62 | 436.27 | 307.97 | 335.03 | 52.75 |
| 34 | 23.0 | 440.82 | 309.25 | 337.49 | 54.57 | 441.02 | 309.11 | 337.38 | 54.71 |
| 35 | 24.0 | 445.56 | 310.45 | 339.89 | 56.48 | 445.76 | 310.31 | 339.76 | 56.62 |
| 36 | 25.0 | 450.31 | 311.71 | 342.32 | 58.35 | 450.50 | 311.58 | 342.19 | 58.50 |
| 37 | 26.0 | 455.05 | 313.02 | 344.79 | 60.17 | 455.25 | 312.90 | 344.66 | 60.33 |
| 38 | 27.0 | 459.80 | 314.40 | 347.30 | 61.97 | 459.99 | 314.28 | 347.16 | 62.12 |
| 39 | 28.0 | 464.54 | 315.83 | 349.84 | 63.73 | 464.73 | 315.72 | 349.69 | 63.89 |
| 40 | 29.0 | 469.28 | 317.31 | 352.42 | 65.45 | 469.48 | 317.20 | 352.26 | 65.62 |
| 41 | 30.0 | 474.03 | 318.84 | 355.03 | 67.15 | 474.22 | 318.74 | 354.87 | 67.32 |
| 42 | 32.0 | 480.93 | 322.05 | 360.17 | 70.03 | 480.94 | 321.96 | 360.00 | 70.19 |
| 43 | 34.0 | 486.49 | 325.45 | 365.21 | 72.26 | 486.74 | 325.37 | 365.04 | 72.45 |
| 44 | 36.0 | 492.11 | 329.02 | 370.21 | 74.10 | 492.27 | 328.94 | 370.04 | 74.31 |
| 45 | 38.0 | 497.39 | 332.74 | 375.17 | 75.63 | 497.65 | 332.65 | 374.99 | 75.85 |
| 46 | 40.0 | 502.72 | 336.58 | 380.09 | 76.92 | 502.92 | 336.48 | 379.91 | 77.15 |
| 47 | 42.0 | 507.87 | 340.52 | 384.97 | 78.03 | 508.13 | 340.41 | 384.78 | 78.27 |
| 48 | 44.0 | 513.07 | 344.53 | 389.81 | 78.99 | 513.29 | 344.41 | 389.60 | 79.24 |
| 49 | 46.0 | 518.15 | 348.59 | 394.60 | 79.83 | 518.41 | 348.47 | 394.39 | 80.09 |
| 50 | 48.0 | 523.26 | 352.70 | 399.36 | 80.59 | 523.49 | 352.58 | 399.14 | 80.85 |
| 51 | 50.0 | 528.30 | 356.84 | 404.08 | 81.27 | 528.56 | 356.73 | 403.86 | 81.54 |
| 52 | 52.0 | 533.36 | 361.01 | 408.77 | 81.90 | 533.61 | 360.90 | 408.55 | 82.17 |
| 53 | 54.0 | 538.37 | 365.19 | 413.43 | 82.48 | 538.63 | 365.08 | 413.21 | 82.75 |
| 54 | 56.0 | 543.39 | 369.39 | 418.07 | 83.03 | 543.64 | 369.27 | 417.84 | 83.29 |

| | | | | | | | | | |
|-----|-------|--------|--------|--------|-------|--------|--------|--------|-------|
| 55 | 58.0 | 548.38 | 373.59 | 422.68 | 83.54 | 548.63 | 373.47 | 422.45 | 83.81 |
| 56 | 60.0 | 553.38 | 377.81 | 427.28 | 84.03 | 553.61 | 377.68 | 427.04 | 84.30 |
| 57 | 62.0 | 558.35 | 382.03 | 431.85 | 84.50 | 558.59 | 381.90 | 431.61 | 84.77 |
| 58 | 64.0 | 563.34 | 386.26 | 436.41 | 84.95 | 563.57 | 386.13 | 436.17 | 85.22 |
| 59 | 66.0 | 568.30 | 390.49 | 440.96 | 85.39 | 568.55 | 390.36 | 440.72 | 85.66 |
| 60 | 68.0 | 573.27 | 394.72 | 445.49 | 85.82 | 573.51 | 394.59 | 445.26 | 86.09 |
| 61 | 70.0 | 578.23 | 398.96 | 450.02 | 86.23 | 578.48 | 398.84 | 449.78 | 86.51 |
| 62 | 72.0 | 580.59 | 403.20 | 454.37 | 86.21 | 580.44 | 403.08 | 454.12 | 86.43 |
| 63 | 74.0 | 581.60 | 407.44 | 458.49 | 85.63 | 581.66 | 407.34 | 458.25 | 85.86 |
| 64 | 76.0 | 582.66 | 411.68 | 462.45 | 84.76 | 582.61 | 411.60 | 462.22 | 84.98 |
| 65 | 78.0 | 583.37 | 415.90 | 466.25 | 83.65 | 583.40 | 415.84 | 466.04 | 83.87 |
| 66 | 80.0 | 584.12 | 420.08 | 469.91 | 82.39 | 584.09 | 420.06 | 469.70 | 82.60 |
| 67 | 82.0 | 582.08 | 424.22 | 473.25 | 80.58 | 581.70 | 424.21 | 473.03 | 80.73 |
| 68 | 84.0 | 578.73 | 428.27 | 476.22 | 78.15 | 578.52 | 428.29 | 476.02 | 78.31 |
| 69 | 86.0 | 575.30 | 432.24 | 478.90 | 75.38 | 575.02 | 432.29 | 478.71 | 75.53 |
| 70 | 88.0 | 571.55 | 436.11 | 481.30 | 72.36 | 571.33 | 436.18 | 481.12 | 72.51 |
| 71 | 90.0 | 567.75 | 439.83 | 483.42 | 69.18 | 567.50 | 439.93 | 483.26 | 69.32 |
| 72 | 92.0 | 563.78 | 443.41 | 485.29 | 65.89 | 563.57 | 443.52 | 485.13 | 66.02 |
| 73 | 94.0 | 559.77 | 446.81 | 486.90 | 62.53 | 559.55 | 446.94 | 486.75 | 62.66 |
| 74 | 96.0 | 555.66 | 450.02 | 488.28 | 59.16 | 555.47 | 450.17 | 488.14 | 59.28 |
| 75 | 98.0 | 551.52 | 453.04 | 489.42 | 55.78 | 551.32 | 453.21 | 489.29 | 55.89 |
| 76 | 100.0 | 547.30 | 455.87 | 490.35 | 52.41 | 547.12 | 456.04 | 490.22 | 52.52 |
| 77 | 102.0 | 545.65 | 458.50 | 491.23 | 49.51 | 545.88 | 458.68 | 491.13 | 49.68 |
| 78 | 104.0 | 545.30 | 460.94 | 492.15 | 47.21 | 545.32 | 461.12 | 492.05 | 47.35 |
| 79 | 106.0 | 544.87 | 463.19 | 493.04 | 45.24 | 545.00 | 463.36 | 492.93 | 45.39 |
| 80 | 108.0 | 544.75 | 465.26 | 493.90 | 43.55 | 544.80 | 465.43 | 493.79 | 43.71 |
| 81 | 110.0 | 544.57 | 467.19 | 494.74 | 42.07 | 544.68 | 467.36 | 494.64 | 42.23 |
| 82 | 115.0 | 547.69 | 471.53 | 497.11 | 39.78 | 548.20 | 471.70 | 497.06 | 40.08 |
| 83 | 120.0 | 552.11 | 475.39 | 499.88 | 38.95 | 552.40 | 475.57 | 499.82 | 39.24 |
| 84 | 125.0 | 556.50 | 479.02 | 502.95 | 38.74 | 556.87 | 479.24 | 502.91 | 39.04 |
| 85 | 130.0 | 561.20 | 482.61 | 506.33 | 38.90 | 561.51 | 482.87 | 506.30 | 39.19 |
| 86 | 135.0 | 565.90 | 486.25 | 509.94 | 39.21 | 566.23 | 486.55 | 509.92 | 39.50 |
| 87 | 140.0 | 570.72 | 489.97 | 513.77 | 39.60 | 571.03 | 490.30 | 513.75 | 39.89 |
| 88 | 145.0 | 575.54 | 493.80 | 517.76 | 40.01 | 575.87 | 494.14 | 517.73 | 40.31 |
| 89 | 150.0 | 580.42 | 497.74 | 521.89 | 40.42 | 580.76 | 498.08 | 521.84 | 40.73 |
| 90 | 155.0 | 585.30 | 501.77 | 526.12 | 40.81 | 585.67 | 502.11 | 526.06 | 41.13 |
| 91 | 160.0 | 590.22 | 505.89 | 530.46 | 41.19 | 590.59 | 506.24 | 530.38 | 41.51 |
| 92 | 170.0 | 592.87 | 514.29 | 538.31 | 39.77 | 592.62 | 514.73 | 538.16 | 39.77 |
| 93 | 180.0 | 593.39 | 522.48 | 544.89 | 36.47 | 593.57 | 522.95 | 544.74 | 36.63 |
| 94 | 190.0 | 594.40 | 529.94 | 550.49 | 33.22 | 594.24 | 530.39 | 550.32 | 33.40 |
| 95 | 200.0 | 594.77 | 536.52 | 555.24 | 30.17 | 594.80 | 536.96 | 555.09 | 30.39 |
| 96 | 210.0 | 595.41 | 542.34 | 559.39 | 27.46 | 595.28 | 542.74 | 559.22 | 27.69 |
| 97 | 220.0 | 595.70 | 547.49 | 563.02 | 25.01 | 595.70 | 547.91 | 562.86 | 25.26 |
| 98 | 230.0 | 596.17 | 552.08 | 566.25 | 22.84 | 596.05 | 552.53 | 566.09 | 23.08 |
| 99 | 240.0 | 596.41 | 556.18 | 569.13 | 20.87 | 596.36 | 556.65 | 568.97 | 21.12 |
| 100 | 250.0 | 596.78 | 559.86 | 571.72 | 19.12 | 596.65 | 560.34 | 571.56 | 19.37 |
| 101 | 260.0 | 596.98 | 563.18 | 574.05 | 17.53 | 596.91 | 563.66 | 573.90 | 17.79 |
| 102 | 270.0 | 597.27 | 566.19 | 576.15 | 16.10 | 597.14 | 566.68 | 576.01 | 16.36 |
| 103 | 280.0 | 597.44 | 568.91 | 578.07 | 14.80 | 597.35 | 569.45 | 577.93 | 15.05 |
| 104 | 290.0 | 597.68 | 571.38 | 579.81 | 13.62 | 597.53 | 571.98 | 579.69 | 13.85 |
| 105 | 300.0 | 597.82 | 573.64 | 581.39 | 12.54 | 597.71 | 574.29 | 581.29 | 12.76 |

表6. 7 評価断面7の温度

FINAS解と簡易計算値との比較 (ホットショック)

断面7の温度

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|--------|--------|--------|--------|--------|--------|--------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 300.00 | 300.00 | 300.00 | 0.00 | 300.00 | 300.00 | 300.00 | 0.00 |
| 2 | 0.5 | 301.63 | 300.00 | 300.07 | 0.21 | 301.96 | 300.00 | 300.08 | 0.23 |
| 3 | 1.0 | 304.56 | 300.00 | 300.25 | 0.68 | 304.73 | 300.00 | 300.26 | 0.70 |
| 4 | 1.5 | 307.61 | 300.00 | 300.49 | 1.31 | 307.85 | 300.00 | 300.50 | 1.32 |
| 5 | 2.0 | 311.01 | 300.00 | 300.79 | 2.07 | 311.20 | 300.00 | 300.80 | 2.08 |
| 6 | 2.5 | 314.49 | 300.00 | 301.14 | 2.94 | 314.70 | 300.00 | 301.14 | 2.95 |
| 7 | 3.0 | 318.14 | 300.00 | 301.53 | 3.91 | 318.33 | 300.00 | 301.53 | 3.92 |
| 8 | 3.5 | 321.86 | 300.00 | 301.96 | 4.95 | 322.04 | 300.00 | 301.95 | 4.96 |
| 9 | 4.0 | 325.67 | 300.00 | 302.42 | 6.07 | 325.84 | 300.00 | 302.41 | 6.08 |
| 10 | 4.5 | 329.53 | 300.00 | 302.91 | 7.26 | 329.70 | 300.00 | 302.91 | 7.26 |
| 11 | 5.0 | 333.45 | 300.00 | 303.44 | 8.50 | 333.61 | 300.00 | 303.43 | 8.50 |
| 12 | 5.5 | 337.42 | 300.00 | 304.00 | 9.81 | 337.57 | 300.00 | 303.98 | 9.80 |
| 13 | 6.0 | 341.43 | 300.00 | 304.58 | 11.16 | 341.56 | 300.00 | 304.56 | 11.15 |
| 14 | 6.5 | 345.48 | 300.00 | 305.19 | 12.56 | 345.60 | 300.00 | 305.17 | 12.55 |
| 15 | 7.0 | 349.55 | 300.00 | 305.83 | 14.01 | 349.67 | 300.00 | 305.81 | 13.99 |
| 16 | 7.5 | 353.66 | 300.00 | 306.50 | 15.49 | 353.76 | 300.00 | 306.47 | 15.48 |
| 17 | 8.0 | 357.79 | 300.00 | 307.19 | 17.02 | 357.88 | 300.00 | 307.15 | 17.00 |
| 18 | 8.5 | 361.95 | 300.00 | 307.90 | 18.58 | 362.03 | 300.00 | 307.86 | 18.56 |
| 19 | 9.0 | 366.13 | 300.00 | 308.63 | 20.18 | 366.20 | 300.00 | 308.59 | 20.16 |
| 20 | 9.5 | 370.33 | 300.00 | 309.39 | 21.81 | 370.39 | 300.00 | 309.34 | 21.79 |
| 21 | 10.0 | 374.55 | 300.00 | 310.18 | 23.47 | 374.60 | 300.00 | 310.12 | 23.45 |
| 22 | 11.0 | 380.94 | 300.00 | 311.68 | 26.56 | 380.82 | 300.00 | 311.61 | 26.53 |
| 23 | 12.0 | 386.05 | 300.00 | 313.12 | 29.37 | 386.13 | 300.00 | 313.04 | 29.35 |
| 24 | 13.0 | 391.18 | 300.01 | 314.54 | 32.07 | 391.16 | 300.00 | 314.46 | 32.05 |
| 25 | 14.0 | 396.00 | 300.01 | 315.97 | 34.68 | 396.05 | 300.00 | 315.87 | 34.68 |
| 26 | 15.0 | 400.84 | 300.02 | 317.40 | 37.24 | 400.84 | 300.00 | 317.29 | 37.24 |
| 27 | 16.0 | 405.56 | 300.04 | 318.84 | 39.75 | 405.59 | 300.00 | 318.73 | 39.77 |
| 28 | 17.0 | 410.29 | 300.06 | 320.30 | 42.24 | 410.30 | 300.02 | 320.18 | 42.26 |
| 29 | 18.0 | 414.96 | 300.08 | 321.78 | 44.69 | 414.98 | 300.04 | 321.66 | 44.72 |
| 30 | 19.0 | 419.64 | 300.12 | 323.28 | 47.13 | 419.64 | 300.07 | 323.15 | 47.15 |
| 31 | 20.0 | 424.28 | 300.17 | 324.79 | 49.54 | 424.29 | 300.12 | 324.66 | 49.57 |
| 32 | 21.0 | 428.94 | 300.23 | 326.33 | 51.93 | 428.93 | 300.17 | 326.19 | 51.96 |
| 33 | 22.0 | 433.57 | 300.30 | 327.89 | 54.31 | 433.57 | 300.24 | 327.74 | 54.34 |
| 34 | 23.0 | 438.21 | 300.40 | 329.47 | 56.67 | 438.20 | 300.33 | 329.31 | 56.70 |
| 35 | 24.0 | 442.84 | 300.50 | 331.07 | 59.02 | 442.82 | 300.44 | 330.90 | 59.05 |
| 36 | 25.0 | 447.47 | 300.63 | 332.69 | 61.35 | 447.45 | 300.57 | 332.52 | 61.38 |
| 37 | 26.0 | 452.10 | 300.78 | 334.33 | 63.66 | 452.07 | 300.72 | 334.16 | 63.69 |
| 38 | 27.0 | 456.73 | 300.94 | 336.00 | 65.97 | 456.70 | 300.89 | 335.81 | 66.00 |
| 39 | 28.0 | 461.36 | 301.13 | 337.68 | 68.26 | 461.32 | 301.08 | 337.49 | 68.29 |
| 40 | 29.0 | 466.00 | 301.35 | 339.39 | 70.54 | 465.95 | 301.29 | 339.20 | 70.57 |
| 41 | 30.0 | 470.63 | 301.58 | 341.12 | 72.80 | 470.57 | 301.53 | 340.92 | 72.84 |
| 42 | 32.0 | 477.34 | 302.13 | 344.45 | 76.81 | 477.08 | 302.09 | 344.23 | 76.82 |
| 43 | 34.0 | 482.71 | 302.78 | 347.64 | 80.22 | 482.69 | 302.76 | 347.42 | 80.27 |
| 44 | 36.0 | 488.17 | 303.54 | 350.79 | 83.34 | 488.04 | 303.53 | 350.56 | 83.40 |
| 45 | 38.0 | 493.28 | 304.40 | 353.90 | 86.20 | 493.24 | 304.41 | 353.67 | 86.28 |
| 46 | 40.0 | 498.45 | 305.37 | 357.01 | 88.88 | 498.35 | 305.39 | 356.77 | 88.95 |
| 47 | 42.0 | 503.45 | 306.44 | 360.11 | 91.38 | 503.40 | 306.47 | 359.86 | 91.46 |
| 48 | 44.0 | 508.50 | 307.63 | 363.20 | 93.74 | 508.39 | 307.66 | 362.95 | 93.82 |
| 49 | 46.0 | 513.44 | 308.91 | 366.30 | 95.97 | 513.35 | 308.95 | 366.04 | 96.06 |
| 50 | 48.0 | 518.41 | 310.30 | 369.41 | 98.09 | 518.28 | 310.33 | 369.14 | 98.18 |
| 51 | 50.0 | 523.31 | 311.79 | 372.52 | 100.10 | 523.20 | 311.81 | 372.25 | 100.20 |
| 52 | 52.0 | 528.23 | 313.37 | 375.65 | 102.03 | 528.10 | 313.39 | 375.38 | 102.13 |
| 53 | 54.0 | 533.11 | 315.04 | 378.79 | 103.88 | 532.99 | 315.05 | 378.51 | 103.99 |
| 54 | 56.0 | 538.00 | 316.79 | 381.95 | 105.65 | 537.86 | 316.80 | 381.66 | 105.77 |

| | | | | | | | | | |
|-----|-------|--------|--------|--------|--------|--------|--------|--------|--------|
| 55 | 58.0 | 542.86 | 318.62 | 385.12 | 107.36 | 542.73 | 318.62 | 384.83 | 107.48 |
| 56 | 60.0 | 547.74 | 320.53 | 388.30 | 109.01 | 547.58 | 320.53 | 388.01 | 109.13 |
| 57 | 62.0 | 552.59 | 322.51 | 391.51 | 110.60 | 552.43 | 322.51 | 391.21 | 110.73 |
| 58 | 64.0 | 557.45 | 324.56 | 394.73 | 112.15 | 557.28 | 324.55 | 394.43 | 112.27 |
| 59 | 66.0 | 562.29 | 326.66 | 397.97 | 113.64 | 562.12 | 326.67 | 397.67 | 113.77 |
| 60 | 68.0 | 567.14 | 328.83 | 401.23 | 115.10 | 566.96 | 328.84 | 400.92 | 115.23 |
| 61 | 70.0 | 571.98 | 331.06 | 404.50 | 116.51 | 571.80 | 331.06 | 404.19 | 116.65 |
| 62 | 72.0 | 574.26 | 333.33 | 407.61 | 117.41 | 573.66 | 333.33 | 407.27 | 117.49 |
| 63 | 74.0 | 575.19 | 335.66 | 410.51 | 117.73 | 574.81 | 335.66 | 410.18 | 117.84 |
| 64 | 76.0 | 576.20 | 338.04 | 413.31 | 117.78 | 575.70 | 338.03 | 412.98 | 117.89 |
| 65 | 78.0 | 576.85 | 340.46 | 416.01 | 117.59 | 576.44 | 340.45 | 415.69 | 117.72 |
| 66 | 80.0 | 577.56 | 342.93 | 418.63 | 117.23 | 577.08 | 342.92 | 418.32 | 117.37 |
| 67 | 82.0 | 575.53 | 345.44 | 421.01 | 116.25 | 574.68 | 345.43 | 420.67 | 116.32 |
| 68 | 84.0 | 572.19 | 347.99 | 423.09 | 114.60 | 571.52 | 347.98 | 422.77 | 114.69 |
| 69 | 86.0 | 568.80 | 350.57 | 424.99 | 112.61 | 568.06 | 350.57 | 424.67 | 112.70 |
| 70 | 88.0 | 565.09 | 353.19 | 426.73 | 110.33 | 564.42 | 353.20 | 426.42 | 110.43 |
| 71 | 90.0 | 561.35 | 355.83 | 428.32 | 107.84 | 560.65 | 355.85 | 428.02 | 107.95 |
| 72 | 92.0 | 557.44 | 358.50 | 429.78 | 105.17 | 556.79 | 358.53 | 429.49 | 105.28 |
| 73 | 94.0 | 553.51 | 361.18 | 431.12 | 102.35 | 552.85 | 361.22 | 430.84 | 102.47 |
| 74 | 96.0 | 549.48 | 363.87 | 432.35 | 99.41 | 548.85 | 363.93 | 432.07 | 99.53 |
| 75 | 98.0 | 545.43 | 366.56 | 433.46 | 96.38 | 544.80 | 366.63 | 433.20 | 96.50 |
| 76 | 100.0 | 541.31 | 369.25 | 434.48 | 93.26 | 540.70 | 369.31 | 434.22 | 93.39 |
| 77 | 102.0 | 539.73 | 371.93 | 435.58 | 90.56 | 539.54 | 371.98 | 435.35 | 90.77 |
| 78 | 104.0 | 539.44 | 374.58 | 436.81 | 88.36 | 539.04 | 374.63 | 436.58 | 88.54 |
| 79 | 106.0 | 539.06 | 377.21 | 438.08 | 86.35 | 538.77 | 377.25 | 437.85 | 86.55 |
| 80 | 108.0 | 538.99 | 379.81 | 439.37 | 84.52 | 538.63 | 379.83 | 439.14 | 84.72 |
| 81 | 110.0 | 538.86 | 382.36 | 440.67 | 82.82 | 538.55 | 382.38 | 440.45 | 83.02 |
| 82 | 115.0 | 542.04 | 388.55 | 444.26 | 79.76 | 542.12 | 388.55 | 444.09 | 80.11 |
| 83 | 120.0 | 546.49 | 394.41 | 448.20 | 77.93 | 546.37 | 394.40 | 448.01 | 78.26 |
| 84 | 125.0 | 550.91 | 399.96 | 452.28 | 76.68 | 550.88 | 399.93 | 452.09 | 77.03 |
| 85 | 130.0 | 555.61 | 405.22 | 456.48 | 75.89 | 555.54 | 405.18 | 456.29 | 76.25 |
| 86 | 135.0 | 560.31 | 410.24 | 460.76 | 75.40 | 560.29 | 410.20 | 460.56 | 75.77 |
| 87 | 140.0 | 565.13 | 415.07 | 465.10 | 75.14 | 565.09 | 415.04 | 464.91 | 75.50 |
| 88 | 145.0 | 569.95 | 419.77 | 469.50 | 75.04 | 569.93 | 419.75 | 469.30 | 75.39 |
| 89 | 150.0 | 574.83 | 424.37 | 473.94 | 75.05 | 574.79 | 424.35 | 473.74 | 75.39 |
| 90 | 155.0 | 579.71 | 428.91 | 478.40 | 75.14 | 579.67 | 428.89 | 478.21 | 75.45 |
| 91 | 160.0 | 584.62 | 433.40 | 482.90 | 75.28 | 584.57 | 433.38 | 482.70 | 75.58 |
| 92 | 170.0 | 587.37 | 442.32 | 491.01 | 73.52 | 586.72 | 442.30 | 490.73 | 73.51 |
| 93 | 180.0 | 588.05 | 451.17 | 498.12 | 70.04 | 587.86 | 451.17 | 497.92 | 70.16 |
| 94 | 190.0 | 589.23 | 459.91 | 504.73 | 66.36 | 588.76 | 459.96 | 504.53 | 66.40 |
| 95 | 200.0 | 589.80 | 468.42 | 510.82 | 62.48 | 589.55 | 468.49 | 510.67 | 62.56 |
| 96 | 210.0 | 590.63 | 476.56 | 516.52 | 58.74 | 590.25 | 476.61 | 516.36 | 58.81 |
| 97 | 220.0 | 591.13 | 484.28 | 521.82 | 55.10 | 590.87 | 484.34 | 521.69 | 55.20 |
| 98 | 230.0 | 591.80 | 491.56 | 526.79 | 51.67 | 591.46 | 491.64 | 526.66 | 51.78 |
| 99 | 240.0 | 592.24 | 498.40 | 531.44 | 48.41 | 592.03 | 498.53 | 531.31 | 48.55 |
| 100 | 250.0 | 592.81 | 504.83 | 535.79 | 45.37 | 592.57 | 505.00 | 535.67 | 45.50 |
| 101 | 260.0 | 593.20 | 510.85 | 539.86 | 42.49 | 593.04 | 511.05 | 539.74 | 42.63 |
| 102 | 270.0 | 593.69 | 516.50 | 543.68 | 39.80 | 593.45 | 516.70 | 543.56 | 39.92 |
| 103 | 280.0 | 594.03 | 521.80 | 547.25 | 37.28 | 593.82 | 521.98 | 547.14 | 37.38 |
| 104 | 290.0 | 594.46 | 526.76 | 550.60 | 34.91 | 594.17 | 526.95 | 550.50 | 34.99 |
| 105 | 300.0 | 594.76 | 531.40 | 553.73 | 32.69 | 594.52 | 531.62 | 553.65 | 32.75 |

表7. 1(1) 評価断面1の応力テンソル成分1

F I N A S解と簡易計算値との比較 (ホットショック)

断面1の応力成分1

| ステップ | 時間(S) | F I N A S解 | | | | 簡易計算値 | | | |
|------|-------|------------|---------|---------|---------|---------|---------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.0098 | -0.0011 | -0.0042 | -0.0028 | -0.0070 | -0.0009 | -0.0051 | -0.0025 |
| 3 | 1.0 | -0.0077 | -0.0040 | -0.0095 | -0.0028 | -0.0109 | -0.0027 | -0.0098 | -0.0032 |
| 4 | 1.5 | -0.0110 | -0.0068 | -0.0132 | -0.0028 | -0.0151 | -0.0043 | -0.0137 | -0.0037 |
| 5 | 2.0 | -0.0103 | -0.0088 | -0.0164 | -0.0030 | -0.0142 | -0.0043 | -0.0167 | -0.0037 |
| 6 | 2.5 | -0.0121 | -0.0106 | -0.0188 | -0.0030 | -0.0115 | -0.0034 | -0.0189 | -0.0037 |
| 7 | 3.0 | -0.0116 | -0.0118 | -0.0208 | -0.0031 | -0.0123 | -0.0025 | -0.0206 | -0.0038 |
| 8 | 3.5 | -0.0130 | -0.0127 | -0.0223 | -0.0031 | -0.0120 | -0.0013 | -0.0219 | -0.0036 |
| 9 | 4.0 | -0.0125 | -0.0136 | -0.0235 | -0.0032 | -0.0064 | 0.0014 | -0.0226 | -0.0031 |
| 10 | 4.5 | -0.0132 | -0.0142 | -0.0245 | -0.0031 | 0.0001 | 0.0042 | -0.0231 | -0.0023 |
| 11 | 5.0 | -0.0131 | -0.0145 | -0.0253 | -0.0033 | 0.0034 | 0.0069 | -0.0235 | -0.0017 |
| 12 | 5.5 | -0.0136 | -0.0149 | -0.0259 | -0.0032 | 0.0090 | 0.0097 | -0.0237 | -0.0009 |
| 13 | 6.0 | -0.0132 | -0.0151 | -0.0264 | -0.0033 | 0.0141 | 0.0124 | -0.0237 | -0.0001 |
| 14 | 6.5 | -0.0134 | -0.0155 | -0.0267 | -0.0033 | 0.0192 | 0.0152 | -0.0237 | 0.0006 |
| 15 | 7.0 | -0.0135 | -0.0157 | -0.0271 | -0.0033 | 0.0239 | 0.0179 | -0.0234 | 0.0012 |
| 16 | 7.5 | -0.0136 | -0.0157 | -0.0273 | -0.0033 | 0.0276 | 0.0207 | -0.0232 | 0.0017 |
| 17 | 8.0 | -0.0138 | -0.0158 | -0.0275 | -0.0034 | 0.0313 | 0.0234 | -0.0229 | 0.0024 |
| 18 | 8.5 | -0.0140 | -0.0160 | -0.0277 | -0.0034 | 0.0354 | 0.0262 | -0.0226 | 0.0032 |
| 19 | 9.0 | -0.0139 | -0.0162 | -0.0278 | -0.0034 | 0.0396 | 0.0289 | -0.0223 | 0.0040 |
| 20 | 9.5 | -0.0139 | -0.0162 | -0.0279 | -0.0033 | 0.0443 | 0.0317 | -0.0220 | 0.0048 |
| 21 | 10.0 | -0.0140 | -0.0162 | -0.0280 | -0.0034 | 0.0493 | 0.0344 | -0.0217 | 0.0056 |
| 22 | 11.0 | -0.0079 | -0.0144 | -0.0237 | -0.0016 | 0.0588 | 0.0408 | -0.0167 | 0.0088 |
| 23 | 12.0 | -0.0099 | -0.0113 | -0.0197 | -0.0022 | 0.0706 | 0.0475 | -0.0127 | 0.0106 |
| 24 | 13.0 | -0.0072 | -0.0102 | -0.0178 | -0.0018 | 0.0804 | 0.0521 | -0.0099 | 0.0123 |
| 25 | 14.0 | -0.0084 | -0.0093 | -0.0163 | -0.0019 | 0.0898 | 0.0559 | -0.0082 | 0.0138 |
| 26 | 15.0 | -0.0068 | -0.0087 | -0.0155 | -0.0018 | 0.0962 | 0.0587 | -0.0071 | 0.0149 |
| 27 | 16.0 | -0.0077 | -0.0082 | -0.0149 | -0.0018 | 0.0976 | 0.0614 | -0.0065 | 0.0151 |
| 28 | 17.0 | -0.0068 | -0.0078 | -0.0146 | -0.0018 | 0.0990 | 0.0642 | -0.0063 | 0.0154 |
| 29 | 18.0 | -0.0079 | -0.0080 | -0.0144 | -0.0018 | 0.1009 | 0.0669 | -0.0062 | 0.0157 |
| 30 | 19.0 | -0.0072 | -0.0078 | -0.0143 | -0.0018 | 0.1027 | 0.0697 | -0.0061 | 0.0159 |
| 31 | 20.0 | -0.0079 | -0.0078 | -0.0142 | -0.0018 | 0.1041 | 0.0724 | -0.0059 | 0.0160 |
| 32 | 21.0 | -0.0071 | -0.0078 | -0.0142 | -0.0018 | 0.1110 | 0.0752 | -0.0056 | 0.0168 |
| 33 | 22.0 | -0.0075 | -0.0078 | -0.0141 | -0.0017 | 0.1124 | 0.0779 | -0.0055 | 0.0170 |
| 34 | 23.0 | -0.0070 | -0.0078 | -0.0141 | -0.0017 | 0.1134 | 0.0807 | -0.0054 | 0.0172 |
| 35 | 24.0 | -0.0075 | -0.0078 | -0.0141 | -0.0017 | 0.1194 | 0.0834 | -0.0051 | 0.0179 |
| 36 | 25.0 | -0.0070 | -0.0078 | -0.0141 | -0.0017 | 0.1254 | 0.0862 | -0.0048 | 0.0186 |
| 37 | 26.0 | -0.0073 | -0.0078 | -0.0141 | -0.0017 | 0.1268 | 0.0889 | -0.0047 | 0.0189 |
| 38 | 27.0 | -0.0070 | -0.0078 | -0.0141 | -0.0017 | 0.1286 | 0.0917 | -0.0046 | 0.0192 |
| 39 | 28.0 | -0.0073 | -0.0078 | -0.0141 | -0.0017 | 0.1360 | 0.0944 | -0.0042 | 0.0202 |
| 40 | 29.0 | -0.0072 | -0.0078 | -0.0141 | -0.0017 | 0.1434 | 0.0972 | -0.0038 | 0.0212 |
| 41 | 30.0 | -0.0072 | -0.0078 | -0.0141 | -0.0017 | 0.1453 | 0.0999 | -0.0037 | 0.0215 |
| 42 | 32.0 | -0.0028 | -0.0060 | -0.0101 | -0.0005 | 0.1709 | 0.1059 | 0.0016 | 0.0249 |
| 43 | 34.0 | -0.0045 | -0.0041 | -0.0078 | -0.0011 | 0.1819 | 0.1091 | 0.0036 | 0.0265 |
| 44 | 36.0 | -0.0024 | -0.0041 | -0.0075 | -0.0006 | 0.1943 | 0.1118 | 0.0047 | 0.0280 |
| 45 | 38.0 | -0.0040 | -0.0036 | -0.0070 | -0.0009 | 0.2091 | 0.1146 | 0.0055 | 0.0297 |
| 46 | 40.0 | -0.0027 | -0.0038 | -0.0071 | -0.0008 | 0.2229 | 0.1173 | 0.0061 | 0.0311 |
| 47 | 42.0 | -0.0040 | -0.0036 | -0.0069 | -0.0009 | 0.2305 | 0.1201 | 0.0065 | 0.0320 |
| 48 | 44.0 | -0.0029 | -0.0036 | -0.0070 | -0.0008 | 0.2287 | 0.1228 | 0.0064 | 0.0319 |
| 49 | 46.0 | -0.0036 | -0.0036 | -0.0069 | -0.0009 | 0.2208 | 0.1256 | 0.0062 | 0.0310 |
| 50 | 48.0 | -0.0026 | -0.0036 | -0.0070 | -0.0009 | 0.2204 | 0.1283 | 0.0062 | 0.0311 |
| 51 | 50.0 | -0.0034 | -0.0034 | -0.0069 | -0.0009 | 0.2289 | 0.1311 | 0.0067 | 0.0322 |
| 52 | 52.0 | -0.0027 | -0.0034 | -0.0070 | -0.0009 | 0.2369 | 0.1338 | 0.0071 | 0.0333 |
| 53 | 54.0 | -0.0032 | -0.0036 | -0.0070 | -0.0008 | 0.2404 | 0.1366 | 0.0073 | 0.0338 |
| 54 | 56.0 | -0.0027 | -0.0034 | -0.0070 | -0.0009 | 0.2406 | 0.1393 | 0.0073 | 0.0339 |

| | | | | | | | | | |
|-----|-------|---------|---------|---------|---------|--------|--------|--------|--------|
| 55 | 58.0 | -0.0032 | -0.0036 | -0.0070 | -0.0008 | 0.2441 | 0.1421 | 0.0076 | 0.0344 |
| 56 | 60.0 | -0.0027 | -0.0036 | -0.0070 | -0.0008 | 0.2521 | 0.1448 | 0.0080 | 0.0355 |
| 57 | 62.0 | -0.0033 | -0.0037 | -0.0070 | -0.0008 | 0.2600 | 0.1476 | 0.0084 | 0.0365 |
| 58 | 64.0 | -0.0027 | -0.0037 | -0.0070 | -0.0008 | 0.2636 | 0.1503 | 0.0086 | 0.0370 |
| 59 | 66.0 | -0.0033 | -0.0036 | -0.0070 | -0.0008 | 0.2638 | 0.1531 | 0.0087 | 0.0372 |
| 60 | 68.0 | -0.0027 | -0.0036 | -0.0070 | -0.0008 | 0.2673 | 0.1558 | 0.0089 | 0.0377 |
| 61 | 70.0 | -0.0033 | -0.0036 | -0.0070 | -0.0008 | 0.2752 | 0.1586 | 0.0093 | 0.0387 |
| 62 | 72.0 | 0.0011 | -0.0016 | -0.0030 | 0.0003 | 0.2785 | 0.1631 | 0.0137 | 0.0395 |
| 63 | 74.0 | -0.0008 | 0.0003 | -0.0008 | -0.0003 | 0.2769 | 0.1650 | 0.0153 | 0.0395 |
| 64 | 76.0 | 0.0016 | 0.0003 | -0.0005 | 0.0002 | 0.2695 | 0.1650 | 0.0155 | 0.0385 |
| 65 | 78.0 | -0.0001 | 0.0006 | 0.0000 | -0.0001 | 0.2662 | 0.1650 | 0.0154 | 0.0382 |
| 66 | 80.0 | 0.0014 | 0.0004 | -0.0001 | 0.0001 | 0.2651 | 0.1650 | 0.0153 | 0.0380 |
| 67 | 82.0 | 0.0039 | 0.0023 | 0.0041 | 0.0011 | 0.2665 | 0.1668 | 0.0195 | 0.0383 |
| 68 | 84.0 | 0.0036 | 0.0041 | 0.0062 | 0.0006 | 0.2621 | 0.1659 | 0.0209 | 0.0377 |
| 69 | 86.0 | 0.0041 | 0.0039 | 0.0066 | 0.0011 | 0.2519 | 0.1631 | 0.0210 | 0.0363 |
| 70 | 88.0 | 0.0040 | 0.0043 | 0.0070 | 0.0008 | 0.2468 | 0.1604 | 0.0207 | 0.0356 |
| 71 | 90.0 | 0.0044 | 0.0045 | 0.0070 | 0.0010 | 0.2438 | 0.1576 | 0.0205 | 0.0350 |
| 72 | 92.0 | 0.0043 | 0.0045 | 0.0071 | 0.0009 | 0.2436 | 0.1549 | 0.0204 | 0.0348 |
| 73 | 94.0 | 0.0045 | 0.0045 | 0.0071 | 0.0010 | 0.2403 | 0.1521 | 0.0201 | 0.0342 |
| 74 | 96.0 | 0.0045 | 0.0045 | 0.0071 | 0.0009 | 0.2347 | 0.1494 | 0.0198 | 0.0334 |
| 75 | 98.0 | 0.0045 | 0.0045 | 0.0071 | 0.0010 | 0.2323 | 0.1466 | 0.0196 | 0.0330 |
| 76 | 100.0 | 0.0045 | 0.0045 | 0.0071 | 0.0009 | 0.2321 | 0.1439 | 0.0195 | 0.0328 |
| 77 | 102.0 | 0.0003 | 0.0028 | 0.0031 | -0.0002 | 0.2343 | 0.1393 | 0.0154 | 0.0327 |
| 78 | 104.0 | 0.0019 | 0.0010 | 0.0009 | 0.0004 | 0.2414 | 0.1375 | 0.0140 | 0.0333 |
| 79 | 106.0 | 0.0001 | 0.0012 | 0.0006 | -0.0001 | 0.2522 | 0.1375 | 0.0139 | 0.0347 |
| 80 | 108.0 | 0.0018 | 0.0008 | 0.0001 | 0.0002 | 0.2522 | 0.1375 | 0.0139 | 0.0346 |
| 81 | 110.0 | 0.0006 | 0.0010 | 0.0002 | 0.0000 | 0.2411 | 0.1375 | 0.0134 | 0.0335 |
| 82 | 115.0 | -0.0003 | -0.0008 | -0.0029 | -0.0004 | 0.2079 | 0.1384 | 0.0102 | 0.0298 |
| 83 | 120.0 | -0.0003 | -0.0008 | -0.0028 | -0.0002 | 0.2297 | 0.1411 | 0.0112 | 0.0325 |
| 84 | 125.0 | -0.0003 | -0.0006 | -0.0026 | -0.0004 | 0.2616 | 0.1439 | 0.0126 | 0.0364 |
| 85 | 130.0 | -0.0003 | -0.0008 | -0.0028 | -0.0002 | 0.2405 | 0.1466 | 0.0118 | 0.0341 |
| 86 | 135.0 | -0.0001 | -0.0006 | -0.0027 | -0.0004 | 0.2210 | 0.1494 | 0.0111 | 0.0320 |
| 87 | 140.0 | -0.0001 | -0.0010 | -0.0027 | -0.0002 | 0.2508 | 0.1521 | 0.0124 | 0.0355 |
| 88 | 145.0 | 0.0003 | -0.0010 | -0.0027 | -0.0003 | 0.2817 | 0.1549 | 0.0138 | 0.0392 |
| 89 | 150.0 | 0.0003 | -0.0010 | -0.0027 | -0.0002 | 0.2606 | 0.1576 | 0.0130 | 0.0369 |
| 90 | 155.0 | 0.0004 | -0.0008 | -0.0027 | -0.0003 | 0.2409 | 0.1604 | 0.0122 | 0.0347 |
| 91 | 160.0 | 0.0003 | -0.0008 | -0.0027 | -0.0002 | 0.2704 | 0.1631 | 0.0135 | 0.0383 |
| 92 | 170.0 | 0.0028 | 0.0016 | 0.0012 | 0.0003 | 0.2797 | 0.1650 | 0.0159 | 0.0395 |
| 93 | 180.0 | 0.0011 | 0.0007 | -0.0002 | -0.0001 | 0.2787 | 0.1650 | 0.0158 | 0.0393 |
| 94 | 190.0 | 0.0025 | 0.0008 | 0.0002 | 0.0002 | 0.2782 | 0.1650 | 0.0158 | 0.0392 |
| 95 | 200.0 | 0.0012 | 0.0010 | 0.0002 | -0.0001 | 0.2776 | 0.1650 | 0.0158 | 0.0391 |
| 96 | 210.0 | 0.0023 | 0.0010 | 0.0001 | 0.0002 | 0.3053 | 0.1650 | 0.0169 | 0.0423 |
| 97 | 220.0 | 0.0014 | 0.0012 | 0.0003 | -0.0001 | 0.2638 | 0.1650 | 0.0152 | 0.0376 |
| 98 | 230.0 | 0.0025 | 0.0010 | 0.0001 | 0.0002 | 0.2500 | 0.1650 | 0.0146 | 0.0360 |
| 99 | 240.0 | 0.0014 | 0.0010 | 0.0003 | 0.0000 | 0.2845 | 0.1650 | 0.0160 | 0.0399 |
| 100 | 250.0 | 0.0023 | 0.0007 | 0.0001 | 0.0002 | 0.3053 | 0.1650 | 0.0169 | 0.0423 |
| 101 | 260.0 | 0.0012 | 0.0010 | 0.0002 | 0.0000 | 0.2707 | 0.1650 | 0.0155 | 0.0384 |
| 102 | 270.0 | 0.0021 | 0.0008 | 0.0001 | 0.0001 | 0.2500 | 0.1650 | 0.0146 | 0.0360 |
| 103 | 280.0 | 0.0010 | 0.0008 | 0.0002 | 0.0000 | 0.2776 | 0.1650 | 0.0158 | 0.0391 |
| 104 | 290.0 | 0.0018 | 0.0008 | 0.0001 | 0.0001 | 0.2984 | 0.1650 | 0.0166 | 0.0415 |
| 105 | 300.0 | 0.0010 | 0.0010 | 0.0002 | 0.0000 | 0.2776 | 0.1650 | 0.0158 | 0.0391 |

表7. 1(2) 評価断面1の応力テンソル成分2

FINAS解と簡易計算値との比較(ホットショック)

断面1の応力成分2

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|---------|--------|---------|---------|---------|--------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.5730 | 0.1925 | -0.0189 | -0.3471 | -0.6755 | 0.2553 | -0.0232 | -0.4485 |
| 3 | 1.0 | -1.2474 | 0.5359 | -0.0428 | -0.8774 | -1.2886 | 0.5630 | -0.0445 | -0.9220 |
| 4 | 1.5 | -1.7132 | 0.7919 | -0.0590 | -1.2507 | -1.7834 | 0.8139 | -0.0618 | -1.3055 |
| 5 | 2.0 | -2.1202 | 0.9894 | -0.0733 | -1.5601 | -2.1688 | 1.0133 | -0.0754 | -1.6105 |
| 6 | 2.5 | -2.4187 | 1.1520 | -0.0838 | -1.8005 | -2.4723 | 1.1709 | -0.0862 | -1.8529 |
| 7 | 3.0 | -2.6750 | 1.2783 | -0.0927 | -1.9953 | -2.7182 | 1.2966 | -0.0948 | -2.0455 |
| 8 | 3.5 | -2.8640 | 1.3804 | -0.0993 | -2.1476 | -2.9141 | 1.3967 | -0.1016 | -2.1989 |
| 9 | 4.0 | -3.0261 | 1.4607 | -0.1050 | -2.2706 | -3.0620 | 1.4747 | -0.1068 | -2.3203 |
| 10 | 4.5 | -3.1449 | 1.5250 | -0.1092 | -2.3668 | -3.1765 | 1.5371 | -0.1109 | -2.4177 |
| 11 | 5.0 | -3.2480 | 1.5762 | -0.1127 | -2.4446 | -3.2707 | 1.5865 | -0.1143 | -2.4958 |
| 12 | 5.5 | -3.3228 | 1.6163 | -0.1154 | -2.5054 | -3.3423 | 1.6269 | -0.1169 | -2.5585 |
| 13 | 6.0 | -3.3881 | 1.6488 | -0.1176 | -2.5547 | -3.3975 | 1.6598 | -0.1189 | -2.6083 |
| 14 | 6.5 | -3.4347 | 1.6739 | -0.1193 | -2.5930 | -3.4391 | 1.6867 | -0.1203 | -2.6482 |
| 15 | 7.0 | -3.4768 | 1.6947 | -0.1207 | -2.6242 | -3.4706 | 1.7089 | -0.1213 | -2.6802 |
| 16 | 7.5 | -3.5057 | 1.7109 | -0.1217 | -2.6483 | -3.4947 | 1.7271 | -0.1220 | -2.7060 |
| 17 | 8.0 | -3.5328 | 1.7237 | -0.1227 | -2.6681 | -3.5123 | 1.7415 | -0.1225 | -2.7267 |
| 18 | 8.5 | -3.5509 | 1.7337 | -0.1233 | -2.6834 | -3.5246 | 1.7531 | -0.1229 | -2.7433 |
| 19 | 9.0 | -3.5686 | 1.7418 | -0.1239 | -2.6958 | -3.5335 | 1.7624 | -0.1233 | -2.7563 |
| 20 | 9.5 | -3.5793 | 1.7480 | -0.1244 | -2.7055 | -3.5384 | 1.7697 | -0.1235 | -2.7662 |
| 21 | 10.0 | -3.5908 | 1.7531 | -0.1248 | -2.7134 | -3.5399 | 1.7759 | -0.1236 | -2.7739 |
| 22 | 11.0 | -3.0239 | 1.5304 | -0.1056 | -2.3373 | -2.9323 | 1.5440 | -0.1027 | -2.3681 |
| 23 | 12.0 | -2.5238 | 1.2476 | -0.0877 | -1.9192 | -2.4829 | 1.3254 | -0.0871 | -2.0292 |
| 24 | 13.0 | -2.2887 | 1.1317 | -0.0797 | -1.7447 | -2.1952 | 1.1886 | -0.0770 | -1.8140 |
| 25 | 14.0 | -2.0945 | 1.0339 | -0.0727 | -1.5915 | -2.0065 | 1.1034 | -0.0705 | -1.6773 |
| 26 | 15.0 | -2.0020 | 0.9809 | -0.0696 | -1.5174 | -1.8857 | 1.0506 | -0.0664 | -1.5891 |
| 27 | 16.0 | -1.9232 | 0.9464 | -0.0667 | -1.4591 | -1.8107 | 1.0166 | -0.0639 | -1.5319 |
| 28 | 17.0 | -1.8893 | 0.9232 | -0.0656 | -1.4292 | -1.7623 | 0.9951 | -0.0625 | -1.4957 |
| 29 | 18.0 | -1.8562 | 0.9105 | -0.0644 | -1.4062 | -1.7307 | 0.9820 | -0.0618 | -1.4724 |
| 30 | 19.0 | -1.8450 | 0.9009 | -0.0640 | -1.3946 | -1.7092 | 0.9750 | -0.0613 | -1.4578 |
| 31 | 20.0 | -1.8297 | 0.8965 | -0.0635 | -1.3852 | -1.6945 | 0.9714 | -0.0609 | -1.4491 |
| 32 | 21.0 | -1.8269 | 0.8924 | -0.0634 | -1.3810 | -1.6761 | 0.9696 | -0.0605 | -1.4428 |
| 33 | 22.0 | -1.8193 | 0.8908 | -0.0631 | -1.3770 | -1.6676 | 0.9691 | -0.0604 | -1.4395 |
| 34 | 23.0 | -1.8195 | 0.8891 | -0.0631 | -1.3756 | -1.6615 | 0.9697 | -0.0603 | -1.4379 |
| 35 | 24.0 | -1.8155 | 0.8886 | -0.0630 | -1.3737 | -1.6495 | 0.9708 | -0.0601 | -1.4365 |
| 36 | 25.0 | -1.8166 | 0.8879 | -0.0630 | -1.3734 | -1.6383 | 0.9722 | -0.0600 | -1.4358 |
| 37 | 26.0 | -1.8142 | 0.8876 | -0.0630 | -1.3725 | -1.6344 | 0.9740 | -0.0600 | -1.4364 |
| 38 | 27.0 | -1.8154 | 0.8873 | -0.0630 | -1.3725 | -1.6305 | 0.9758 | -0.0599 | -1.4368 |
| 39 | 28.0 | -1.8137 | 0.8872 | -0.0629 | -1.3720 | -1.6189 | 0.9774 | -0.0597 | -1.4363 |
| 40 | 29.0 | -1.8147 | 0.8871 | -0.0630 | -1.3721 | -1.6072 | 0.9790 | -0.0594 | -1.4358 |
| 41 | 30.0 | -1.8132 | 0.8872 | -0.0629 | -1.3719 | -1.6033 | 0.9808 | -0.0594 | -1.4361 |
| 42 | 32.0 | -1.2903 | 0.6581 | -0.0450 | -1.0015 | -1.0073 | 0.7196 | -0.0392 | -1.0164 |
| 43 | 34.0 | -1.0155 | 0.4908 | -0.0351 | -0.7618 | -0.7597 | 0.6062 | -0.0310 | -0.8351 |
| 44 | 36.0 | -0.9722 | 0.4836 | -0.0338 | -0.7438 | -0.6483 | 0.5631 | -0.0273 | -0.7614 |
| 45 | 38.0 | -0.9113 | 0.4437 | -0.0315 | -0.6866 | -0.5894 | 0.5464 | -0.0256 | -0.7304 |
| 46 | 40.0 | -0.9227 | 0.4536 | -0.0320 | -0.7009 | -0.5538 | 0.5410 | -0.0247 | -0.7171 |
| 47 | 42.0 | -0.9005 | 0.4412 | -0.0312 | -0.6809 | -0.5355 | 0.5398 | -0.0243 | -0.7115 |
| 48 | 44.0 | -0.9134 | 0.4469 | -0.0317 | -0.6916 | -0.5337 | 0.5405 | -0.0244 | -0.7105 |
| 49 | 46.0 | -0.9007 | 0.4427 | -0.0312 | -0.6825 | -0.5426 | 0.5421 | -0.0248 | -0.7119 |
| 50 | 48.0 | -0.9104 | 0.4449 | -0.0315 | -0.6886 | -0.5418 | 0.5439 | -0.0249 | -0.7126 |
| 51 | 50.0 | -0.9017 | 0.4440 | -0.0312 | -0.6838 | -0.5286 | 0.5455 | -0.0246 | -0.7119 |
| 52 | 52.0 | -0.9091 | 0.4443 | -0.0315 | -0.6872 | -0.5162 | 0.5472 | -0.0243 | -0.7113 |
| 53 | 54.0 | -0.9027 | 0.4444 | -0.0313 | -0.6845 | -0.5100 | 0.5489 | -0.0242 | -0.7114 |
| 54 | 56.0 | -0.9084 | 0.4441 | -0.0315 | -0.6867 | -0.5084 | 0.5506 | -0.0242 | -0.7121 |

| | | | | | | | | | |
|-----|-------|---------|---------|---------|---------|---------|---------|---------|---------|
| 55 | 58.0 | -0.9033 | 0.4447 | -0.0313 | -0.6850 | -0.5021 | 0.5523 | -0.0241 | -0.7122 |
| 56 | 60.0 | -0.9082 | 0.4444 | -0.0315 | -0.6865 | -0.4897 | 0.5540 | -0.0239 | -0.7116 |
| 57 | 62.0 | -0.9039 | 0.4450 | -0.0313 | -0.6854 | -0.4773 | 0.5556 | -0.0236 | -0.7110 |
| 58 | 64.0 | -0.9079 | 0.4446 | -0.0315 | -0.6865 | -0.4711 | 0.5573 | -0.0235 | -0.7111 |
| 59 | 66.0 | -0.9041 | 0.4453 | -0.0313 | -0.6856 | -0.4695 | 0.5591 | -0.0236 | -0.7117 |
| 60 | 68.0 | -0.9077 | 0.4449 | -0.0315 | -0.6864 | -0.4632 | 0.5608 | -0.0235 | -0.7118 |
| 61 | 70.0 | -0.9043 | 0.4451 | -0.0314 | -0.6857 | -0.4508 | 0.5624 | -0.0232 | -0.7112 |
| 62 | 72.0 | -0.3838 | 0.2154 | -0.0135 | -0.3156 | 0.0990 | 0.2841 | -0.0040 | -0.2834 |
| 63 | 74.0 | -0.1072 | 0.0486 | -0.0036 | -0.0757 | 0.3168 | 0.1733 | 0.0036 | -0.1118 |
| 64 | 76.0 | -0.0656 | 0.0411 | -0.0023 | -0.0578 | 0.3966 | 0.1302 | 0.0065 | -0.0428 |
| 65 | 78.0 | -0.0032 | 0.0018 | 0.0000 | -0.0006 | 0.4263 | 0.1117 | 0.0072 | -0.0145 |
| 66 | 80.0 | -0.0164 | 0.0113 | -0.0006 | -0.0151 | 0.4389 | 0.1052 | 0.0076 | -0.0034 |
| 67 | 82.0 | 0.5309 | -0.2304 | 0.0183 | 0.3758 | 0.9911 | -0.1778 | 0.0269 | 0.4295 |
| 68 | 84.0 | 0.7903 | -0.3922 | 0.0276 | 0.6043 | 1.2065 | -0.2909 | 0.0345 | 0.6025 |
| 69 | 86.0 | 0.8482 | -0.4033 | 0.0295 | 0.6320 | 1.2823 | -0.3356 | 0.0372 | 0.6715 |
| 70 | 88.0 | 0.8976 | -0.4407 | 0.0313 | 0.6825 | 1.3080 | -0.3559 | 0.0380 | 0.7001 |
| 71 | 90.0 | 0.8967 | -0.4320 | 0.0312 | 0.6733 | 1.3167 | -0.3641 | 0.0383 | 0.7116 |
| 72 | 92.0 | 0.9097 | -0.4443 | 0.0317 | 0.6893 | 1.3214 | -0.3688 | 0.0385 | 0.7169 |
| 73 | 94.0 | 0.9052 | -0.4387 | 0.0315 | 0.6817 | 1.3182 | -0.3712 | 0.0384 | 0.7182 |
| 74 | 96.0 | 0.9103 | -0.4432 | 0.0317 | 0.6884 | 1.3105 | -0.3727 | 0.0382 | 0.7177 |
| 75 | 98.0 | 0.9073 | -0.4407 | 0.0316 | 0.6843 | 1.3058 | -0.3745 | 0.0382 | 0.7180 |
| 76 | 100.0 | 0.9095 | -0.4422 | 0.0317 | 0.6873 | 1.3042 | -0.3762 | 0.0382 | 0.7186 |
| 77 | 102.0 | 0.3842 | -0.2118 | 0.0137 | 0.3146 | 0.7620 | -0.0980 | 0.0193 | 0.2917 |
| 78 | 104.0 | 0.1114 | -0.0452 | 0.0039 | 0.0767 | 0.5520 | 0.0127 | 0.0119 | 0.1210 |
| 79 | 106.0 | 0.0664 | -0.0379 | 0.0025 | 0.0574 | 0.4769 | 0.0557 | 0.0092 | 0.0525 |
| 80 | 108.0 | 0.0072 | 0.0018 | 0.0003 | 0.0013 | 0.4426 | 0.0743 | 0.0083 | 0.0237 |
| 81 | 110.0 | 0.0178 | -0.0080 | 0.0008 | 0.0149 | 0.4129 | 0.0810 | 0.0074 | 0.0106 |
| 82 | 115.0 | -0.3816 | 0.1817 | -0.0131 | -0.2832 | 0.0824 | 0.2259 | -0.0037 | -0.2165 |
| 83 | 120.0 | -0.3649 | 0.1874 | -0.0126 | -0.2824 | 0.0873 | 0.2417 | -0.0035 | -0.2365 |
| 84 | 125.0 | -0.3581 | 0.1712 | -0.0122 | -0.2661 | 0.1296 | 0.2440 | -0.0023 | -0.2341 |
| 85 | 130.0 | -0.3651 | 0.1862 | -0.0126 | -0.2815 | 0.1014 | 0.2462 | -0.0033 | -0.2381 |
| 86 | 135.0 | -0.3592 | 0.1733 | -0.0123 | -0.2684 | 0.0756 | 0.2483 | -0.0041 | -0.2419 |
| 87 | 140.0 | -0.3642 | 0.1843 | -0.0125 | -0.2798 | 0.1185 | 0.2495 | -0.0029 | -0.2378 |
| 88 | 145.0 | -0.3601 | 0.1746 | -0.0123 | -0.2700 | 0.1631 | 0.2508 | -0.0017 | -0.2336 |
| 89 | 150.0 | -0.3630 | 0.1831 | -0.0125 | -0.2783 | 0.1349 | 0.2529 | -0.0026 | -0.2376 |
| 90 | 155.0 | -0.3605 | 0.1760 | -0.0123 | -0.2711 | 0.1086 | 0.2550 | -0.0035 | -0.2414 |
| 91 | 160.0 | -0.3623 | 0.1825 | -0.0124 | -0.2773 | 0.1512 | 0.2563 | -0.0023 | -0.2374 |
| 92 | 170.0 | 0.1349 | -0.0599 | 0.0040 | 0.0980 | 0.4661 | 0.1026 | 0.0083 | 0.0025 |
| 93 | 180.0 | -0.0427 | 0.0186 | -0.0012 | -0.0286 | 0.4683 | 0.1015 | 0.0083 | 0.0044 |
| 94 | 190.0 | 0.0105 | 0.0026 | 0.0005 | 0.0020 | 0.4675 | 0.1015 | 0.0083 | 0.0043 |
| 95 | 200.0 | 0.0048 | -0.0046 | 0.0004 | 0.0077 | 0.4667 | 0.1015 | 0.0083 | 0.0042 |
| 96 | 210.0 | -0.0074 | 0.0111 | -0.0001 | -0.0109 | 0.5054 | 0.1011 | 0.0094 | 0.0086 |
| 97 | 220.0 | 0.0109 | -0.0067 | 0.0007 | 0.0116 | 0.4474 | 0.1018 | 0.0077 | 0.0020 |
| 98 | 230.0 | -0.0091 | 0.0112 | -0.0002 | -0.0115 | 0.4281 | 0.1020 | 0.0071 | -0.0002 |
| 99 | 240.0 | 0.0109 | -0.0059 | 0.0007 | 0.0111 | 0.4764 | 0.1014 | 0.0085 | 0.0053 |
| 100 | 250.0 | -0.0086 | 0.0098 | -0.0001 | -0.0102 | 0.5054 | 0.1011 | 0.0094 | 0.0086 |
| 101 | 260.0 | 0.0100 | -0.0050 | 0.0006 | 0.0097 | 0.4571 | 0.1017 | 0.0080 | 0.0031 |
| 102 | 270.0 | -0.0075 | 0.0086 | -0.0001 | -0.0090 | 0.4281 | 0.1020 | 0.0071 | -0.0002 |
| 103 | 280.0 | 0.0093 | -0.0043 | 0.0005 | 0.0086 | 0.4667 | 0.1015 | 0.0083 | 0.0042 |
| 104 | 290.0 | -0.0068 | 0.0076 | -0.0001 | -0.0077 | 0.4957 | 0.1012 | 0.0091 | 0.0075 |
| 105 | 300.0 | 0.0085 | -0.0032 | 0.0005 | 0.0076 | 0.4667 | 0.1015 | 0.0083 | 0.0042 |

表 7. 1 (3) 評価断面 1 の応力テンソル成分 3

FINAS解と簡易計算値との比較 (ホットショック)

断面 1 の応力成分 3

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|---------|--------|---------|---------|---------|--------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.5729 | 0.1925 | -0.0167 | -0.3464 | -0.6754 | 0.2553 | -0.0203 | -0.4478 |
| 3 | 1.0 | -1.2473 | 0.5359 | -0.0370 | -0.8761 | -1.2885 | 0.5630 | -0.0385 | -0.9207 |
| 4 | 1.5 | -1.7132 | 0.7919 | -0.0508 | -1.2491 | -1.7834 | 0.8139 | -0.0532 | -1.3038 |
| 5 | 2.0 | -2.1202 | 0.9893 | -0.0631 | -1.5581 | -2.1688 | 1.0133 | -0.0649 | -1.6084 |
| 6 | 2.5 | -2.4186 | 1.1520 | -0.0720 | -1.7983 | -2.4723 | 1.1708 | -0.0741 | -1.8505 |
| 7 | 3.0 | -2.6750 | 1.2782 | -0.0796 | -1.9928 | -2.7182 | 1.2965 | -0.0814 | -2.0430 |
| 8 | 3.5 | -2.8640 | 1.3803 | -0.0853 | -2.1449 | -2.9141 | 1.3966 | -0.0872 | -2.1961 |
| 9 | 4.0 | -3.0261 | 1.4606 | -0.0901 | -2.2678 | -3.0620 | 1.4746 | -0.0916 | -2.3175 |
| 10 | 4.5 | -3.1449 | 1.5248 | -0.0937 | -2.3639 | -3.1765 | 1.5370 | -0.0951 | -2.4147 |
| 11 | 5.0 | -3.2480 | 1.5761 | -0.0967 | -2.4416 | -3.2707 | 1.5863 | -0.0980 | -2.4928 |
| 12 | 5.5 | -3.3228 | 1.6162 | -0.0990 | -2.5023 | -3.3424 | 1.6268 | -0.1002 | -2.5553 |
| 13 | 6.0 | -3.3881 | 1.6487 | -0.1009 | -2.5516 | -3.3976 | 1.6597 | -0.1018 | -2.6051 |
| 14 | 6.5 | -3.4347 | 1.6738 | -0.1023 | -2.5899 | -3.4392 | 1.6866 | -0.1030 | -2.6449 |
| 15 | 7.0 | -3.4768 | 1.6946 | -0.1035 | -2.6210 | -3.4707 | 1.7087 | -0.1037 | -2.6769 |
| 16 | 7.5 | -3.5057 | 1.7108 | -0.1044 | -2.6451 | -3.4949 | 1.7269 | -0.1043 | -2.7027 |
| 17 | 8.0 | -3.5328 | 1.7237 | -0.1052 | -2.6648 | -3.5125 | 1.7413 | -0.1047 | -2.7234 |
| 18 | 8.5 | -3.5509 | 1.7336 | -0.1058 | -2.6801 | -3.5249 | 1.7529 | -0.1050 | -2.7400 |
| 19 | 9.0 | -3.5685 | 1.7417 | -0.1063 | -2.6926 | -3.5337 | 1.7621 | -0.1053 | -2.7529 |
| 20 | 9.5 | -3.5793 | 1.7479 | -0.1066 | -2.7022 | -3.5387 | 1.7695 | -0.1054 | -2.7629 |
| 21 | 10.0 | -3.5908 | 1.7530 | -0.1070 | -2.7102 | -3.5402 | 1.7756 | -0.1055 | -2.7706 |
| 22 | 11.0 | -3.0239 | 1.5304 | -0.0903 | -2.3347 | -2.9327 | 1.5437 | -0.0872 | -2.3655 |
| 23 | 12.0 | -2.5238 | 1.2475 | -0.0752 | -1.9170 | -2.4833 | 1.3251 | -0.0739 | -2.0269 |
| 24 | 13.0 | -2.2887 | 1.1316 | -0.0683 | -1.7426 | -2.1957 | 1.1882 | -0.0652 | -1.8120 |
| 25 | 14.0 | -2.0945 | 1.0338 | -0.0623 | -1.5896 | -2.0070 | 1.1031 | -0.0597 | -1.6755 |
| 26 | 15.0 | -2.0020 | 0.9809 | -0.0596 | -1.5156 | -1.8862 | 1.0503 | -0.0561 | -1.5875 |
| 27 | 16.0 | -1.9232 | 0.9464 | -0.0572 | -1.4574 | -1.8112 | 1.0163 | -0.0540 | -1.5304 |
| 28 | 17.0 | -1.8893 | 0.9232 | -0.0562 | -1.4275 | -1.7629 | 0.9947 | -0.0529 | -1.4942 |
| 29 | 18.0 | -1.8562 | 0.9105 | -0.0552 | -1.4045 | -1.7313 | 0.9816 | -0.0523 | -1.4709 |
| 30 | 19.0 | -1.8450 | 0.9009 | -0.0548 | -1.3929 | -1.7098 | 0.9745 | -0.0519 | -1.4563 |
| 31 | 20.0 | -1.8297 | 0.8965 | -0.0544 | -1.3836 | -1.6952 | 0.9710 | -0.0516 | -1.4476 |
| 32 | 21.0 | -1.8269 | 0.8924 | -0.0543 | -1.3794 | -1.6767 | 0.9692 | -0.0512 | -1.4414 |
| 33 | 22.0 | -1.8193 | 0.8908 | -0.0541 | -1.3753 | -1.6683 | 0.9686 | -0.0512 | -1.4381 |
| 34 | 23.0 | -1.8195 | 0.8891 | -0.0541 | -1.3740 | -1.6622 | 0.9693 | -0.0511 | -1.4365 |
| 35 | 24.0 | -1.8155 | 0.8886 | -0.0540 | -1.3721 | -1.6502 | 0.9703 | -0.0510 | -1.4351 |
| 36 | 25.0 | -1.8166 | 0.8879 | -0.0540 | -1.3718 | -1.6391 | 0.9718 | -0.0508 | -1.4344 |
| 37 | 26.0 | -1.8142 | 0.8876 | -0.0540 | -1.3709 | -1.6352 | 0.9736 | -0.0508 | -1.4350 |
| 38 | 27.0 | -1.8154 | 0.8872 | -0.0540 | -1.3708 | -1.6313 | 0.9753 | -0.0508 | -1.4354 |
| 39 | 28.0 | -1.8136 | 0.8872 | -0.0539 | -1.3704 | -1.6197 | 0.9769 | -0.0505 | -1.4349 |
| 40 | 29.0 | -1.8146 | 0.8871 | -0.0540 | -1.3705 | -1.6080 | 0.9786 | -0.0503 | -1.4344 |
| 41 | 30.0 | -1.8132 | 0.8872 | -0.0539 | -1.3703 | -1.6041 | 0.9803 | -0.0503 | -1.4348 |
| 42 | 32.0 | -1.2903 | 0.6581 | -0.0384 | -1.0004 | -1.0082 | 0.7190 | -0.0328 | -1.0156 |
| 43 | 34.0 | -1.0155 | 0.4908 | -0.0301 | -0.7608 | -0.7606 | 0.6056 | -0.0258 | -0.8346 |
| 44 | 36.0 | -0.9722 | 0.4837 | -0.0289 | -0.7429 | -0.6492 | 0.5625 | -0.0226 | -0.7610 |
| 45 | 38.0 | -0.9112 | 0.4437 | -0.0270 | -0.6858 | -0.5903 | 0.5458 | -0.0211 | -0.7300 |
| 46 | 40.0 | -0.9227 | 0.4537 | -0.0274 | -0.7001 | -0.5548 | 0.5404 | -0.0203 | -0.7166 |
| 47 | 42.0 | -0.9005 | 0.4412 | -0.0267 | -0.6801 | -0.5365 | 0.5392 | -0.0199 | -0.7112 |
| 48 | 44.0 | -0.9134 | 0.4470 | -0.0271 | -0.6908 | -0.5347 | 0.5399 | -0.0200 | -0.7101 |
| 49 | 46.0 | -0.9007 | 0.4428 | -0.0267 | -0.6817 | -0.5436 | 0.5415 | -0.0204 | -0.7115 |
| 50 | 48.0 | -0.9103 | 0.4449 | -0.0270 | -0.6878 | -0.5428 | 0.5433 | -0.0205 | -0.7122 |
| 51 | 50.0 | -0.9017 | 0.4440 | -0.0267 | -0.6830 | -0.5296 | 0.5449 | -0.0202 | -0.7116 |
| 52 | 52.0 | -0.9091 | 0.4444 | -0.0270 | -0.6864 | -0.5173 | 0.5465 | -0.0199 | -0.7110 |
| 53 | 54.0 | -0.9026 | 0.4444 | -0.0267 | -0.6837 | -0.5110 | 0.5482 | -0.0199 | -0.7111 |
| 54 | 56.0 | -0.9084 | 0.4441 | -0.0270 | -0.6859 | -0.5095 | 0.5500 | -0.0199 | -0.7117 |

| | | | | | | | | | |
|-----|-------|---------|---------|---------|---------|---------|---------|---------|---------|
| 55 | 58.0 | -0.9033 | 0.4447 | -0.0268 | -0.6842 | -0.5033 | 0.5517 | -0.0198 | -0.7119 |
| 56 | 60.0 | -0.9081 | 0.4444 | -0.0269 | -0.6857 | -0.4909 | 0.5533 | -0.0196 | -0.7113 |
| 57 | 62.0 | -0.9038 | 0.4451 | -0.0268 | -0.6846 | -0.4785 | 0.5549 | -0.0193 | -0.7107 |
| 58 | 64.0 | -0.9079 | 0.4446 | -0.0269 | -0.6857 | -0.4723 | 0.5566 | -0.0192 | -0.7108 |
| 59 | 66.0 | -0.9041 | 0.4453 | -0.0268 | -0.6848 | -0.4707 | 0.5584 | -0.0193 | -0.7114 |
| 60 | 68.0 | -0.9076 | 0.4449 | -0.0269 | -0.6856 | -0.4645 | 0.5601 | -0.0192 | -0.7116 |
| 61 | 70.0 | -0.9043 | 0.4451 | -0.0269 | -0.6849 | -0.4521 | 0.5617 | -0.0189 | -0.7110 |
| 62 | 72.0 | -0.9038 | 0.2154 | -0.0114 | -0.3153 | 0.0978 | 0.2834 | -0.0025 | -0.2836 |
| 63 | 74.0 | -0.1072 | 0.0486 | -0.0031 | -0.0756 | 0.3155 | 0.1726 | 0.0040 | -0.1123 |
| 64 | 76.0 | -0.0655 | 0.0412 | -0.0019 | -0.0578 | 0.3953 | 0.1295 | 0.0063 | -0.0433 |
| 65 | 78.0 | -0.0031 | 0.0018 | 0.0001 | -0.0006 | 0.4250 | 0.1110 | 0.0069 | -0.0151 |
| 66 | 80.0 | -0.0163 | 0.0114 | -0.0004 | -0.0151 | 0.4376 | 0.1045 | 0.0072 | -0.0039 |
| 67 | 82.0 | 0.5310 | -0.2303 | 0.0159 | 0.3752 | 0.9898 | -0.1785 | 0.0237 | 0.4284 |
| 68 | 84.0 | 0.7903 | -0.3921 | 0.0237 | 0.6037 | 1.2052 | -0.2916 | 0.0301 | 0.6012 |
| 69 | 86.0 | 0.8483 | -0.4032 | 0.0254 | 0.6312 | 1.2811 | -0.3363 | 0.0324 | 0.6701 |
| 70 | 88.0 | 0.8977 | -0.4407 | 0.0269 | 0.6817 | 1.3068 | -0.3566 | 0.0330 | 0.6987 |
| 71 | 90.0 | 0.8968 | -0.4319 | 0.0269 | 0.6725 | 1.3155 | -0.3648 | 0.0333 | 0.7103 |
| 72 | 92.0 | 0.9098 | -0.4442 | 0.0273 | 0.6885 | 1.3202 | -0.3695 | 0.0334 | 0.7155 |
| 73 | 94.0 | 0.9053 | -0.4386 | 0.0271 | 0.6809 | 1.3171 | -0.3718 | 0.0333 | 0.7169 |
| 74 | 96.0 | 0.9104 | -0.4431 | 0.0273 | 0.6876 | 1.3093 | -0.3733 | 0.0332 | 0.7164 |
| 75 | 98.0 | 0.9074 | -0.4406 | 0.0272 | 0.6835 | 1.3047 | -0.3751 | 0.0331 | 0.7167 |
| 76 | 100.0 | 0.9096 | -0.4421 | 0.0273 | 0.6865 | 1.3031 | -0.3768 | 0.0332 | 0.7173 |
| 77 | 102.0 | 0.3843 | -0.2117 | 0.0117 | 0.3143 | 0.7610 | -0.0986 | 0.0170 | 0.2908 |
| 78 | 104.0 | 0.1116 | -0.0451 | 0.0035 | 0.0766 | 0.5509 | 0.0121 | 0.0108 | 0.1204 |
| 79 | 106.0 | 0.0665 | -0.0379 | 0.0022 | 0.0574 | 0.4758 | 0.0552 | 0.0085 | 0.0519 |
| 80 | 108.0 | 0.0073 | 0.0018 | 0.0004 | 0.0013 | 0.4415 | 0.0737 | 0.0078 | 0.0232 |
| 81 | 110.0 | 0.0179 | -0.0080 | 0.0008 | 0.0149 | 0.4119 | 0.0804 | 0.0070 | 0.0101 |
| 82 | 115.0 | -0.3815 | 0.1817 | -0.0112 | -0.2829 | 0.0814 | 0.2253 | -0.0026 | -0.2168 |
| 83 | 120.0 | -0.3648 | 0.1874 | -0.0107 | -0.2821 | 0.0862 | 0.2411 | -0.0023 | -0.2367 |
| 84 | 125.0 | -0.3580 | 0.1712 | -0.0104 | -0.2658 | 0.1285 | 0.2434 | -0.0011 | -0.2344 |
| 85 | 130.0 | -0.3651 | 0.1862 | -0.0107 | -0.2811 | 0.1003 | 0.2455 | -0.0021 | -0.2384 |
| 86 | 135.0 | -0.3591 | 0.1733 | -0.0105 | -0.2680 | 0.0744 | 0.2476 | -0.0029 | -0.2421 |
| 87 | 140.0 | -0.3642 | 0.1843 | -0.0107 | -0.2794 | 0.1173 | 0.2489 | -0.0018 | -0.2381 |
| 88 | 145.0 | -0.3600 | 0.1746 | -0.0105 | -0.2696 | 0.1618 | 0.2501 | -0.0005 | -0.2339 |
| 89 | 150.0 | -0.3630 | 0.1831 | -0.0106 | -0.2780 | 0.1336 | 0.2522 | -0.0015 | -0.2379 |
| 90 | 155.0 | -0.3605 | 0.1760 | -0.0105 | -0.2707 | 0.1074 | 0.2543 | -0.0024 | -0.2417 |
| 91 | 160.0 | -0.3623 | 0.1825 | -0.0106 | -0.2769 | 0.1499 | 0.2555 | -0.0012 | -0.2377 |
| 92 | 170.0 | 0.1350 | -0.0599 | 0.0042 | 0.0978 | 0.4648 | 0.1019 | 0.0079 | 0.0019 |
| 93 | 180.0 | -0.0426 | 0.0187 | -0.0010 | -0.0286 | 0.4670 | 0.1008 | 0.0079 | 0.0038 |
| 94 | 190.0 | 0.0105 | 0.0027 | 0.0005 | 0.0020 | 0.4662 | 0.1008 | 0.0078 | 0.0037 |
| 95 | 200.0 | 0.0049 | -0.0045 | 0.0004 | 0.0077 | 0.4654 | 0.1008 | 0.0078 | -0.0036 |
| 96 | 210.0 | -0.0073 | 0.0111 | 0.0000 | -0.0109 | 0.5041 | 0.1004 | 0.0090 | 0.0080 |
| 97 | 220.0 | 0.0110 | -0.0067 | 0.0006 | 0.0116 | 0.4461 | 0.1011 | 0.0072 | 0.0014 |
| 98 | 230.0 | -0.0090 | 0.0112 | 0.0000 | -0.0115 | 0.4268 | 0.1013 | 0.0067 | -0.0008 |
| 99 | 240.0 | 0.0109 | -0.0059 | 0.0006 | 0.0111 | 0.4751 | 0.1007 | 0.0081 | 0.0047 |
| 100 | 250.0 | -0.0085 | 0.0098 | 0.0000 | -0.0101 | 0.5041 | 0.1004 | 0.0090 | 0.0080 |
| 101 | 260.0 | 0.0100 | -0.0049 | 0.0006 | 0.0097 | 0.4558 | 0.1010 | 0.0075 | 0.0025 |
| 102 | 270.0 | -0.0074 | 0.0087 | 0.0000 | -0.0090 | 0.4268 | 0.1013 | 0.0067 | -0.0008 |
| 103 | 280.0 | 0.0093 | -0.0042 | 0.0005 | 0.0086 | 0.4655 | 0.1008 | 0.0078 | 0.0036 |
| 104 | 290.0 | -0.0067 | 0.0077 | 0.0000 | -0.0077 | 0.4945 | 0.1005 | 0.0087 | 0.0069 |
| 105 | 300.0 | 0.0086 | -0.0031 | 0.0005 | 0.0076 | 0.4654 | 0.1008 | 0.0078 | 0.0036 |

表7. 1(4) 評価断面1の応力テンソル成分4

FINAS解と簡易計算値との比較 (ホットショック)

断面1の応力成分4

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|--------|--------|--------|--------|--------|--------|--------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 3 | 1.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 4 | 1.5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 5 | 2.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 6 | 2.5 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 7 | 3.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 8 | 3.5 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 9 | 4.0 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 10 | 4.5 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 |
| 11 | 5.0 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 |
| 12 | 5.5 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 |
| 13 | 6.0 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0000 |
| 14 | 6.5 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0000 |
| 15 | 7.0 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0000 |
| 16 | 7.5 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0000 |
| 17 | 8.0 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0000 |
| 18 | 8.5 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0000 |
| 19 | 9.0 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0000 |
| 20 | 9.5 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0000 |
| 21 | 10.0 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0000 |
| 22 | 11.0 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0000 |
| 23 | 12.0 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0001 | 0.0000 |
| 24 | 13.0 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0001 | 0.0000 |
| 25 | 14.0 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0001 | 0.0000 |
| 26 | 15.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0001 | 0.0000 |
| 27 | 16.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0001 | 0.0000 |
| 28 | 17.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0001 | 0.0000 |
| 29 | 18.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0001 | 0.0000 |
| 30 | 19.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0001 | 0.0000 |
| 31 | 20.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0001 | 0.0000 |
| 32 | 21.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0001 | 0.0000 |
| 33 | 22.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0001 | 0.0000 |
| 34 | 23.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0001 | 0.0000 |
| 35 | 24.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0001 | 0.0000 |
| 36 | 25.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0001 | 0.0000 |
| 37 | 26.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0002 | 0.0001 | 0.0000 |
| 38 | 27.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0002 | 0.0002 | 0.0000 |
| 39 | 28.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0002 | 0.0002 | 0.0000 |
| 40 | 29.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0002 | 0.0002 | 0.0000 |
| 41 | 30.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0002 | 0.0002 | 0.0000 |
| 42 | 32.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0003 | 0.0002 | 0.0000 |
| 43 | 34.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0003 | 0.0002 | 0.0000 |
| 44 | 36.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0003 | 0.0002 | 0.0000 |
| 45 | 38.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0003 | 0.0002 | 0.0000 |
| 46 | 40.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0003 | 0.0002 | 0.0000 |
| 47 | 42.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0003 | 0.0002 | 0.0000 |
| 48 | 44.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0003 | 0.0002 | 0.0000 |
| 49 | 46.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0003 | 0.0002 | 0.0000 |
| 50 | 48.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0003 | 0.0002 | 0.0000 |
| 51 | 50.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0003 | 0.0002 | 0.0000 |
| 52 | 52.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0003 | 0.0002 | 0.0000 |
| 53 | 54.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0003 | 0.0002 | 0.0000 |
| 54 | 56.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0003 | 0.0002 | 0.0000 |

表7. 2(1) 評価断面2の応力テンソル成分1

F I N A S解と簡易計算値との比較 (ホットショック)

断面2の応力成分1

| ステップ | 時間(S) | F I N A S解 | | | | 簡易計算値 | | | |
|------|-------|------------|---------|---------|---------|---------|---------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.0037 | -0.0017 | -0.0244 | -0.0171 | 0.0014 | -0.0010 | -0.0308 | -0.0205 |
| 3 | 1.0 | -0.0004 | -0.0061 | -0.0649 | -0.0429 | 0.0005 | -0.0050 | -0.0680 | -0.0445 |
| 4 | 1.5 | -0.0037 | -0.0102 | -0.0983 | -0.0648 | -0.0002 | -0.0069 | -0.1019 | -0.0672 |
| 5 | 2.0 | -0.0030 | -0.0132 | -0.1288 | -0.0856 | 0.0021 | -0.0095 | -0.1320 | -0.0877 |
| 6 | 2.5 | -0.0058 | -0.0159 | -0.1552 | -0.1039 | 0.0031 | -0.0110 | -0.1588 | -0.1061 |
| 7 | 3.0 | -0.0072 | -0.0181 | -0.1791 | -0.1208 | 0.0013 | -0.0108 | -0.1829 | -0.1230 |
| 8 | 3.5 | -0.0104 | -0.0199 | -0.2003 | -0.1360 | -0.0007 | -0.0101 | -0.2046 | -0.1383 |
| 9 | 4.0 | -0.0123 | -0.0213 | -0.2195 | -0.1500 | -0.0011 | -0.0094 | -0.2242 | -0.1520 |
| 10 | 4.5 | -0.0159 | -0.0221 | -0.2367 | -0.1628 | -0.0022 | -0.0078 | -0.2420 | -0.1646 |
| 11 | 5.0 | -0.0185 | -0.0230 | -0.2524 | -0.1746 | -0.0056 | -0.0059 | -0.2584 | -0.1766 |
| 12 | 5.5 | -0.0219 | -0.0236 | -0.2667 | -0.1856 | -0.0075 | -0.0035 | -0.2734 | -0.1875 |
| 13 | 6.0 | -0.0243 | -0.0243 | -0.2798 | -0.1956 | -0.0097 | -0.0003 | -0.2873 | -0.1974 |
| 14 | 6.5 | -0.0273 | -0.0249 | -0.2918 | -0.2051 | -0.0124 | 0.0036 | -0.3003 | -0.2066 |
| 15 | 7.0 | -0.0302 | -0.0253 | -0.3029 | -0.2139 | -0.0150 | 0.0079 | -0.3124 | -0.2151 |
| 16 | 7.5 | -0.0332 | -0.0255 | -0.3131 | -0.2221 | -0.0176 | 0.0122 | -0.3238 | -0.2229 |
| 17 | 8.0 | -0.0355 | -0.0254 | -0.3226 | -0.2297 | -0.0210 | 0.0167 | -0.3343 | -0.2302 |
| 18 | 8.5 | -0.0379 | -0.0254 | -0.3313 | -0.2369 | -0.0240 | 0.0210 | -0.3442 | -0.2370 |
| 19 | 9.0 | -0.0403 | -0.0252 | -0.3394 | -0.2436 | -0.0260 | 0.0254 | -0.3532 | -0.2434 |
| 20 | 9.5 | -0.0425 | -0.0254 | -0.3470 | -0.2498 | -0.0278 | 0.0298 | -0.3616 | -0.2493 |
| 21 | 10.0 | -0.0446 | -0.0255 | -0.3541 | -0.2557 | -0.0304 | 0.0341 | -0.3694 | -0.2550 |
| 22 | 11.0 | -0.0466 | -0.0228 | -0.3380 | -0.2469 | -0.0405 | 0.0438 | -0.3526 | -0.2447 |
| 23 | 12.0 | -0.0514 | -0.0186 | -0.3117 | -0.2321 | -0.0495 | 0.0540 | -0.3331 | -0.2321 |
| 24 | 13.0 | -0.0510 | -0.0163 | -0.2982 | -0.2237 | -0.0579 | 0.0637 | -0.3187 | -0.2224 |
| 25 | 14.0 | -0.0526 | -0.0144 | -0.2853 | -0.2156 | -0.0643 | 0.0720 | -0.3077 | -0.2149 |
| 26 | 15.0 | -0.0508 | -0.0134 | -0.2766 | -0.2098 | -0.0705 | 0.0790 | -0.2991 | -0.2089 |
| 27 | 16.0 | -0.0507 | -0.0128 | -0.2686 | -0.2043 | -0.0790 | 0.0838 | -0.2920 | -0.2044 |
| 28 | 17.0 | -0.0487 | -0.0120 | -0.2626 | -0.2000 | -0.0889 | 0.0873 | -0.2860 | -0.2006 |
| 29 | 18.0 | -0.0483 | -0.0116 | -0.2570 | -0.1957 | -0.0980 | 0.0903 | -0.2809 | -0.1972 |
| 30 | 19.0 | -0.0465 | -0.0115 | -0.2524 | -0.1920 | -0.1084 | 0.0931 | -0.2767 | -0.1944 |
| 31 | 20.0 | -0.0459 | -0.0115 | -0.2481 | -0.1884 | -0.1194 | 0.0960 | -0.2732 | -0.1918 |
| 32 | 21.0 | -0.0448 | -0.0116 | -0.2442 | -0.1852 | -0.1248 | 0.0991 | -0.2701 | -0.1892 |
| 33 | 22.0 | -0.0440 | -0.0117 | -0.2406 | -0.1820 | -0.1350 | 0.1024 | -0.2674 | -0.1874 |
| 34 | 23.0 | -0.0429 | -0.0116 | -0.2373 | -0.1791 | -0.1452 | 0.1058 | -0.2649 | -0.1857 |
| 35 | 24.0 | -0.0425 | -0.0117 | -0.2342 | -0.1762 | -0.1502 | 0.1087 | -0.2625 | -0.1836 |
| 36 | 25.0 | -0.0414 | -0.0119 | -0.2313 | -0.1734 | -0.1552 | 0.1118 | -0.2604 | -0.1814 |
| 37 | 26.0 | -0.0410 | -0.0118 | -0.2285 | -0.1708 | -0.1640 | 0.1155 | -0.2587 | -0.1797 |
| 38 | 27.0 | -0.0400 | -0.0117 | -0.2258 | -0.1682 | -0.1721 | 0.1191 | -0.2570 | -0.1780 |
| 39 | 28.0 | -0.0399 | -0.0117 | -0.2232 | -0.1657 | -0.1759 | 0.1228 | -0.2553 | -0.1761 |
| 40 | 29.0 | -0.0393 | -0.0119 | -0.2208 | -0.1633 | -0.1791 | 0.1264 | -0.2536 | -0.1742 |
| 41 | 30.0 | -0.0393 | -0.0122 | -0.2184 | -0.1610 | -0.1863 | 0.1299 | -0.2521 | -0.1727 |
| 42 | 32.0 | -0.0370 | -0.0097 | -0.1840 | -0.1364 | -0.1904 | 0.1400 | -0.2158 | -0.1467 |
| 43 | 34.0 | -0.0355 | -0.0071 | -0.1521 | -0.1132 | -0.1970 | 0.1471 | -0.1898 | -0.1269 |
| 44 | 36.0 | -0.0310 | -0.0074 | -0.1362 | -0.0994 | -0.2004 | 0.1512 | -0.1713 | -0.1118 |
| 45 | 38.0 | -0.0290 | -0.0073 | -0.1198 | -0.0858 | -0.2009 | 0.1534 | -0.1570 | -0.0998 |
| 46 | 40.0 | -0.0252 | -0.0081 | -0.1096 | -0.0762 | -0.2026 | 0.1561 | -0.1458 | -0.0899 |
| 47 | 42.0 | -0.0243 | -0.0087 | -0.0992 | -0.0669 | -0.2081 | 0.1587 | -0.1369 | -0.0817 |
| 48 | 44.0 | -0.0216 | -0.0092 | -0.0920 | -0.0597 | -0.2198 | 0.1611 | -0.1300 | -0.0754 |
| 49 | 46.0 | -0.0210 | -0.0101 | -0.0848 | -0.0530 | -0.2363 | 0.1637 | -0.1245 | -0.0705 |
| 50 | 48.0 | -0.0193 | -0.0105 | -0.0795 | -0.0476 | -0.2474 | 0.1669 | -0.1197 | -0.0658 |
| 51 | 50.0 | -0.0195 | -0.0108 | -0.0743 | -0.0425 | -0.2516 | 0.1702 | -0.1155 | -0.0612 |
| 52 | 52.0 | -0.0184 | -0.0112 | -0.0703 | -0.0384 | -0.2554 | 0.1734 | -0.1119 | -0.0570 |
| 53 | 54.0 | -0.0186 | -0.0118 | -0.0664 | -0.0345 | -0.2624 | 0.1766 | -0.1090 | -0.0536 |
| 54 | 56.0 | -0.0177 | -0.0118 | -0.0633 | -0.0312 | -0.2723 | 0.1798 | -0.1067 | -0.0508 |

| | | | | | | | | | |
|-----|-------|---------|---------|---------|---------|---------|--------|---------|---------|
| 55 | 58.0 | -0.0181 | -0.0122 | -0.0603 | -0.0281 | -0.2797 | 0.1830 | -0.1046 | -0.0482 |
| 56 | 60.0 | -0.0174 | -0.0124 | -0.0579 | -0.0254 | -0.2837 | 0.1864 | -0.1027 | -0.0456 |
| 57 | 62.0 | -0.0182 | -0.0124 | -0.0556 | -0.0228 | -0.2876 | 0.1897 | -0.1011 | -0.0432 |
| 58 | 64.0 | -0.0178 | -0.0126 | -0.0536 | -0.0206 | -0.2949 | 0.1931 | -0.0999 | -0.0414 |
| 59 | 66.0 | -0.0183 | -0.0130 | -0.0517 | -0.0185 | -0.3047 | 0.1965 | -0.0990 | -0.0401 |
| 60 | 68.0 | -0.0179 | -0.0135 | -0.0500 | -0.0167 | -0.3119 | 0.1999 | -0.0981 | -0.0386 |
| 61 | 70.0 | -0.0186 | -0.0138 | -0.0484 | -0.0149 | -0.3155 | 0.2033 | -0.0972 | -0.0370 |
| 62 | 72.0 | -0.0169 | -0.0109 | -0.0171 | 0.0068 | -0.3236 | 0.2100 | -0.0608 | -0.0124 |
| 63 | 74.0 | -0.0164 | -0.0084 | 0.0118 | 0.0272 | -0.3323 | 0.2124 | -0.0375 | 0.0044 |
| 64 | 76.0 | -0.0122 | -0.0084 | 0.0248 | 0.0383 | -0.3409 | 0.2138 | -0.0215 | 0.0164 |
| 65 | 78.0 | -0.0106 | -0.0083 | 0.0386 | 0.0491 | -0.3474 | 0.2130 | -0.0095 | 0.0253 |
| 66 | 80.0 | -0.0073 | -0.0083 | 0.0461 | 0.0562 | -0.3530 | 0.2121 | -0.0005 | 0.0323 |
| 67 | 82.0 | -0.0051 | -0.0057 | 0.0839 | 0.0830 | -0.3551 | 0.2147 | 0.0423 | 0.0614 |
| 68 | 84.0 | -0.0017 | -0.0029 | 0.1162 | 0.1065 | -0.3571 | 0.2129 | 0.0704 | 0.0819 |
| 69 | 86.0 | 0.0025 | -0.0032 | 0.1327 | 0.1205 | -0.3596 | 0.2105 | 0.0901 | 0.0969 |
| 70 | 88.0 | 0.0060 | -0.0027 | 0.1482 | 0.1329 | -0.3588 | 0.2061 | 0.1050 | 0.1079 |
| 71 | 90.0 | 0.0089 | -0.0028 | 0.1575 | 0.1413 | -0.3563 | 0.2015 | 0.1162 | 0.1165 |
| 72 | 92.0 | 0.0110 | -0.0029 | 0.1660 | 0.1486 | -0.3494 | 0.1972 | 0.1249 | 0.1235 |
| 73 | 94.0 | 0.0129 | -0.0032 | 0.1714 | 0.1537 | -0.3434 | 0.1928 | 0.1315 | 0.1291 |
| 74 | 96.0 | 0.0141 | -0.0036 | 0.1761 | 0.1577 | -0.3401 | 0.1887 | 0.1365 | 0.1332 |
| 75 | 98.0 | 0.0150 | -0.0035 | 0.1790 | 0.1604 | -0.3338 | 0.1849 | 0.1402 | 0.1364 |
| 76 | 100.0 | 0.0157 | -0.0037 | 0.1812 | 0.1624 | -0.3252 | 0.1811 | 0.1431 | 0.1389 |
| 77 | 102.0 | 0.0145 | -0.0064 | 0.1525 | 0.1434 | -0.3140 | 0.1741 | 0.1095 | 0.1176 |
| 78 | 104.0 | 0.0138 | -0.0094 | 0.1256 | 0.1251 | -0.3019 | 0.1714 | 0.0883 | 0.1033 |
| 79 | 106.0 | 0.0102 | -0.0094 | 0.1138 | 0.1153 | -0.2920 | 0.1696 | 0.0737 | 0.0930 |
| 80 | 108.0 | 0.0083 | -0.0102 | 0.1009 | 0.1054 | -0.2891 | 0.1702 | 0.0623 | 0.0849 |
| 81 | 110.0 | 0.0051 | -0.0100 | 0.0936 | 0.0988 | -0.2940 | 0.1710 | 0.0533 | 0.0774 |
| 82 | 115.0 | 0.0003 | -0.0121 | 0.0514 | 0.0668 | -0.3204 | 0.1726 | 0.0118 | 0.0447 |
| 83 | 120.0 | -0.0055 | -0.0119 | 0.0309 | 0.0489 | -0.3077 | 0.1775 | -0.0084 | 0.0299 |
| 84 | 125.0 | -0.0080 | -0.0108 | 0.0212 | 0.0393 | -0.2924 | 0.1823 | -0.0201 | 0.0211 |
| 85 | 130.0 | -0.0097 | -0.0107 | 0.0127 | 0.0317 | -0.3164 | 0.1865 | -0.0287 | 0.0121 |
| 86 | 135.0 | -0.0100 | -0.0100 | 0.0095 | 0.0280 | -0.3400 | 0.1907 | -0.0347 | 0.0052 |
| 87 | 140.0 | -0.0110 | -0.0100 | 0.0059 | 0.0248 | -0.3255 | 0.1946 | -0.0376 | 0.0039 |
| 88 | 145.0 | -0.0107 | -0.0095 | 0.0050 | 0.0235 | -0.3103 | 0.1984 | -0.0394 | 0.0036 |
| 89 | 150.0 | -0.0112 | -0.0095 | 0.0034 | 0.0222 | -0.3355 | 0.2022 | -0.0421 | 0.0000 |
| 90 | 155.0 | -0.0108 | -0.0092 | 0.0034 | 0.0218 | -0.3599 | 0.2060 | -0.0442 | -0.0030 |
| 91 | 160.0 | -0.0113 | -0.0093 | 0.0027 | 0.0213 | -0.3466 | 0.2097 | -0.0446 | -0.0019 |
| 92 | 170.0 | -0.0071 | -0.0059 | 0.0430 | 0.0494 | -0.3519 | 0.2125 | -0.0100 | 0.0223 |
| 93 | 180.0 | -0.0036 | -0.0069 | 0.0463 | 0.0539 | -0.3544 | 0.2120 | -0.0031 | 0.0276 |
| 94 | 190.0 | -0.0029 | -0.0070 | 0.0462 | 0.0536 | -0.3550 | 0.2119 | -0.0024 | 0.0282 |
| 95 | 200.0 | -0.0039 | -0.0067 | 0.0462 | 0.0528 | -0.3563 | 0.2121 | -0.0039 | 0.0265 |
| 96 | 210.0 | -0.0031 | -0.0068 | 0.0418 | 0.0490 | -0.3353 | 0.2124 | -0.0055 | 0.0261 |
| 97 | 220.0 | -0.0039 | -0.0061 | 0.0412 | 0.0475 | -0.3672 | 0.2127 | -0.0092 | 0.0202 |
| 98 | 230.0 | -0.0031 | -0.0063 | 0.0368 | 0.0436 | -0.3779 | 0.2130 | -0.0122 | 0.0163 |
| 99 | 240.0 | -0.0041 | -0.0054 | 0.0361 | 0.0419 | -0.3513 | 0.2133 | -0.0137 | 0.0163 |
| 100 | 250.0 | -0.0032 | -0.0054 | 0.0323 | 0.0385 | -0.3353 | 0.2136 | -0.0154 | 0.0153 |
| 101 | 260.0 | -0.0039 | -0.0049 | 0.0316 | 0.0369 | -0.3618 | 0.2139 | -0.0186 | 0.0102 |
| 102 | 270.0 | -0.0031 | -0.0050 | 0.0282 | 0.0339 | -0.3777 | 0.2143 | -0.0213 | 0.0063 |
| 103 | 280.0 | -0.0037 | -0.0045 | 0.0276 | 0.0324 | -0.3563 | 0.2145 | -0.0224 | 0.0063 |
| 104 | 290.0 | -0.0029 | -0.0046 | 0.0247 | 0.0298 | -0.3402 | 0.2148 | -0.0236 | 0.0058 |
| 105 | 300.0 | -0.0036 | -0.0043 | 0.0241 | 0.0285 | -0.3561 | 0.2151 | -0.0259 | 0.0023 |

表7. 2 (2) 評価断面2の応力テンソル成分2

FINAS解と簡易計算値との比較 (ホットショック)

断面2の応力成分2

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|---------|--------|---------|---------|---------|--------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.7634 | 0.3117 | -0.0146 | -0.4714 | -0.9039 | 0.3981 | -0.0196 | -0.6001 |
| 3 | 1.0 | -1.8410 | 0.9172 | -0.0380 | -1.3031 | -1.9098 | 0.9688 | -0.0399 | -1.3704 |
| 4 | 1.5 | -2.7304 | 1.4677 | -0.0548 | -2.0132 | -2.8250 | 1.5180 | -0.0573 | -2.0864 |
| 5 | 2.0 | -3.5532 | 1.9657 | -0.0706 | -2.6600 | -3.6293 | 2.0214 | -0.0717 | -2.7305 |
| 6 | 2.5 | -4.2540 | 2.4244 | -0.0828 | -3.2346 | -4.3420 | 2.4832 | -0.0839 | -3.3084 |
| 7 | 3.0 | -4.8983 | 2.8412 | -0.0936 | -3.7547 | -4.9820 | 2.9071 | -0.0942 | -3.8293 |
| 8 | 3.5 | -5.4582 | 3.2251 | -0.1026 | -4.2230 | -5.5524 | 3.2974 | -0.1029 | -4.3002 |
| 9 | 4.0 | -5.9745 | 3.5786 | -0.1101 | -4.6498 | -6.0617 | 3.6575 | -0.1105 | -4.7280 |
| 10 | 4.5 | -6.4305 | 3.9054 | -0.1167 | -5.0384 | -6.5227 | 3.9902 | -0.1170 | -5.1185 |
| 11 | 5.0 | -6.8538 | 4.2085 | -0.1222 | -5.3952 | -6.9447 | 4.3008 | -0.1224 | -5.4771 |
| 12 | 5.5 | -7.2318 | 4.4898 | -0.1270 | -5.7230 | -7.3283 | 4.5912 | -0.1268 | -5.8074 |
| 13 | 6.0 | -7.5846 | 4.7517 | -0.1311 | -6.0255 | -7.6800 | 4.8624 | -0.1307 | -6.1117 |
| 14 | 6.5 | -7.9031 | 4.9958 | -0.1348 | -6.3053 | -8.0028 | 5.1165 | -0.1343 | -6.3928 |
| 15 | 7.0 | -8.2018 | 5.2241 | -0.1379 | -6.5649 | -8.3002 | 5.3548 | -0.1375 | -6.6532 |
| 16 | 7.5 | -8.4730 | 5.4371 | -0.1408 | -6.8059 | -8.5759 | 5.5783 | -0.1407 | -6.8951 |
| 17 | 8.0 | -8.7283 | 5.6371 | -0.1431 | -7.0302 | -8.8332 | 5.7873 | -0.1438 | -7.1201 |
| 18 | 8.5 | -8.9613 | 5.8239 | -0.1454 | -7.2392 | -9.0730 | 5.9829 | -0.1466 | -7.3294 |
| 19 | 9.0 | -9.1814 | 5.9992 | -0.1473 | -7.4341 | -9.2960 | 6.1667 | -0.1490 | -7.5246 |
| 20 | 9.5 | -9.3830 | 6.1629 | -0.1492 | -7.6159 | -9.5030 | 6.3401 | -0.1508 | -7.7067 |
| 21 | 10.0 | -9.5734 | 6.3164 | -0.1507 | -7.7857 | -9.6957 | 6.5039 | -0.1524 | -7.8770 |
| 22 | 11.0 | -9.0693 | 6.1939 | -0.1368 | -7.5182 | -9.1591 | 6.3758 | -0.1362 | -7.5687 |
| 23 | 12.0 | -8.3969 | 5.8326 | -0.1194 | -6.9961 | -8.6038 | 6.1141 | -0.1226 | -7.1571 |
| 24 | 13.0 | -8.0248 | 5.6346 | -0.1114 | -6.7233 | -8.1931 | 5.9062 | -0.1130 | -6.8413 |
| 25 | 14.0 | -7.6844 | 5.4427 | -0.1036 | -6.4591 | -7.8837 | 5.7374 | -0.1062 | -6.5952 |
| 26 | 15.0 | -7.4527 | 5.2910 | -0.0998 | -6.2711 | -7.6425 | 5.5956 | -0.1012 | -6.3965 |
| 27 | 16.0 | -7.2415 | 5.1577 | -0.0959 | -6.1020 | -7.4530 | 5.4702 | -0.0975 | -6.2304 |
| 28 | 17.0 | -7.0825 | 5.0393 | -0.0940 | -5.9638 | -7.2978 | 5.3597 | -0.0943 | -6.0889 |
| 29 | 18.0 | -6.9313 | 4.9339 | -0.0919 | -5.8381 | -7.1648 | 5.2612 | -0.0913 | -5.9649 |
| 30 | 19.0 | -6.8099 | 4.8352 | -0.0907 | -5.7282 | -7.0467 | 5.1727 | -0.0890 | -5.8541 |
| 31 | 20.0 | -6.6907 | 4.7459 | -0.0894 | -5.6259 | -6.9409 | 5.0905 | -0.0875 | -5.7535 |
| 32 | 21.0 | -6.5910 | 4.6609 | -0.0886 | -5.5331 | -6.8364 | 5.0140 | -0.0862 | -5.6609 |
| 33 | 22.0 | -6.4907 | 4.5825 | -0.0876 | -5.4452 | -6.7474 | 4.9431 | -0.0851 | -5.5756 |
| 34 | 23.0 | -6.4036 | 4.5075 | -0.0870 | -5.3637 | -6.6640 | 4.8765 | -0.0840 | -5.4955 |
| 35 | 24.0 | -6.3160 | 4.4369 | -0.0862 | -5.2856 | -6.5774 | 4.8128 | -0.0829 | -5.4191 |
| 36 | 25.0 | -6.2379 | 4.3689 | -0.0856 | -5.2121 | -6.4953 | 4.7529 | -0.0820 | -5.3465 |
| 37 | 26.0 | -6.1593 | 4.3042 | -0.0850 | -5.1412 | -6.4248 | 4.6971 | -0.0814 | -5.2777 |
| 38 | 27.0 | -6.0879 | 4.2419 | -0.0844 | -5.0739 | -6.3571 | 4.6438 | -0.0808 | -5.2118 |
| 39 | 28.0 | -6.0160 | 4.1820 | -0.0839 | -5.0086 | -6.2847 | 4.5925 | -0.0800 | -5.1482 |
| 40 | 29.0 | -5.9498 | 4.1241 | -0.0833 | -4.9461 | -6.2151 | 4.5431 | -0.0792 | -5.0867 |
| 41 | 30.0 | -5.8834 | 4.0679 | -0.0828 | -4.8852 | -6.1556 | 4.4957 | -0.0784 | -5.0275 |
| 42 | 32.0 | -4.9168 | 3.5153 | -0.0652 | -4.1575 | -5.1086 | 3.9033 | -0.0584 | -4.2280 |
| 43 | 34.0 | -4.0874 | 2.9239 | -0.0517 | -3.4420 | -4.3776 | 3.4061 | -0.0469 | -3.6163 |
| 44 | 36.0 | -3.6457 | 2.5862 | -0.0475 | -3.0640 | -3.8549 | 3.0252 | -0.0400 | -3.1658 |
| 45 | 38.0 | -3.2121 | 2.2422 | -0.0425 | -2.6726 | -3.4501 | 2.7177 | -0.0351 | -2.8130 |
| 46 | 40.0 | -2.9305 | 2.0018 | -0.0407 | -2.4162 | -3.1250 | 2.4650 | -0.0314 | -2.5270 |
| 47 | 42.0 | -2.6513 | 1.7734 | -0.0379 | -2.1615 | -2.8633 | 2.2538 | -0.0288 | -2.2898 |
| 48 | 44.0 | -2.4521 | 1.5968 | -0.0368 | -1.9750 | -2.6562 | 2.0765 | -0.0269 | -2.0912 |
| 49 | 46.0 | -2.2566 | 1.4362 | -0.0348 | -1.7973 | -2.4906 | 1.9264 | -0.0255 | -1.9222 |
| 50 | 48.0 | -2.1111 | 1.3042 | -0.0340 | -1.6584 | -2.3428 | 1.7999 | -0.0242 | -1.7776 |
| 51 | 50.0 | -1.9683 | 1.1876 | -0.0326 | -1.5290 | -2.2050 | 1.6914 | -0.0226 | -1.6523 |
| 52 | 52.0 | -1.8595 | 1.0875 | -0.0319 | -1.4236 | -2.0857 | 1.5977 | -0.0213 | -1.5426 |
| 53 | 54.0 | -1.7513 | 0.9995 | -0.0308 | -1.3265 | -1.9876 | 1.5166 | -0.0203 | -1.4467 |
| 54 | 56.0 | -1.6678 | 0.9222 | -0.0302 | -1.2448 | -1.9070 | 1.4464 | -0.0194 | -1.3628 |

| | | | | | | | | | |
|-----|-------|---------|---------|---------|---------|---------|---------|---------|---------|
| 55 | 58.0 | -1.5837 | 0.8538 | -0.0293 | -1.1695 | -1.8320 | 1.3851 | -0.0185 | -1.2883 |
| 56 | 60.0 | -1.5181 | 0.7926 | -0.0288 | -1.1047 | -1.7599 | 1.3313 | -0.0175 | -1.2216 |
| 57 | 62.0 | -1.4513 | 0.7386 | -0.0281 | -1.0446 | -1.6953 | 1.2840 | -0.0166 | -1.1619 |
| 58 | 64.0 | -1.3988 | 0.6888 | -0.0277 | -0.9920 | -1.6431 | 1.2424 | -0.0159 | -1.1086 |
| 59 | 66.0 | -1.3432 | 0.6439 | -0.0271 | -0.9427 | -1.6006 | 1.2054 | -0.0153 | -1.0605 |
| 60 | 68.0 | -1.2998 | 0.6020 | -0.0267 | -0.8988 | -1.5581 | 1.1722 | -0.0146 | -1.0162 |
| 61 | 70.0 | -1.2533 | 0.5641 | -0.0262 | -0.8573 | -1.5133 | 1.1422 | -0.0139 | -0.9752 |
| 62 | 72.0 | -0.3732 | 0.0835 | -0.0093 | -0.2079 | -0.5182 | 0.5486 | 0.0055 | -0.1881 |
| 63 | 74.0 | 0.3771 | -0.4393 | 0.0037 | 0.4333 | 0.1102 | 0.1169 | 0.0153 | 0.3417 |
| 64 | 76.0 | 0.7403 | -0.7108 | 0.0073 | 0.7395 | 0.5341 | -0.2065 | 0.0205 | 0.7184 |
| 65 | 78.0 | 1.1010 | -0.9905 | 0.0118 | 1.0619 | 0.8442 | -0.4583 | 0.0242 | 0.9998 |
| 66 | 80.0 | 1.3090 | -1.1686 | 0.0129 | 1.2510 | 1.0852 | -0.6561 | 0.0268 | 1.2175 |
| 67 | 82.0 | 2.3623 | -1.7816 | 0.0317 | 2.0522 | 2.2368 | -1.3806 | 0.0474 | 2.1383 |
| 68 | 84.0 | 3.2021 | -2.3888 | 0.0449 | 2.7804 | 2.9845 | -1.9139 | 0.0579 | 2.7687 |
| 69 | 86.0 | 3.6628 | -2.7317 | 0.0495 | 3.1692 | 3.4975 | -2.3134 | 0.0634 | 3.2195 |
| 70 | 88.0 | 4.0667 | -3.0573 | 0.0540 | 3.5376 | 3.8745 | -2.6221 | 0.0671 | 3.5537 |
| 71 | 90.0 | 4.3258 | -3.2688 | 0.0557 | 3.7669 | 4.1627 | -2.8610 | 0.0698 | 3.8070 |
| 72 | 92.0 | 4.5491 | -3.4555 | 0.0579 | 3.9742 | 4.3862 | -3.0478 | 0.0715 | 4.0007 |
| 73 | 94.0 | 4.6998 | -3.5821 | 0.0588 | 4.1094 | 4.5540 | -3.1923 | 0.0726 | 4.1475 |
| 74 | 96.0 | 4.8220 | -3.6854 | 0.0600 | 4.2234 | 4.6755 | -3.3002 | 0.0732 | 4.2558 |
| 75 | 98.0 | 4.9023 | -3.7531 | 0.0604 | 4.2956 | 4.7676 | -3.3801 | 0.0734 | 4.3333 |
| 76 | 100.0 | 4.9605 | -3.8023 | 0.0611 | 4.3502 | 4.8344 | -3.4368 | 0.0737 | 4.3857 |
| 77 | 102.0 | 4.1501 | -3.3848 | 0.0445 | 3.7676 | 3.9216 | -2.9083 | 0.0552 | 3.6689 |
| 78 | 104.0 | 3.4563 | -2.9084 | 0.0322 | 3.1776 | 3.3539 | -2.5236 | 0.0459 | 3.1899 |
| 79 | 106.0 | 3.1258 | -2.6681 | 0.0289 | 2.9034 | 2.9697 | -2.2320 | 0.0412 | 2.8475 |
| 80 | 108.0 | 2.7891 | -2.4073 | 0.0248 | 2.6022 | 2.6760 | -1.9990 | 0.0376 | 2.5862 |
| 81 | 110.0 | 2.5875 | -2.2379 | 0.0236 | 2.4213 | 2.4272 | -1.8094 | 0.0349 | 2.3766 |
| 82 | 115.0 | 1.4365 | -1.4592 | 0.0067 | 1.4748 | 1.2794 | -1.0126 | 0.0198 | 1.4452 |
| 83 | 120.0 | 0.8971 | -0.9888 | 0.0024 | 0.9666 | 0.7650 | -0.5655 | 0.0151 | 0.9642 |
| 84 | 125.0 | 0.6210 | -0.7588 | 0.0011 | 0.7194 | 0.4754 | -0.2842 | 0.0135 | 0.6712 |
| 85 | 130.0 | 0.4002 | -0.5646 | -0.0011 | 0.5080 | 0.2382 | -0.1053 | 0.0117 | 0.4857 |
| 86 | 135.0 | 0.3032 | -0.4852 | -0.0014 | 0.4236 | 0.0772 | 0.0120 | 0.0105 | 0.3665 |
| 87 | 140.0 | 0.2122 | -0.4024 | -0.0025 | 0.3333 | 0.0298 | 0.0882 | 0.0107 | 0.2943 |
| 88 | 145.0 | 0.1810 | -0.3788 | -0.0024 | 0.3089 | 0.0129 | 0.1391 | 0.0112 | 0.2493 |
| 89 | 150.0 | 0.1437 | -0.3429 | -0.0030 | 0.2695 | -0.0560 | 0.1751 | 0.0105 | 0.2176 |
| 90 | 155.0 | 0.1368 | -0.3398 | -0.0030 | 0.2671 | -0.1110 | 0.2005 | 0.0100 | 0.1975 |
| 91 | 160.0 | 0.1232 | -0.3244 | -0.0032 | 0.2501 | -0.0908 | 0.2174 | 0.0108 | 0.1892 |
| 92 | 170.0 | 1.2164 | -1.0072 | 0.0157 | 1.1171 | 0.8419 | -0.4194 | 0.0255 | 0.9631 |
| 93 | 180.0 | 1.2915 | -1.1545 | 0.0128 | 1.2361 | 1.0367 | -0.5809 | 0.0268 | 1.1368 |
| 94 | 190.0 | 1.3006 | -1.1332 | 0.0133 | 1.2230 | 1.0571 | -0.5986 | 0.0269 | 1.1558 |
| 95 | 200.0 | 1.2882 | -1.1303 | 0.0136 | 1.2205 | 1.0136 | -0.5616 | 0.0264 | 1.1158 |
| 96 | 210.0 | 1.1766 | -1.0333 | 0.0120 | 1.1116 | 0.9868 | -0.5063 | 0.0265 | 1.0576 |
| 97 | 220.0 | 1.1508 | -1.0077 | 0.0125 | 1.0897 | 0.8585 | -0.4425 | 0.0249 | 0.9868 |
| 98 | 230.0 | 1.0373 | -0.9131 | 0.0108 | 0.9815 | 0.7682 | -0.3797 | 0.0240 | 0.9184 |
| 99 | 240.0 | 1.0104 | -0.8845 | 0.0111 | 0.9567 | 0.7468 | -0.3209 | 0.0242 | 0.8568 |
| 100 | 250.0 | 0.9102 | -0.8017 | 0.0096 | 0.8618 | 0.7102 | -0.2648 | 0.0240 | 0.7974 |
| 101 | 260.0 | 0.8843 | -0.7741 | 0.0098 | 0.8372 | 0.6020 | -0.2102 | 0.0226 | 0.7368 |
| 102 | 270.0 | 0.7975 | -0.7031 | 0.0085 | 0.7556 | 0.5162 | -0.1592 | 0.0216 | 0.6808 |
| 103 | 280.0 | 0.7738 | -0.6770 | 0.0088 | 0.7323 | 0.5001 | -0.1127 | 0.0217 | 0.6321 |
| 104 | 290.0 | 0.6984 | -0.6163 | 0.0076 | 0.6620 | 0.4778 | -0.0690 | 0.0217 | 0.5861 |
| 105 | 300.0 | 0.6767 | -0.5921 | 0.0077 | 0.6404 | 0.4022 | -0.0268 | 0.0208 | 0.5395 |

表7. 2 (3) 評価断面2の応力テンソル成分3

FINAS解と簡易計算値との比較 (ホットショック)

断面2の応力成分3

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|---------|--------|---------|---------|---------|--------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.5856 | 0.2521 | 0.0163 | -0.3707 | -0.6870 | 0.3257 | 0.0163 | -0.4781 |
| 3 | 1.0 | -1.2897 | 0.7333 | 0.0692 | -0.9806 | -1.3266 | 0.7762 | 0.0739 | -1.0299 |
| 4 | 1.5 | -1.7910 | 1.1554 | 0.1416 | -1.4529 | -1.8562 | 1.1997 | 0.1450 | -1.5117 |
| 5 | 2.0 | -2.2403 | 1.5260 | 0.2118 | -1.8376 | -2.2863 | 1.5758 | 0.2167 | -1.9233 |
| 6 | 2.5 | -2.5386 | 1.8556 | 0.2788 | -2.2164 | -2.6442 | 1.9080 | 0.2837 | -2.2746 |
| 7 | 3.0 | -2.9011 | 2.1420 | 0.3391 | -2.5187 | -2.9505 | 2.2012 | 0.3448 | -2.5767 |
| 8 | 3.5 | -3.1505 | 2.3953 | 0.3935 | -2.7777 | -3.2093 | 2.4598 | 0.3991 | -2.8376 |
| 9 | 4.0 | -3.3757 | 2.6186 | 0.4421 | -3.0039 | -3.4259 | 2.6887 | 0.4474 | -3.0639 |
| 10 | 4.5 | -3.5590 | 2.8172 | 0.4857 | -3.2007 | -3.6125 | 2.8917 | 0.4905 | -3.2615 |
| 11 | 5.0 | -3.7262 | 2.9944 | 0.5249 | -3.3742 | -3.7774 | 3.0750 | 0.5291 | -3.4360 |
| 12 | 5.5 | -3.8637 | 3.1530 | 0.5603 | -3.5272 | -3.9194 | 3.2412 | 0.5641 | -3.5908 |
| 13 | 6.0 | -3.9903 | 3.2962 | 0.5927 | -3.6635 | -4.0436 | 3.3916 | 0.5957 | -3.7277 |
| 14 | 6.5 | -4.0957 | 3.4260 | 0.6224 | -3.7851 | -4.1525 | 3.5286 | 0.6242 | -3.8493 |
| 15 | 7.0 | -4.1938 | 3.5447 | 0.6500 | -3.8946 | -4.2484 | 3.6544 | 0.6502 | -3.9581 |
| 16 | 7.5 | -4.2760 | 3.6529 | 0.6754 | -3.9932 | -4.3340 | 3.7704 | 0.6741 | -4.0562 |
| 17 | 8.0 | -4.3531 | 3.7532 | 0.6994 | -4.0826 | -4.4112 | 3.8770 | 0.6964 | -4.1446 |
| 18 | 8.5 | -4.4181 | 3.8453 | 0.7219 | -4.1640 | -4.4809 | 3.9752 | 0.7173 | -4.2245 |
| 19 | 9.0 | -4.4799 | 3.9309 | 0.7432 | -4.2383 | -4.5439 | 4.0668 | 0.7372 | -4.2976 |
| 20 | 9.5 | -4.5322 | 4.0098 | 0.7631 | -4.3063 | -4.6004 | 4.1531 | 0.7561 | -4.3646 |
| 21 | 10.0 | -4.5822 | 4.0831 | 0.7820 | -4.3687 | -4.6515 | 4.2344 | 0.7740 | -4.4263 |
| 22 | 11.0 | -4.0652 | 3.8959 | 0.7862 | -4.0475 | -4.1178 | 4.0406 | 0.7744 | -4.0707 |
| 23 | 12.0 | -3.5837 | 3.5469 | 0.7443 | -3.6082 | -3.7116 | 3.7710 | 0.7325 | -3.7153 |
| 24 | 13.0 | -3.3498 | 3.3605 | 0.7043 | -3.4015 | -3.4441 | 3.5748 | 0.6937 | -3.4672 |
| 25 | 14.0 | -3.1386 | 3.1996 | 0.6780 | -3.2092 | -3.2612 | 3.4335 | 0.6640 | -3.2915 |
| 26 | 15.0 | -3.0207 | 3.0889 | 0.6560 | -3.0937 | -3.1333 | 3.3294 | 0.6418 | -3.1634 |
| 27 | 16.0 | -2.9133 | 3.0011 | 0.6404 | -2.9948 | -3.0467 | 3.2476 | 0.6243 | -3.0672 |
| 28 | 17.0 | -2.8509 | 2.9300 | 0.6254 | -2.9257 | -2.9870 | 3.1824 | 0.6096 | -2.9935 |
| 29 | 18.0 | -2.7913 | 2.8710 | 0.6122 | -2.8662 | -2.9456 | 3.1275 | 0.5951 | -2.9349 |
| 30 | 19.0 | -2.7572 | 2.8168 | 0.5981 | -2.8202 | -2.9157 | 3.0801 | 0.5799 | -2.8870 |
| 31 | 20.0 | -2.7223 | 2.7690 | 0.5838 | -2.7789 | -2.8951 | 3.0373 | 0.5642 | -2.8471 |
| 32 | 21.0 | -2.7038 | 2.7225 | 0.5686 | -2.7445 | -2.8728 | 2.9981 | 0.5481 | -2.8131 |
| 33 | 22.0 | -2.6829 | 2.6795 | 0.5525 | -2.7126 | -2.8639 | 2.9619 | 0.5313 | -2.7841 |
| 34 | 23.0 | -2.6728 | 2.6371 | 0.5355 | -2.6847 | -2.8591 | 2.9271 | 0.5138 | -2.7582 |
| 35 | 24.0 | -2.6606 | 2.5963 | 0.5179 | -2.6581 | -2.8494 | 2.8931 | 0.4958 | -2.7343 |
| 36 | 25.0 | -2.6560 | 2.5556 | 0.4995 | -2.6341 | -2.8428 | 2.8608 | 0.4769 | -2.7123 |
| 37 | 26.0 | -2.6492 | 2.5159 | 0.4806 | -2.6106 | -2.8467 | 2.8301 | 0.4572 | -2.6923 |
| 38 | 27.0 | -2.6482 | 2.4765 | 0.4612 | -2.5891 | -2.8521 | 2.8003 | 0.4372 | -2.6739 |
| 39 | 28.0 | -2.6454 | 2.4377 | 0.4413 | -2.5681 | -2.8510 | 2.7714 | 0.4173 | -2.6565 |
| 40 | 29.0 | -2.6469 | 2.3993 | 0.4212 | -2.5485 | -2.8514 | 2.7431 | 0.3973 | -2.6399 |
| 41 | 30.0 | -2.6469 | 2.3610 | 0.4008 | -2.5291 | -2.8604 | 2.7147 | 0.3769 | -2.6239 |
| 42 | 32.0 | -2.1010 | 1.9405 | 0.3159 | -2.0566 | -2.2680 | 2.2658 | 0.2880 | -2.1004 |
| 43 | 34.0 | -1.7774 | 1.5207 | 0.2027 | -1.6632 | -1.9898 | 1.9286 | 0.1883 | -1.7815 |
| 44 | 36.0 | -1.6819 | 1.3218 | 0.1242 | -1.5218 | -1.8431 | 1.6978 | 0.1081 | -1.5855 |
| 45 | 38.0 | -1.5747 | 1.1136 | 0.0559 | -1.3544 | -1.7568 | 1.5220 | 0.0396 | -1.4520 |
| 46 | 40.0 | -1.5571 | 0.9774 | -0.0080 | -1.2790 | -1.7062 | 1.3786 | -0.0230 | -1.3537 |
| 47 | 42.0 | -1.5163 | 0.8365 | -0.0665 | -1.1833 | -1.6830 | 1.2555 | -0.0821 | -1.2765 |
| 48 | 44.0 | -1.5209 | 0.7274 | -0.1233 | -1.1305 | -1.6842 | 1.1484 | -0.1377 | -1.2147 |
| 49 | 46.0 | -1.5065 | 0.6209 | -0.1751 | -1.0679 | -1.7029 | 1.0543 | -0.1905 | -1.1637 |
| 50 | 48.0 | -1.5196 | 0.5311 | -0.2250 | -1.0281 | -1.7180 | 0.9725 | -0.2399 | -1.1213 |
| 51 | 50.0 | -1.5178 | 0.4477 | -0.2707 | -0.9842 | -1.7247 | 0.8995 | -0.2860 | -1.0847 |
| 52 | 52.0 | -1.5345 | 0.3733 | -0.3142 | -0.9535 | -1.7345 | 0.8333 | -0.3295 | -1.0524 |
| 53 | 54.0 | -1.5389 | 0.3053 | -0.3542 | -0.9215 | -1.7521 | 0.7734 | -0.3704 | -1.0243 |
| 54 | 56.0 | -1.5565 | 0.2433 | -0.3923 | -0.8975 | -1.7755 | 0.7193 | -0.4091 | -0.9998 |

| | | | | | | | | | |
|-----|-------|---------|---------|---------|---------|---------|---------|---------|---------|
| 55 | 58.0 | -1.5641 | 0.1865 | -0.4276 | -0.8730 | -1.7950 | 0.6700 | -0.4455 | -0.9781 |
| 56 | 60.0 | -1.5820 | 0.1338 | -0.4612 | -0.8538 | -1.8092 | 0.6251 | -0.4799 | -0.9588 |
| 57 | 62.0 | -1.5916 | 0.0859 | -0.4926 | -0.8344 | -1.8236 | 0.5840 | -0.5125 | -0.9416 |
| 58 | 64.0 | -1.6093 | 0.0405 | -0.5225 | -0.8188 | -1.8441 | 0.5465 | -0.5434 | -0.9266 |
| 59 | 66.0 | -1.6192 | -0.0015 | -0.5507 | -0.8033 | -1.8691 | 0.5119 | -0.5728 | -0.9133 |
| 60 | 68.0 | -1.6364 | -0.0418 | -0.5776 | -0.7903 | -1.8894 | 0.4799 | -0.6008 | -0.9011 |
| 61 | 70.0 | -1.6467 | -0.0792 | -0.6032 | -0.7772 | -1.9037 | 0.4500 | -0.6276 | -0.8897 |
| 62 | 72.0 | -1.1109 | -0.4601 | -0.6711 | -0.3298 | -1.3467 | -0.0201 | -0.7203 | -0.3604 |
| 63 | 74.0 | -0.7908 | -0.8397 | -0.7655 | 0.0403 | -1.0938 | -0.3220 | -0.8031 | -0.0709 |
| 64 | 76.0 | -0.6993 | -0.9979 | -0.8240 | 0.1592 | -0.9692 | -0.5214 | -0.8639 | 0.1018 |
| 65 | 78.0 | -0.5911 | -1.1645 | -0.8711 | 0.3050 | -0.9026 | -0.6657 | -0.9121 | 0.2127 |
| 66 | 80.0 | -0.5738 | -1.2593 | -0.9131 | 0.3595 | -0.8629 | -0.7768 | -0.9542 | 0.2901 |
| 67 | 82.0 | 0.0231 | -1.7036 | -0.9919 | 0.8713 | -0.2594 | -1.3090 | -1.0581 | 0.8663 |
| 68 | 84.0 | 0.3516 | -2.1166 | -1.0962 | 1.2631 | 0.0292 | -1.6593 | -1.1490 | 1.1904 |
| 69 | 86.0 | 0.4787 | -2.3065 | -1.1600 | 1.4155 | 0.1815 | -1.8944 | -1.2152 | 1.3880 |
| 70 | 88.0 | 0.5883 | -2.4898 | -1.2108 | 1.5725 | 0.2720 | -2.0644 | -1.2656 | 1.5161 |
| 71 | 90.0 | 0.6297 | -2.5963 | -1.2525 | 1.6436 | 0.3322 | -2.1932 | -1.3069 | 1.6049 |
| 72 | 92.0 | 0.6737 | -2.6989 | -1.2863 | 1.7226 | 0.3767 | -2.2949 | -1.3406 | 1.6701 |
| 73 | 94.0 | 0.6900 | -2.7646 | -1.3146 | 1.7619 | 0.4060 | -2.3759 | -1.3680 | 1.7186 |
| 74 | 96.0 | 0.7093 | -2.8226 | -1.3358 | 1.8036 | 0.4234 | -2.4377 | -1.3897 | 1.7540 |
| 75 | 98.0 | 0.7162 | -2.8589 | -1.3523 | 1.8242 | 0.4401 | -2.4844 | -1.4057 | 1.7787 |
| 76 | 100.0 | 0.7249 | -2.8867 | -1.3627 | 1.8442 | 0.4560 | -2.5182 | -1.4162 | 1.7953 |
| 77 | 102.0 | 0.1762 | -2.5558 | -1.3257 | 1.4162 | -0.1045 | -2.0997 | -1.3551 | 1.2874 |
| 78 | 104.0 | -0.1497 | -2.2164 | -1.2560 | 1.0636 | -0.3619 | -1.8388 | -1.2987 | 1.0135 |
| 79 | 106.0 | -0.2539 | -2.0884 | -1.2179 | 0.9538 | -0.4946 | -1.6710 | -1.2596 | 0.8514 |
| 80 | 108.0 | -0.3690 | -1.9438 | -1.1866 | 0.8153 | -0.5778 | -1.5501 | -1.2291 | 0.7463 |
| 81 | 110.0 | -0.3983 | -1.8643 | -1.1567 | 0.7629 | -0.6457 | -1.4552 | -1.2009 | 0.6708 |
| 82 | 115.0 | -0.8976 | -1.3656 | -1.0421 | 0.2599 | -1.0964 | -0.9603 | -1.0725 | 0.2184 |
| 83 | 120.0 | -0.9601 | -1.1070 | -0.9420 | 0.0889 | -1.1746 | -0.7219 | -0.9926 | 0.0508 |
| 84 | 125.0 | -0.9861 | -0.9905 | -0.8891 | 0.0204 | -1.1778 | -0.5641 | -0.9307 | -0.0423 |
| 85 | 130.0 | -0.9983 | -0.8635 | -0.8321 | -0.0560 | -1.2271 | -0.4558 | -0.8842 | -0.1011 |
| 86 | 135.0 | -0.9908 | -0.8129 | -0.7991 | -0.0743 | -1.2643 | -0.3781 | -0.8497 | -0.1402 |
| 87 | 140.0 | -0.9916 | -0.7517 | -0.7707 | -0.1100 | -1.2314 | -0.3232 | -0.8243 | -0.1630 |
| 88 | 145.0 | -0.9816 | -0.7327 | -0.7535 | -0.1114 | -1.1959 | -0.2834 | -0.8061 | -0.1773 |
| 89 | 150.0 | -0.9803 | -0.7028 | -0.7400 | -0.1291 | -1.2304 | -0.2529 | -0.7935 | -0.1892 |
| 90 | 155.0 | -0.9729 | -0.6978 | -0.7318 | -0.1251 | -1.2635 | -0.2296 | -0.7848 | -0.1975 |
| 91 | 160.0 | -0.9716 | -0.6833 | -0.7259 | -0.1345 | -1.2311 | -0.2126 | -0.7788 | -0.2004 |
| 92 | 170.0 | -0.3839 | -1.1505 | -0.8021 | 0.3958 | -0.8176 | -0.6109 | -0.8593 | 0.2136 |
| 93 | 180.0 | -0.4880 | -1.1711 | -0.8246 | 0.3603 | -0.7731 | -0.6795 | -0.8756 | 0.2688 |
| 94 | 190.0 | -0.4394 | -1.1548 | -0.8071 | 0.3704 | -0.7606 | -0.6779 | -0.8684 | 0.2748 |
| 95 | 200.0 | -0.4347 | -1.1524 | -0.7988 | 0.3769 | -0.7521 | -0.6447 | -0.8468 | 0.2625 |
| 96 | 210.0 | -0.4327 | -1.0685 | -0.7559 | 0.3297 | -0.7042 | -0.5988 | -0.8175 | 0.2456 |
| 97 | 220.0 | -0.4034 | -1.0480 | -0.7314 | 0.3386 | -0.7469 | -0.5450 | -0.7843 | 0.2223 |
| 98 | 230.0 | -0.4059 | -0.9645 | -0.6889 | 0.2898 | -0.7513 | -0.4909 | -0.7499 | 0.2008 |
| 99 | 240.0 | -0.3707 | -0.9367 | -0.6589 | 0.2971 | -0.6900 | -0.4389 | -0.7156 | 0.1832 |
| 100 | 250.0 | -0.3727 | -0.8622 | -0.6206 | 0.2539 | -0.6464 | -0.3878 | -0.6815 | 0.1657 |
| 101 | 260.0 | -0.3377 | -0.8327 | -0.5898 | 0.2596 | -0.6765 | -0.3367 | -0.6480 | 0.1460 |
| 102 | 270.0 | -0.3390 | -0.7676 | -0.5556 | 0.2224 | -0.6878 | -0.2880 | -0.6154 | 0.1281 |
| 103 | 280.0 | -0.3054 | -0.7385 | -0.5261 | 0.2268 | -0.6344 | -0.2427 | -0.5839 | 0.1143 |
| 104 | 290.0 | -0.3063 | -0.6816 | -0.4956 | 0.1946 | -0.5907 | -0.1994 | -0.5538 | 0.1010 |
| 105 | 300.0 | -0.2752 | -0.6539 | -0.4682 | 0.1981 | -0.6031 | -0.1574 | -0.5252 | 0.0861 |

表7. 2(4) 評価断面2の応力テンソル成分4

FINAS解と簡易計算値との比較 (ホットショック)

断面2の応力成分4

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|---------|---------|---------|--------|---------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.0092 | -0.0024 | -0.0067 | 0.0034 | 0.0107 | -0.0031 | -0.0079 | 0.0043 |
| 3 | 1.0 | 0.0186 | -0.0071 | -0.0226 | 0.0069 | 0.0190 | -0.0075 | -0.0240 | 0.0065 |
| 4 | 1.5 | 0.0250 | -0.0113 | -0.0408 | 0.0078 | 0.0263 | -0.0114 | -0.0421 | 0.0071 |
| 5 | 2.0 | 0.0313 | -0.0150 | -0.0588 | 0.0082 | 0.0326 | -0.0149 | -0.0602 | 0.0067 |
| 6 | 2.5 | 0.0358 | -0.0185 | -0.0761 | 0.0077 | 0.0377 | -0.0180 | -0.0777 | 0.0059 |
| 7 | 3.0 | 0.0400 | -0.0215 | -0.0925 | 0.0071 | 0.0420 | -0.0208 | -0.0943 | 0.0048 |
| 8 | 3.5 | 0.0431 | -0.0243 | -0.1080 | 0.0061 | 0.0455 | -0.0234 | -0.1100 | 0.0034 |
| 9 | 4.0 | 0.0458 | -0.0269 | -0.1226 | 0.0049 | 0.0487 | -0.0258 | -0.1248 | 0.0018 |
| 10 | 4.5 | 0.0479 | -0.0292 | -0.1363 | 0.0036 | 0.0518 | -0.0279 | -0.1388 | 0.0001 |
| 11 | 5.0 | 0.0497 | -0.0314 | -0.1492 | 0.0023 | 0.0547 | -0.0299 | -0.1520 | -0.0018 |
| 12 | 5.5 | 0.0510 | -0.0334 | -0.1613 | 0.0009 | 0.0574 | -0.0316 | -0.1646 | -0.0041 |
| 13 | 6.0 | 0.0522 | -0.0352 | -0.1728 | -0.0005 | 0.0598 | -0.0332 | -0.1764 | -0.0066 |
| 14 | 6.5 | 0.0531 | -0.0369 | -0.1836 | -0.0019 | 0.0618 | -0.0346 | -0.1877 | -0.0092 |
| 15 | 7.0 | 0.0539 | -0.0385 | -0.1938 | -0.0033 | 0.0638 | -0.0358 | -0.1983 | -0.0118 |
| 16 | 7.5 | 0.0545 | -0.0400 | -0.2035 | -0.0046 | 0.0659 | -0.0370 | -0.2084 | -0.0142 |
| 17 | 8.0 | 0.0550 | -0.0413 | -0.2126 | -0.0060 | 0.0679 | -0.0380 | -0.2179 | -0.0166 |
| 18 | 8.5 | 0.0554 | -0.0426 | -0.2212 | -0.0073 | 0.0700 | -0.0390 | -0.2268 | -0.0187 |
| 19 | 9.0 | 0.0558 | -0.0437 | -0.2293 | -0.0086 | 0.0720 | -0.0398 | -0.2353 | -0.0209 |
| 20 | 9.5 | 0.0562 | -0.0448 | -0.2370 | -0.0098 | 0.0739 | -0.0406 | -0.2434 | -0.0232 |
| 21 | 10.0 | 0.0565 | -0.0458 | -0.2442 | -0.0110 | 0.0759 | -0.0413 | -0.2511 | -0.0255 |
| 22 | 11.0 | 0.0478 | -0.0446 | -0.2474 | -0.0164 | 0.0705 | -0.0391 | -0.2544 | -0.0333 |
| 23 | 12.0 | 0.0412 | -0.0415 | -0.2398 | -0.0198 | 0.0678 | -0.0364 | -0.2490 | -0.0379 |
| 24 | 13.0 | 0.0375 | -0.0398 | -0.2332 | -0.0205 | 0.0673 | -0.0341 | -0.2432 | -0.0411 |
| 25 | 14.0 | 0.0343 | -0.0383 | -0.2272 | -0.0213 | 0.0680 | -0.0321 | -0.2378 | -0.0436 |
| 26 | 15.0 | 0.0329 | -0.0371 | -0.2217 | -0.0213 | 0.0688 | -0.0303 | -0.2329 | -0.0456 |
| 27 | 16.0 | 0.0314 | -0.0361 | -0.2166 | -0.0212 | 0.0707 | -0.0288 | -0.2282 | -0.0470 |
| 28 | 17.0 | 0.0308 | -0.0352 | -0.2118 | -0.0208 | 0.0729 | -0.0275 | -0.2238 | -0.0481 |
| 29 | 18.0 | 0.0301 | -0.0344 | -0.2072 | -0.0203 | 0.0748 | -0.0263 | -0.2197 | -0.0492 |
| 30 | 19.0 | 0.0299 | -0.0337 | -0.2027 | -0.0196 | 0.0769 | -0.0251 | -0.2156 | -0.0503 |
| 31 | 20.0 | 0.0296 | -0.0332 | -0.1983 | -0.0189 | 0.0794 | -0.0240 | -0.2116 | -0.0512 |
| 32 | 21.0 | 0.0294 | -0.0326 | -0.1940 | -0.0182 | 0.0819 | -0.0230 | -0.2076 | -0.0517 |
| 33 | 22.0 | 0.0291 | -0.0321 | -0.1898 | -0.0174 | 0.0847 | -0.0220 | -0.2037 | -0.0522 |
| 34 | 23.0 | 0.0290 | -0.0317 | -0.1856 | -0.0165 | 0.0876 | -0.0210 | -0.1997 | -0.0527 |
| 35 | 24.0 | 0.0287 | -0.0313 | -0.1815 | -0.0156 | 0.0903 | -0.0201 | -0.1958 | -0.0531 |
| 36 | 25.0 | 0.0286 | -0.0309 | -0.1774 | -0.0147 | 0.0932 | -0.0193 | -0.1920 | -0.0533 |
| 37 | 26.0 | 0.0283 | -0.0306 | -0.1734 | -0.0138 | 0.0961 | -0.0184 | -0.1882 | -0.0534 |
| 38 | 27.0 | 0.0282 | -0.0303 | -0.1695 | -0.0128 | 0.0992 | -0.0176 | -0.1844 | -0.0535 |
| 39 | 28.0 | 0.0279 | -0.0299 | -0.1656 | -0.0119 | 0.1023 | -0.0168 | -0.1807 | -0.0535 |
| 40 | 29.0 | 0.0277 | -0.0297 | -0.1617 | -0.0109 | 0.1053 | -0.0161 | -0.1771 | -0.0535 |
| 41 | 30.0 | 0.0275 | -0.0294 | -0.1579 | -0.0100 | 0.1081 | -0.0153 | -0.1735 | -0.0535 |
| 42 | 32.0 | 0.0191 | -0.0255 | -0.1377 | -0.0104 | 0.1047 | -0.0102 | -0.1526 | -0.0559 |
| 43 | 34.0 | 0.0148 | -0.0214 | -0.1117 | -0.0078 | 0.1054 | -0.0060 | -0.1297 | -0.0552 |
| 44 | 36.0 | 0.0131 | -0.0193 | -0.0929 | -0.0042 | 0.1074 | -0.0028 | -0.1103 | -0.0536 |
| 45 | 38.0 | 0.0118 | -0.0171 | -0.0757 | -0.0013 | 0.1098 | -0.0003 | -0.0935 | -0.0514 |
| 46 | 40.0 | 0.0114 | -0.0158 | -0.0611 | 0.0020 | 0.1124 | 0.0018 | -0.0789 | -0.0496 |
| 47 | 42.0 | 0.0105 | -0.0145 | -0.0481 | 0.0047 | 0.1151 | 0.0036 | -0.0661 | -0.0479 |
| 48 | 44.0 | 0.0102 | -0.0136 | -0.0366 | 0.0076 | 0.1179 | 0.0051 | -0.0547 | -0.0463 |
| 49 | 46.0 | 0.0094 | -0.0128 | -0.0264 | 0.0099 | 0.1208 | 0.0064 | -0.0446 | -0.0449 |
| 50 | 48.0 | 0.0092 | -0.0121 | -0.0174 | 0.0122 | 0.1237 | 0.0076 | -0.0357 | -0.0436 |
| 51 | 50.0 | 0.0086 | -0.0116 | -0.0093 | 0.0141 | 0.1263 | 0.0087 | -0.0277 | -0.0425 |
| 52 | 52.0 | 0.0083 | -0.0111 | -0.0020 | 0.0161 | 0.1287 | 0.0096 | -0.0206 | -0.0417 |
| 53 | 54.0 | 0.0078 | -0.0107 | 0.0046 | 0.0177 | 0.1310 | 0.0105 | -0.0141 | -0.0409 |
| 54 | 56.0 | 0.0076 | -0.0104 | 0.0105 | 0.0194 | 0.1334 | 0.0113 | -0.0084 | -0.0404 |

| | | | | | | | | | |
|-----|-------|---------|---------|--------|--------|--------|--------|---------|---------|
| 55 | 58.0 | 0.0070 | -0.0102 | 0.0159 | 0.0208 | 0.1356 | 0.0120 | -0.0031 | -0.0401 |
| 56 | 60.0 | 0.0063 | -0.0099 | 0.0209 | 0.0222 | 0.1379 | 0.0127 | 0.0017 | -0.0398 |
| 57 | 62.0 | 0.0064 | -0.0097 | 0.0254 | 0.0234 | 0.1401 | 0.0133 | 0.0060 | -0.0397 |
| 58 | 64.0 | 0.0061 | -0.0095 | 0.0296 | 0.0246 | 0.1424 | 0.0140 | 0.0101 | -0.0396 |
| 59 | 66.0 | 0.0057 | -0.0094 | 0.0335 | 0.0257 | 0.1448 | 0.0146 | 0.0138 | -0.0396 |
| 60 | 68.0 | 0.0056 | -0.0093 | 0.0372 | 0.0267 | 0.1471 | 0.0151 | 0.0172 | -0.0397 |
| 61 | 70.0 | 0.0052 | -0.0091 | 0.0406 | 0.0277 | 0.1494 | 0.0157 | 0.0205 | -0.0398 |
| 62 | 72.0 | -0.0029 | -0.0056 | 0.0566 | 0.0263 | 0.1442 | 0.0204 | 0.0411 | -0.0411 |
| 63 | 74.0 | -0.0071 | -0.0019 | 0.0784 | 0.0279 | 0.1429 | 0.0236 | 0.0602 | -0.0399 |
| 64 | 76.0 | -0.0086 | -0.0001 | 0.0930 | 0.0305 | 0.1427 | 0.0260 | 0.0758 | -0.0379 |
| 65 | 78.0 | -0.0098 | 0.0017 | 0.1061 | 0.0324 | 0.1431 | 0.0277 | 0.0888 | -0.0357 |
| 66 | 80.0 | -0.0100 | 0.0028 | 0.1165 | 0.0348 | 0.1436 | 0.0290 | 0.0995 | -0.0338 |
| 67 | 82.0 | -0.0186 | 0.0072 | 0.1381 | 0.0341 | 0.1363 | 0.0342 | 0.1262 | -0.0329 |
| 68 | 84.0 | -0.0225 | 0.0115 | 0.1641 | 0.0366 | 0.1328 | 0.0376 | 0.1500 | -0.0298 |
| 69 | 86.0 | -0.0244 | 0.0137 | 0.1818 | 0.0396 | 0.1304 | 0.0400 | 0.1691 | -0.0261 |
| 70 | 88.0 | -0.0252 | 0.0158 | 0.1970 | 0.0420 | 0.1288 | 0.0417 | 0.1846 | -0.0222 |
| 71 | 90.0 | -0.0257 | 0.0171 | 0.2087 | 0.0443 | 0.1271 | 0.0429 | 0.1970 | -0.0187 |
| 72 | 92.0 | -0.0259 | 0.0183 | 0.2181 | 0.0461 | 0.1250 | 0.0436 | 0.2070 | -0.0154 |
| 73 | 94.0 | -0.0261 | 0.0190 | 0.2254 | 0.0476 | 0.1223 | 0.0441 | 0.2149 | -0.0127 |
| 74 | 96.0 | -0.0264 | 0.0196 | 0.2309 | 0.0487 | 0.1206 | 0.0443 | 0.2209 | -0.0102 |
| 75 | 98.0 | -0.0265 | 0.0200 | 0.2349 | 0.0496 | 0.1184 | 0.0443 | 0.2254 | -0.0080 |
| 76 | 100.0 | -0.0266 | 0.0203 | 0.2376 | 0.0501 | 0.1161 | 0.0442 | 0.2286 | -0.0061 |
| 77 | 102.0 | -0.0187 | 0.0171 | 0.2264 | 0.0527 | 0.1212 | 0.0399 | 0.2130 | -0.0033 |
| 78 | 104.0 | -0.0148 | 0.0135 | 0.2083 | 0.0520 | 0.1223 | 0.0369 | 0.1978 | -0.0034 |
| 79 | 106.0 | -0.0135 | 0.0119 | 0.1964 | 0.0502 | 0.1223 | 0.0346 | 0.1850 | -0.0046 |
| 80 | 108.0 | -0.0126 | 0.0101 | 0.1852 | 0.0488 | 0.1217 | 0.0330 | 0.1742 | -0.0062 |
| 81 | 110.0 | -0.0124 | 0.0091 | 0.1760 | 0.0468 | 0.1213 | 0.0316 | 0.1648 | -0.0076 |
| 82 | 115.0 | -0.0058 | 0.0037 | 0.1433 | 0.0441 | 0.1258 | 0.0263 | 0.1287 | -0.0126 |
| 83 | 120.0 | -0.0054 | 0.0008 | 0.1174 | 0.0387 | 0.1267 | 0.0238 | 0.1050 | -0.0184 |
| 84 | 125.0 | -0.0048 | -0.0004 | 0.1038 | 0.0355 | 0.1285 | 0.0226 | 0.0889 | -0.0233 |
| 85 | 130.0 | -0.0044 | -0.0014 | 0.0922 | 0.0330 | 0.1313 | 0.0220 | 0.0781 | -0.0269 |
| 86 | 135.0 | -0.0040 | -0.0018 | 0.0861 | 0.0314 | 0.1344 | 0.0219 | 0.0708 | -0.0298 |
| 87 | 140.0 | -0.0039 | -0.0022 | 0.0810 | 0.0302 | 0.1370 | 0.0220 | 0.0658 | -0.0322 |
| 88 | 145.0 | -0.0036 | -0.0022 | 0.0785 | 0.0294 | 0.1394 | 0.0223 | 0.0624 | -0.0342 |
| 89 | 150.0 | -0.0036 | -0.0024 | 0.0763 | 0.0290 | 0.1425 | 0.0226 | 0.0600 | -0.0358 |
| 90 | 155.0 | -0.0034 | -0.0024 | 0.0754 | 0.0287 | 0.1455 | 0.0230 | 0.0584 | -0.0372 |
| 91 | 160.0 | -0.0035 | -0.0025 | 0.0745 | 0.0285 | 0.1479 | 0.0234 | 0.0573 | -0.0387 |
| 92 | 170.0 | -0.0109 | 0.0026 | 0.0985 | 0.0282 | 0.1464 | 0.0283 | 0.0827 | -0.0379 |
| 93 | 180.0 | -0.0086 | 0.0034 | 0.1087 | 0.0315 | 0.1476 | 0.0296 | 0.0906 | -0.0363 |
| 94 | 190.0 | -0.0093 | 0.0033 | 0.1061 | 0.0306 | 0.1478 | 0.0298 | 0.0908 | -0.0363 |
| 95 | 200.0 | -0.0090 | 0.0034 | 0.1050 | 0.0301 | 0.1480 | 0.0296 | 0.0877 | -0.0372 |
| 96 | 210.0 | -0.0084 | 0.0029 | 0.0984 | 0.0285 | 0.1480 | 0.0294 | 0.0832 | -0.0385 |
| 97 | 220.0 | -0.0083 | 0.0030 | 0.0949 | 0.0273 | 0.1489 | 0.0292 | 0.0782 | -0.0398 |
| 98 | 230.0 | -0.0076 | 0.0025 | 0.0885 | 0.0258 | 0.1495 | 0.0289 | 0.0731 | -0.0411 |
| 99 | 240.0 | -0.0074 | 0.0025 | 0.0845 | 0.0244 | 0.1494 | 0.0287 | 0.0681 | -0.0426 |
| 100 | 250.0 | -0.0069 | 0.0021 | 0.0788 | 0.0232 | 0.1495 | 0.0286 | 0.0633 | -0.0440 |
| 101 | 260.0 | -0.0067 | 0.0022 | 0.0749 | 0.0218 | 0.1503 | 0.0284 | 0.0586 | -0.0452 |
| 102 | 270.0 | -0.0062 | 0.0018 | 0.0700 | 0.0206 | 0.1509 | 0.0282 | 0.0541 | -0.0465 |
| 103 | 280.0 | -0.0061 | 0.0018 | 0.0663 | 0.0193 | 0.1509 | 0.0281 | 0.0499 | -0.0477 |
| 104 | 290.0 | -0.0056 | 0.0016 | 0.0619 | 0.0183 | 0.1510 | 0.0279 | 0.0458 | -0.0489 |
| 105 | 300.0 | -0.0055 | 0.0016 | 0.0585 | 0.0171 | 0.1515 | 0.0278 | 0.0420 | -0.0500 |

表7. 3(1) 評価断面3の応力テンソル成分1

F I N A S解と簡易計算値との比較 (ホットショック)

断面3の応力成分1

| ステップ | 時間(S) | F I N A S解 | | | | 簡易計算値 | | | |
|------|-------|------------|---------|--------|---------|---------|---------|--------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.0078 | -0.0031 | 0.0145 | -0.0001 | -0.0020 | -0.0028 | 0.0182 | 0.0006 |
| 3 | 1.0 | -0.0040 | -0.0103 | 0.0441 | -0.0014 | -0.0011 | -0.0090 | 0.0465 | -0.0021 |
| 4 | 1.5 | -0.0067 | -0.0188 | 0.0726 | -0.0054 | -0.0033 | -0.0155 | 0.0749 | -0.0061 |
| 5 | 2.0 | -0.0060 | -0.0268 | 0.0992 | -0.0089 | -0.0037 | -0.0208 | 0.1016 | -0.0102 |
| 6 | 2.5 | -0.0086 | -0.0341 | 0.1234 | -0.0129 | -0.0063 | -0.0258 | 0.1259 | -0.0145 |
| 7 | 3.0 | -0.0088 | -0.0410 | 0.1456 | -0.0167 | -0.0137 | -0.0296 | 0.1482 | -0.0193 |
| 8 | 3.5 | -0.0111 | -0.0470 | 0.1659 | -0.0205 | -0.0210 | -0.0321 | 0.1686 | -0.0241 |
| 9 | 4.0 | -0.0120 | -0.0525 | 0.1844 | -0.0242 | -0.0242 | -0.0350 | 0.1876 | -0.0285 |
| 10 | 4.5 | -0.0141 | -0.0577 | 0.2014 | -0.0277 | -0.0272 | -0.0371 | 0.2049 | -0.0331 |
| 11 | 5.0 | -0.0151 | -0.0624 | 0.2170 | -0.0312 | -0.0333 | -0.0392 | 0.2208 | -0.0375 |
| 12 | 5.5 | -0.0173 | -0.0668 | 0.2314 | -0.0345 | -0.0373 | -0.0409 | 0.2354 | -0.0413 |
| 13 | 6.0 | -0.0187 | -0.0707 | 0.2447 | -0.0377 | -0.0410 | -0.0421 | 0.2490 | -0.0450 |
| 14 | 6.5 | -0.0204 | -0.0744 | 0.2570 | -0.0407 | -0.0448 | -0.0430 | 0.2616 | -0.0485 |
| 15 | 7.0 | -0.0219 | -0.0777 | 0.2684 | -0.0437 | -0.0486 | -0.0434 | 0.2732 | -0.0519 |
| 16 | 7.5 | -0.0236 | -0.0807 | 0.2791 | -0.0466 | -0.0521 | -0.0435 | 0.2841 | -0.0552 |
| 17 | 8.0 | -0.0251 | -0.0838 | 0.2890 | -0.0492 | -0.0551 | -0.0430 | 0.2943 | -0.0583 |
| 18 | 8.5 | -0.0267 | -0.0866 | 0.2982 | -0.0518 | -0.0572 | -0.0419 | 0.3038 | -0.0613 |
| 19 | 9.0 | -0.0279 | -0.0891 | 0.3070 | -0.0542 | -0.0590 | -0.0400 | 0.3128 | -0.0642 |
| 20 | 9.5 | -0.0292 | -0.0915 | 0.3150 | -0.0565 | -0.0604 | -0.0376 | 0.3212 | -0.0670 |
| 21 | 10.0 | -0.0305 | -0.0938 | 0.3226 | -0.0587 | -0.0613 | -0.0348 | 0.3290 | -0.0695 |
| 22 | 11.0 | -0.0284 | -0.0930 | 0.3171 | -0.0620 | -0.0660 | -0.0255 | 0.3223 | -0.0735 |
| 23 | 12.0 | -0.0328 | -0.0876 | 0.2982 | -0.0622 | -0.0657 | -0.0134 | 0.3069 | -0.0734 |
| 24 | 13.0 | -0.0312 | -0.0833 | 0.2863 | -0.0610 | -0.0612 | -0.0017 | 0.2941 | -0.0722 |
| 25 | 14.0 | -0.0329 | -0.0799 | 0.2757 | -0.0605 | -0.0549 | 0.0094 | 0.2837 | -0.0704 |
| 26 | 15.0 | -0.0315 | -0.0769 | 0.2675 | -0.0591 | -0.0497 | 0.0195 | 0.2748 | -0.0683 |
| 27 | 16.0 | -0.0320 | -0.0750 | 0.2605 | -0.0581 | -0.0460 | 0.0293 | 0.2672 | -0.0667 |
| 28 | 17.0 | -0.0306 | -0.0730 | 0.2544 | -0.0568 | -0.0413 | 0.0388 | 0.2606 | -0.0653 |
| 29 | 18.0 | -0.0308 | -0.0715 | 0.2490 | -0.0556 | -0.0375 | 0.0474 | 0.2546 | -0.0638 |
| 30 | 19.0 | -0.0293 | -0.0700 | 0.2441 | -0.0543 | -0.0346 | 0.0552 | 0.2490 | -0.0621 |
| 31 | 20.0 | -0.0292 | -0.0685 | 0.2395 | -0.0530 | -0.0306 | 0.0626 | 0.2443 | -0.0605 |
| 32 | 21.0 | -0.0276 | -0.0671 | 0.2351 | -0.0517 | -0.0201 | 0.0701 | 0.2402 | -0.0587 |
| 33 | 22.0 | -0.0270 | -0.0659 | 0.2309 | -0.0505 | -0.0145 | 0.0776 | 0.2362 | -0.0575 |
| 34 | 23.0 | -0.0256 | -0.0647 | 0.2269 | -0.0492 | -0.0083 | 0.0848 | 0.2324 | -0.0563 |
| 35 | 24.0 | -0.0247 | -0.0639 | 0.2230 | -0.0479 | 0.0042 | 0.0920 | 0.2289 | -0.0550 |
| 36 | 25.0 | -0.0235 | -0.0629 | 0.2192 | -0.0467 | 0.0167 | 0.0993 | 0.2257 | -0.0537 |
| 37 | 26.0 | -0.0228 | -0.0618 | 0.2155 | -0.0455 | 0.0225 | 0.1066 | 0.2223 | -0.0528 |
| 38 | 27.0 | -0.0216 | -0.0608 | 0.2119 | -0.0443 | 0.0276 | 0.1135 | 0.2189 | -0.0518 |
| 39 | 28.0 | -0.0207 | -0.0599 | 0.2083 | -0.0431 | 0.0388 | 0.1202 | 0.2158 | -0.0505 |
| 40 | 29.0 | -0.0193 | -0.0588 | 0.2048 | -0.0420 | 0.0505 | 0.1266 | 0.2127 | -0.0492 |
| 41 | 30.0 | -0.0185 | -0.0579 | 0.2014 | -0.0408 | 0.0564 | 0.1327 | 0.2094 | -0.0482 |
| 42 | 32.0 | -0.0135 | -0.0503 | 0.1726 | -0.0369 | 0.0818 | 0.1490 | 0.1789 | -0.0430 |
| 43 | 34.0 | -0.0125 | -0.0406 | 0.1402 | -0.0305 | 0.1014 | 0.1642 | 0.1520 | -0.0362 |
| 44 | 36.0 | -0.0070 | -0.0350 | 0.1211 | -0.0249 | 0.1211 | 0.1769 | 0.1314 | -0.0297 |
| 45 | 38.0 | -0.0051 | -0.0301 | 0.1026 | -0.0202 | 0.1414 | 0.1890 | 0.1148 | -0.0242 |
| 46 | 40.0 | -0.0004 | -0.0262 | 0.0889 | -0.0156 | 0.1563 | 0.1997 | 0.1008 | -0.0198 |
| 47 | 42.0 | 0.0013 | -0.0230 | 0.0760 | -0.0120 | 0.1646 | 0.2095 | 0.0887 | -0.0166 |
| 48 | 44.0 | 0.0053 | -0.0202 | 0.0654 | -0.0084 | 0.1638 | 0.2186 | 0.0779 | -0.0147 |
| 49 | 46.0 | 0.0066 | -0.0176 | 0.0557 | -0.0056 | 0.1557 | 0.2272 | 0.0684 | -0.0138 |
| 50 | 48.0 | 0.0098 | -0.0154 | 0.0474 | -0.0028 | 0.1536 | 0.2356 | 0.0602 | -0.0127 |
| 51 | 50.0 | 0.0110 | -0.0135 | 0.0399 | -0.0007 | 0.1595 | 0.2434 | 0.0531 | -0.0114 |
| 52 | 52.0 | 0.0135 | -0.0119 | 0.0332 | 0.0016 | 0.1638 | 0.2508 | 0.0464 | -0.0102 |
| 53 | 54.0 | 0.0144 | -0.0100 | 0.0272 | 0.0032 | 0.1630 | 0.2580 | 0.0402 | -0.0094 |
| 54 | 56.0 | 0.0165 | -0.0088 | 0.0217 | 0.0050 | 0.1589 | 0.2650 | 0.0344 | -0.0089 |

| | | | | | | | | | |
|-----|-------|--------|---------|---------|--------|--------|--------|---------|---------|
| 55 | 58.0 | 0.0173 | -0.0076 | 0.0168 | 0.0064 | 0.1584 | 0.2720 | 0.0293 | -0.0082 |
| 56 | 60.0 | 0.0192 | -0.0065 | 0.0122 | 0.0079 | 0.1621 | 0.2790 | 0.0249 | -0.0074 |
| 57 | 62.0 | 0.0200 | -0.0055 | 0.0081 | 0.0091 | 0.1661 | 0.2858 | 0.0207 | -0.0068 |
| 58 | 64.0 | 0.0215 | -0.0045 | 0.0042 | 0.0103 | 0.1661 | 0.2924 | 0.0167 | -0.0065 |
| 59 | 66.0 | 0.0219 | -0.0037 | 0.0006 | 0.0113 | 0.1632 | 0.2990 | 0.0129 | -0.0064 |
| 60 | 68.0 | 0.0233 | -0.0029 | -0.0027 | 0.0123 | 0.1640 | 0.3054 | 0.0095 | -0.0061 |
| 61 | 70.0 | 0.0237 | -0.0024 | -0.0059 | 0.0132 | 0.1695 | 0.3118 | 0.0065 | -0.0056 |
| 62 | 72.0 | 0.0278 | 0.0041 | -0.0309 | 0.0158 | 0.1686 | 0.3246 | -0.0255 | -0.0019 |
| 63 | 74.0 | 0.0276 | 0.0129 | -0.0597 | 0.0210 | 0.1728 | 0.3339 | -0.0499 | 0.0028 |
| 64 | 76.0 | 0.0322 | 0.0175 | -0.0751 | 0.0252 | 0.1742 | 0.3423 | -0.0680 | 0.0067 |
| 65 | 78.0 | 0.0325 | 0.0216 | -0.0898 | 0.0286 | 0.1773 | 0.3488 | -0.0819 | 0.0101 |
| 66 | 80.0 | 0.0362 | 0.0246 | -0.0998 | 0.0319 | 0.1811 | 0.3528 | -0.0930 | 0.0132 |
| 67 | 82.0 | 0.0392 | 0.0327 | -0.1311 | 0.0360 | 0.1844 | 0.3628 | -0.1308 | 0.0190 |
| 68 | 84.0 | 0.0413 | 0.0427 | -0.1640 | 0.0427 | 0.1920 | 0.3680 | -0.1594 | 0.0254 |
| 69 | 86.0 | 0.0449 | 0.0483 | -0.1827 | 0.0477 | 0.1959 | 0.3724 | -0.1804 | 0.0305 |
| 70 | 88.0 | 0.0470 | 0.0529 | -0.1996 | 0.0520 | 0.2000 | 0.3743 | -0.1963 | 0.0348 |
| 71 | 90.0 | 0.0494 | 0.0563 | -0.2111 | 0.0555 | 0.2043 | 0.3734 | -0.2087 | 0.0383 |
| 72 | 92.0 | 0.0512 | 0.0589 | -0.2210 | 0.0583 | 0.2091 | 0.3716 | -0.2183 | 0.0411 |
| 73 | 94.0 | 0.0526 | 0.0610 | -0.2280 | 0.0605 | 0.2096 | 0.3683 | -0.2257 | 0.0431 |
| 74 | 96.0 | 0.0536 | 0.0627 | -0.2337 | 0.0620 | 0.2070 | 0.3648 | -0.2312 | 0.0443 |
| 75 | 98.0 | 0.0544 | 0.0636 | -0.2376 | 0.0633 | 0.2051 | 0.3608 | -0.2351 | 0.0453 |
| 76 | 100.0 | 0.0548 | 0.0645 | -0.2405 | 0.0640 | 0.2049 | 0.3565 | -0.2378 | 0.0458 |
| 77 | 102.0 | 0.0519 | 0.0592 | -0.2201 | 0.0627 | 0.2077 | 0.3452 | -0.2107 | 0.0428 |
| 78 | 104.0 | 0.0526 | 0.0515 | -0.1950 | 0.0585 | 0.2048 | 0.3370 | -0.1902 | 0.0385 |
| 79 | 106.0 | 0.0488 | 0.0474 | -0.1822 | 0.0549 | 0.2026 | 0.3294 | -0.1752 | 0.0348 |
| 80 | 108.0 | 0.0486 | 0.0439 | -0.1694 | 0.0519 | 0.1928 | 0.3237 | -0.1636 | 0.0310 |
| 81 | 110.0 | 0.0456 | 0.0413 | -0.1606 | 0.0489 | 0.1736 | 0.3203 | -0.1543 | 0.0267 |
| 82 | 115.0 | 0.0406 | 0.0303 | -0.1208 | 0.0407 | 0.1170 | 0.3098 | -0.1149 | 0.0135 |
| 83 | 120.0 | 0.0351 | 0.0227 | -0.0951 | 0.0326 | 0.1256 | 0.3063 | -0.0922 | 0.0078 |
| 84 | 125.0 | 0.0317 | 0.0200 | -0.0829 | 0.0286 | 0.1529 | 0.3077 | -0.0768 | 0.0055 |
| 85 | 130.0 | 0.0292 | 0.0167 | -0.0715 | 0.0251 | 0.1334 | 0.3101 | -0.0681 | 0.0017 |
| 86 | 135.0 | 0.0275 | 0.0156 | -0.0663 | 0.0233 | 0.1191 | 0.3135 | -0.0617 | -0.0010 |
| 87 | 140.0 | 0.0262 | 0.0140 | -0.0612 | 0.0218 | 0.1515 | 0.3174 | -0.0563 | -0.0001 |
| 88 | 145.0 | 0.0256 | 0.0137 | -0.0592 | 0.0212 | 0.1835 | 0.3219 | -0.0522 | 0.0011 |
| 89 | 150.0 | 0.0249 | 0.0130 | -0.0568 | 0.0206 | 0.1620 | 0.3268 | -0.0506 | -0.0013 |
| 90 | 155.0 | 0.0246 | 0.0129 | -0.0562 | 0.0203 | 0.1405 | 0.3321 | -0.0498 | -0.0036 |
| 91 | 160.0 | 0.0244 | 0.0125 | -0.0552 | 0.0201 | 0.1673 | 0.3375 | -0.0481 | -0.0025 |
| 92 | 170.0 | 0.0278 | 0.0223 | -0.0895 | 0.0253 | 0.1835 | 0.3527 | -0.0807 | 0.0046 |
| 93 | 180.0 | 0.0287 | 0.0252 | -0.0970 | 0.0291 | 0.1860 | 0.3557 | -0.0880 | 0.0062 |
| 94 | 190.0 | 0.0296 | 0.0239 | -0.0948 | 0.0282 | 0.1807 | 0.3559 | -0.0884 | 0.0055 |
| 95 | 200.0 | 0.0273 | 0.0244 | -0.0947 | 0.0278 | 0.1756 | 0.3556 | -0.0861 | 0.0039 |
| 96 | 210.0 | 0.0272 | 0.0221 | -0.0880 | 0.0261 | 0.2011 | 0.3546 | -0.0816 | 0.0044 |
| 97 | 220.0 | 0.0247 | 0.0217 | -0.0858 | 0.0250 | 0.1589 | 0.3535 | -0.0782 | 0.0002 |
| 98 | 230.0 | 0.0243 | 0.0198 | -0.0793 | 0.0233 | 0.1441 | 0.3524 | -0.0740 | -0.0022 |
| 99 | 240.0 | 0.0217 | 0.0195 | -0.0764 | 0.0220 | 0.1771 | 0.3513 | -0.0687 | -0.0013 |
| 100 | 250.0 | 0.0215 | 0.0182 | -0.0706 | 0.0206 | 0.1964 | 0.3503 | -0.0638 | -0.0012 |
| 101 | 260.0 | 0.0191 | 0.0174 | -0.0678 | 0.0194 | 0.1608 | 0.3492 | -0.0605 | -0.0048 |
| 102 | 270.0 | 0.0190 | 0.0164 | -0.0627 | 0.0182 | 0.1391 | 0.3483 | -0.0570 | -0.0074 |
| 103 | 280.0 | 0.0170 | 0.0155 | -0.0599 | 0.0171 | 0.1654 | 0.3473 | -0.0525 | -0.0067 |
| 104 | 290.0 | 0.0170 | 0.0143 | -0.0555 | 0.0161 | 0.1848 | 0.3465 | -0.0483 | -0.0064 |
| 105 | 300.0 | 0.0151 | 0.0137 | -0.0529 | 0.0150 | 0.1632 | 0.3456 | -0.0454 | -0.0088 |

表7. 3(2) 評価断面3の応力テンソル成分2

FINAS解と簡易計算値との比較 (ホットショック)

断面3の応力成分2

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|---------|--------|---------|---------|---------|--------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.6264 | 0.2429 | 0.0050 | -0.3522 | -0.7259 | 0.2909 | 0.0066 | -0.4361 |
| 3 | 1.0 | -1.4568 | 0.7784 | 0.0145 | -1.0202 | -1.5057 | 0.8188 | 0.0152 | -1.0725 |
| 4 | 1.5 | -2.1605 | 1.3476 | 0.0215 | -1.6543 | -2.2424 | 1.3766 | 0.0222 | -1.7071 |
| 5 | 2.0 | -2.8466 | 1.8859 | 0.0267 | -2.2513 | -2.9100 | 1.9169 | 0.0275 | -2.3019 |
| 6 | 2.5 | -3.4385 | 2.3968 | 0.0305 | -2.7972 | -3.5158 | 2.4267 | 0.0312 | -2.8495 |
| 7 | 3.0 | -3.9938 | 2.8734 | 0.0334 | -3.2992 | -4.0706 | 2.9035 | 0.0340 | -3.3523 |
| 8 | 3.5 | -4.4808 | 3.3174 | 0.0354 | -3.7580 | -4.5749 | 3.3478 | 0.0359 | -3.8137 |
| 9 | 4.0 | -4.9362 | 3.7323 | 0.0367 | -4.1805 | -5.0274 | 3.7612 | 0.0373 | -4.2374 |
| 10 | 4.5 | -5.3407 | 4.1190 | 0.0375 | -4.5688 | -5.4403 | 4.1464 | 0.0382 | -4.6278 |
| 11 | 5.0 | -5.7198 | 4.4814 | 0.0379 | -4.9281 | -5.8226 | 4.5073 | 0.0387 | -4.9885 |
| 12 | 5.5 | -6.0608 | 4.8200 | 0.0379 | -5.2605 | -6.1710 | 4.8461 | 0.0388 | -5.3231 |
| 13 | 6.0 | -6.3820 | 5.1379 | 0.0376 | -5.5698 | -6.4923 | 5.1637 | 0.0386 | -5.6339 |
| 14 | 6.5 | -6.6729 | 5.4367 | 0.0371 | -5.8573 | -6.7895 | 5.4618 | 0.0382 | -5.9232 |
| 15 | 7.0 | -6.9482 | 5.7177 | 0.0363 | -6.1260 | -7.0647 | 5.7420 | 0.0376 | -6.1930 |
| 16 | 7.5 | -7.1992 | 5.9824 | 0.0354 | -6.3769 | -7.3200 | 6.0055 | 0.0369 | -6.4452 |
| 17 | 8.0 | -7.4377 | 6.2314 | 0.0344 | -6.6120 | -7.5574 | 6.2534 | 0.0360 | -6.6812 |
| 18 | 8.5 | -7.6559 | 6.4657 | 0.0333 | -6.8320 | -7.7781 | 6.4872 | 0.0352 | -6.9023 |
| 19 | 9.0 | -7.8633 | 6.6868 | 0.0323 | -7.0384 | -7.9841 | 6.7075 | 0.0344 | -7.1096 |
| 20 | 9.5 | -8.0537 | 6.8950 | 0.0311 | -7.2318 | -8.1768 | 6.9147 | 0.0334 | -7.3041 |
| 21 | 10.0 | -8.2352 | 7.0912 | 0.0299 | -7.4135 | -8.3574 | 7.1096 | 0.0324 | -7.4865 |
| 22 | 11.0 | -7.8815 | 7.1069 | 0.0214 | -7.2923 | -7.9707 | 7.1063 | 0.0235 | -7.3353 |
| 23 | 12.0 | -7.4048 | 6.8161 | 0.0114 | -6.8919 | -7.5544 | 6.8743 | 0.0151 | -7.0141 |
| 24 | 13.0 | -7.1058 | 6.6055 | 0.0066 | -6.6411 | -7.2217 | 6.6569 | 0.0096 | -6.7438 |
| 25 | 14.0 | -6.8286 | 6.4182 | 0.0029 | -6.4115 | -6.9575 | 6.4689 | 0.0061 | -6.5231 |
| 26 | 15.0 | -6.6381 | 6.2517 | 0.0008 | -6.2335 | -6.7460 | 6.3038 | 0.0035 | -6.3394 |
| 27 | 16.0 | -6.4553 | 6.1061 | -0.0003 | -6.0747 | -6.5739 | 6.1531 | 0.0017 | -6.1808 |
| 28 | 17.0 | -6.3166 | 5.9683 | -0.0007 | -5.9374 | -6.4257 | 6.0141 | 0.0007 | -6.0405 |
| 29 | 18.0 | -6.1779 | 5.8413 | -0.0006 | -5.8101 | -6.2966 | 5.8836 | 0.0000 | -5.9134 |
| 30 | 19.0 | -6.0633 | 5.7183 | 0.0000 | -5.6931 | -6.1811 | 5.7594 | -0.0002 | -5.7951 |
| 31 | 20.0 | -5.9463 | 5.6009 | 0.0009 | -5.5812 | -6.0727 | 5.6397 | 0.0002 | -5.6833 |
| 32 | 21.0 | -5.8441 | 5.4868 | 0.0020 | -5.4752 | -5.9614 | 5.5243 | 0.0013 | -5.5767 |
| 33 | 22.0 | -5.7386 | 5.3756 | 0.0034 | -5.3721 | -5.8638 | 5.4125 | 0.0026 | -5.4747 |
| 34 | 23.0 | -5.6434 | 5.2672 | 0.0048 | -5.2729 | -5.7697 | 5.3037 | 0.0040 | -5.3761 |
| 35 | 24.0 | -5.5454 | 5.1607 | 0.0064 | -5.1757 | -5.6697 | 5.1970 | 0.0058 | -5.2799 |
| 36 | 25.0 | -5.4549 | 5.0569 | 0.0080 | -5.0813 | -5.5716 | 5.0923 | 0.0077 | -5.1862 |
| 37 | 26.0 | -5.3626 | 4.9547 | 0.0097 | -4.9885 | -5.4846 | 4.9898 | 0.0096 | -5.0951 |
| 38 | 27.0 | -5.2760 | 4.8548 | 0.0115 | -4.8980 | -5.3993 | 4.8893 | 0.0115 | -5.0059 |
| 39 | 28.0 | -5.1874 | 4.7563 | 0.0132 | -4.8089 | -5.3055 | 4.7907 | 0.0137 | -4.9180 |
| 40 | 29.0 | -5.1037 | 4.6597 | 0.0150 | -4.7216 | -5.2115 | 4.6941 | 0.0159 | -4.8317 |
| 41 | 30.0 | -5.0185 | 4.5644 | 0.0168 | -4.6355 | -5.1266 | 4.5998 | 0.0180 | -4.7470 |
| 42 | 32.0 | -4.1775 | 3.9641 | 0.0143 | -3.9604 | -4.2103 | 3.9564 | 0.0156 | -4.0185 |
| 43 | 34.0 | -3.4265 | 3.2324 | 0.0139 | -3.2182 | -3.5046 | 3.3095 | 0.0174 | -3.3697 |
| 44 | 36.0 | -2.9504 | 2.7423 | 0.0185 | -2.7607 | -2.9657 | 2.7774 | 0.0210 | -2.8612 |
| 45 | 38.0 | -2.5132 | 2.2806 | 0.0221 | -2.3206 | -2.5295 | 2.3259 | 0.0251 | -2.4439 |
| 46 | 40.0 | -2.1870 | 1.9065 | 0.0272 | -1.9856 | -2.1664 | 1.9338 | 0.0289 | -2.0910 |
| 47 | 42.0 | -1.8746 | 1.5690 | 0.0316 | -1.6720 | -1.8623 | 1.5928 | 0.0326 | -1.7882 |
| 48 | 44.0 | -1.6294 | 1.2777 | 0.0362 | -1.4135 | -1.6110 | 1.2940 | 0.0359 | -1.5255 |
| 49 | 46.0 | -1.3917 | 1.0202 | 0.0402 | -1.1762 | -1.3997 | 1.0292 | 0.0391 | -1.2944 |
| 50 | 48.0 | -1.2016 | 0.7914 | 0.0441 | -0.9735 | -1.2050 | 0.7955 | 0.0424 | -1.0906 |
| 51 | 50.0 | -1.0157 | 0.5898 | 0.0476 | -0.7886 | -1.0197 | 0.5869 | 0.0456 | -0.9088 |
| 52 | 52.0 | -0.8649 | 0.4082 | 0.0509 | -0.6270 | -0.8534 | 0.3989 | 0.0483 | -0.7458 |
| 53 | 54.0 | -0.7161 | 0.2472 | 0.0539 | -0.4794 | -0.7094 | 0.2293 | 0.0507 | -0.5995 |
| 54 | 56.0 | -0.5940 | 0.0998 | 0.0566 | -0.3483 | -0.5838 | 0.0759 | 0.0528 | -0.4676 |

| | | | | | | | | | |
|-----|-------|---------|---------|--------|---------|---------|---------|--------|---------|
| 55 | 58.0 | -0.4722 | -0.0324 | 0.0591 | -0.2276 | -0.4659 | -0.0639 | 0.0548 | -0.3475 |
| 56 | 60.0 | -0.3711 | -0.1541 | 0.0615 | -0.1187 | -0.3535 | -0.1923 | 0.0568 | -0.2376 |
| 57 | 62.0 | -0.2691 | -0.2648 | 0.0637 | -0.0178 | -0.2502 | -0.3104 | 0.0586 | -0.1370 |
| 58 | 64.0 | -0.1837 | -0.3677 | 0.0657 | 0.0744 | -0.1605 | -0.4190 | 0.0601 | -0.0446 |
| 59 | 66.0 | -0.0966 | -0.4625 | 0.0677 | 0.1608 | -0.0814 | -0.5197 | 0.0615 | 0.0409 |
| 60 | 68.0 | -0.0226 | -0.5513 | 0.0695 | 0.2406 | -0.0032 | -0.6134 | 0.0630 | 0.1209 |
| 61 | 70.0 | 0.0535 | -0.6345 | 0.0712 | 0.3160 | 0.0762 | -0.7012 | 0.0646 | 0.1961 |
| 62 | 72.0 | 0.7978 | -1.1271 | 0.0668 | 0.8937 | 0.9011 | -1.3388 | 0.0580 | 0.9120 |
| 63 | 74.0 | 1.4565 | -1.7519 | 0.0642 | 1.5396 | 1.4869 | -1.8781 | 0.0569 | 1.4603 |
| 64 | 76.0 | 1.8380 | -2.1358 | 0.0668 | 1.9013 | 1.9059 | -2.3030 | 0.0577 | 1.8710 |
| 65 | 78.0 | 2.1839 | -2.4922 | 0.0684 | 2.2465 | 2.2270 | -2.6465 | 0.0596 | 2.1925 |
| 66 | 80.0 | 2.4166 | -2.7620 | 0.0713 | 2.4872 | 2.4832 | -2.9288 | 0.0617 | 2.4517 |
| 67 | 82.0 | 3.3177 | -3.4097 | 0.0675 | 3.2143 | 3.4508 | -3.7170 | 0.0560 | 3.3085 |
| 68 | 84.0 | 4.0615 | -4.1484 | 0.0659 | 3.9584 | 4.1435 | -4.3699 | 0.0558 | 3.9629 |
| 69 | 86.0 | 4.5326 | -4.6170 | 0.0688 | 4.4016 | 4.6413 | -4.8773 | 0.0575 | 4.4508 |
| 70 | 88.0 | 4.9167 | -5.0326 | 0.0707 | 4.7966 | 5.0172 | -5.2772 | 0.0599 | 4.8254 |
| 71 | 90.0 | 5.1931 | -5.3382 | 0.0737 | 5.0730 | 5.3100 | -5.5942 | 0.0622 | 5.1178 |
| 72 | 92.0 | 5.4207 | -5.5905 | 0.0757 | 5.3076 | 5.5416 | -5.8449 | 0.0644 | 5.3465 |
| 73 | 94.0 | 5.5854 | -5.7805 | 0.0777 | 5.4767 | 5.7168 | -6.0392 | 0.0661 | 5.5227 |
| 74 | 96.0 | 5.7157 | -5.9253 | 0.0791 | 5.6108 | 5.8459 | -6.1850 | 0.0675 | 5.6546 |
| 75 | 98.0 | 5.8039 | -6.0297 | 0.0800 | 5.7029 | 5.9411 | -6.2905 | 0.0684 | 5.7500 |
| 76 | 100.0 | 5.8669 | -6.0991 | 0.0804 | 5.7676 | 6.0094 | -6.3625 | 0.0689 | 5.8145 |
| 77 | 102.0 | 5.2222 | -5.7266 | 0.0865 | 5.2968 | 5.2986 | -5.8517 | 0.0769 | 5.2083 |
| 78 | 104.0 | 4.6466 | -5.1920 | 0.0903 | 4.7338 | 4.8018 | -5.4101 | 0.0788 | 4.7440 |
| 79 | 106.0 | 4.3196 | -4.8752 | 0.0887 | 4.4316 | 4.4477 | -5.0577 | 0.0785 | 4.3954 |
| 80 | 108.0 | 4.0165 | -4.5639 | 0.0877 | 4.1283 | 4.1639 | -4.7654 | 0.0768 | 4.1169 |
| 81 | 110.0 | 3.8056 | -4.3227 | 0.0851 | 3.9129 | 3.9163 | -4.5168 | 0.0745 | 3.8840 |
| 82 | 115.0 | 2.7642 | -3.4002 | 0.0835 | 2.9705 | 2.8406 | -3.5345 | 0.0702 | 2.9094 |
| 83 | 120.0 | 2.1944 | -2.7222 | 0.0770 | 2.3570 | 2.3096 | -2.9275 | 0.0641 | 2.3519 |
| 84 | 125.0 | 1.8703 | -2.3742 | 0.0709 | 2.0444 | 1.9891 | -2.5229 | 0.0597 | 1.9900 |
| 85 | 130.0 | 1.6227 | -2.0732 | 0.0672 | 1.7716 | 1.7226 | -2.2551 | 0.0556 | 1.7499 |
| 86 | 135.0 | 1.4816 | -1.9260 | 0.0639 | 1.6403 | 1.5381 | -2.0751 | 0.0533 | 1.5898 |
| 87 | 140.0 | 1.3765 | -1.7946 | 0.0624 | 1.5202 | 1.4739 | -1.9578 | 0.0522 | 1.4868 |
| 88 | 145.0 | 1.3170 | -1.7359 | 0.0608 | 1.4685 | 1.4456 | -1.8809 | 0.0518 | 1.4191 |
| 89 | 150.0 | 1.2745 | -1.6789 | 0.0603 | 1.4159 | 1.3673 | -1.8324 | 0.0502 | 1.3710 |
| 90 | 155.0 | 1.2505 | -1.6588 | 0.0595 | 1.3987 | 1.3064 | -1.8022 | 0.0489 | 1.3387 |
| 91 | 160.0 | 1.2360 | -1.6360 | 0.0595 | 1.3772 | 1.3243 | -1.7849 | 0.0488 | 1.3215 |
| 92 | 170.0 | 2.1429 | -2.3570 | 0.0539 | 2.1631 | 2.1415 | -2.5213 | 0.0458 | 2.0720 |
| 93 | 180.0 | 2.2598 | -2.6040 | 0.0582 | 2.3465 | 2.3247 | -2.7280 | 0.0470 | 2.2562 |
| 94 | 190.0 | 2.2456 | -2.5442 | 0.0574 | 2.3008 | 2.3313 | -2.7401 | 0.0459 | 2.2627 |
| 95 | 200.0 | 2.2086 | -2.5234 | 0.0550 | 2.2833 | 2.2620 | -2.6665 | 0.0435 | 2.1931 |
| 96 | 210.0 | 2.0704 | -2.3558 | 0.0530 | 2.1271 | 2.2043 | -2.5578 | 0.0416 | 2.0966 |
| 97 | 220.0 | 1.9976 | -2.2787 | 0.0498 | 2.0632 | 2.0390 | -2.4349 | 0.0380 | 1.9823 |
| 98 | 230.0 | 1.8565 | -2.1156 | 0.0476 | 1.9097 | 1.9108 | -2.3105 | 0.0351 | 1.8690 |
| 99 | 240.0 | 1.7775 | -2.0263 | 0.0444 | 1.8352 | 1.8524 | -2.1895 | 0.0332 | 1.7625 |
| 100 | 250.0 | 1.6506 | -1.8823 | 0.0424 | 1.6993 | 1.7782 | -2.0723 | 0.0311 | 1.6583 |
| 101 | 260.0 | 1.5745 | -1.7941 | 0.0395 | 1.6250 | 1.6310 | -1.9592 | 0.0279 | 1.5533 |
| 102 | 270.0 | 1.4620 | -1.6687 | 0.0376 | 1.5064 | 1.5075 | -1.8511 | 0.0250 | 1.4540 |
| 103 | 280.0 | 1.3920 | -1.5853 | 0.0350 | 1.4359 | 1.4559 | -1.7488 | 0.0234 | 1.3637 |
| 104 | 290.0 | 1.2926 | -1.4765 | 0.0333 | 1.3325 | 1.3994 | -1.6517 | 0.0217 | 1.2776 |
| 105 | 300.0 | 1.2292 | -1.3991 | 0.0310 | 1.2674 | 1.2900 | -1.5598 | 0.0192 | 1.1929 |

表 7. 3 (3) 評価断面 3 の応力テンソル成分 3

F I N A S 解と簡易計算値との比較 (ホットショック)

断面 3 の応力成分 3

| ステップ | 時間(S) | F I N A S 解 | | | | 簡易計算値 | | | |
|------|-------|-------------|--------|---------|---------|---------|--------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.6103 | 0.2200 | 0.0299 | -0.3318 | -0.7138 | 0.2693 | 0.0364 | -0.4176 |
| 3 | 1.0 | -1.3802 | 0.6855 | 0.0927 | -0.9393 | -1.4263 | 0.7248 | 0.0985 | -0.9900 |
| 4 | 1.5 | -1.9734 | 1.1438 | 0.1584 | -1.4719 | -2.0493 | 1.1719 | 0.1651 | -1.5207 |
| 5 | 2.0 | -2.5211 | 1.5451 | 0.2204 | -1.9402 | -2.5797 | 1.5768 | 0.2269 | -1.9883 |
| 6 | 2.5 | -2.9669 | 1.9024 | 0.2728 | -2.3460 | -3.0403 | 1.9352 | 0.2794 | -2.3970 |
| 7 | 3.0 | -3.3762 | 2.2143 | 0.3148 | -2.7022 | -3.4491 | 2.2498 | 0.3221 | -2.7549 |
| 8 | 3.5 | -3.7210 | 2.4862 | 0.3467 | -3.0133 | -3.8108 | 2.5247 | 0.3547 | -3.0695 |
| 9 | 4.0 | -4.0396 | 2.7244 | 0.3696 | -3.2882 | -4.1264 | 2.7646 | 0.3785 | -3.3468 |
| 10 | 4.5 | -4.3133 | 2.9322 | 0.3846 | -3.5306 | -4.4084 | 2.9738 | 0.3943 | -3.5923 |
| 11 | 5.0 | -4.5680 | 3.1151 | 0.3930 | -3.7466 | -4.6666 | 3.1584 | 0.4035 | -3.8110 |
| 12 | 5.5 | -4.7906 | 3.2756 | 0.3961 | -3.9391 | -4.8970 | 3.3217 | 0.4073 | -4.0067 |
| 13 | 6.0 | -4.9990 | 3.4178 | 0.3949 | -4.1121 | -5.1060 | 3.4664 | 0.4068 | -4.1825 |
| 14 | 6.5 | -5.1826 | 3.5443 | 0.3904 | -4.2676 | -5.2963 | 3.5951 | 0.4031 | -4.3410 |
| 15 | 7.0 | -5.3555 | 3.6574 | 0.3835 | -4.4085 | -5.4696 | 3.7105 | 0.3970 | -4.4844 |
| 16 | 7.5 | -5.5089 | 3.7591 | 0.3747 | -4.5363 | -5.6277 | 3.8143 | 0.3890 | -4.6147 |
| 17 | 8.0 | -5.6544 | 3.8507 | 0.3646 | -4.6529 | -5.7724 | 3.9080 | 0.3798 | -4.7336 |
| 18 | 8.5 | -5.7841 | 3.9335 | 0.3537 | -4.7593 | -5.9048 | 3.9934 | 0.3698 | -4.8424 |
| 19 | 9.0 | -5.9073 | 4.0090 | 0.3423 | -4.8569 | -6.0268 | 4.0712 | 0.3592 | -4.9421 |
| 20 | 9.5 | -6.0174 | 4.0781 | 0.3306 | -4.9465 | -6.1397 | 4.1422 | 0.3484 | -5.0340 |
| 21 | 10.0 | -6.1225 | 4.1414 | 0.3190 | -5.0291 | -6.2445 | 4.2074 | 0.3375 | -5.1188 |
| 22 | 11.0 | -5.6652 | 3.9551 | 0.2555 | -4.7638 | -5.7603 | 4.0108 | 0.2715 | -4.8302 |
| 23 | 12.0 | -5.1779 | 3.5644 | 0.1657 | -4.3081 | -5.3415 | 3.6860 | 0.1883 | -4.4608 |
| 24 | 13.0 | -4.9209 | 3.3193 | 0.0981 | -4.0589 | -5.0428 | 3.4357 | 0.1229 | -4.1887 |
| 25 | 14.0 | -4.6861 | 3.1331 | 0.0516 | -3.8493 | -4.8215 | 3.2534 | 0.0784 | -3.9889 |
| 26 | 15.0 | -4.5376 | 2.9948 | 0.0245 | -3.7033 | -4.6542 | 3.1204 | 0.0510 | -3.8399 |
| 27 | 16.0 | -4.3984 | 2.8958 | 0.0093 | -3.5869 | -4.5270 | 3.0199 | 0.0357 | -3.7252 |
| 28 | 17.0 | -4.3032 | 2.8166 | 0.0028 | -3.4975 | -4.4251 | 2.9434 | 0.0285 | -3.6353 |
| 29 | 18.0 | -4.2105 | 2.7560 | 0.0009 | -3.4233 | -4.3433 | 2.8833 | 0.0263 | -3.5628 |
| 30 | 19.0 | -4.1438 | 2.7039 | 0.0018 | -3.3623 | -4.2770 | 2.8336 | 0.0271 | -3.5022 |
| 31 | 20.0 | -4.0768 | 2.6594 | 0.0039 | -3.3088 | -4.2202 | 2.7906 | 0.0293 | -3.4503 |
| 32 | 21.0 | -4.0267 | 2.6189 | 0.0061 | -3.2623 | -4.1624 | 2.7524 | 0.0318 | -3.4049 |
| 33 | 22.0 | -3.9754 | 2.5808 | 0.0078 | -3.2197 | -4.1201 | 2.7162 | 0.0336 | -3.3645 |
| 34 | 23.0 | -3.9360 | 2.5447 | 0.0088 | -3.1812 | -4.0829 | 2.6827 | 0.0347 | -3.3275 |
| 35 | 24.0 | -3.8951 | 2.5089 | 0.0088 | -3.1447 | -4.0409 | 2.6499 | 0.0352 | -3.2933 |
| 36 | 25.0 | -3.8629 | 2.4742 | 0.0078 | -3.1108 | -4.0022 | 2.6183 | 0.0349 | -3.2616 |
| 37 | 26.0 | -3.8298 | 2.4392 | 0.0057 | -3.0782 | -3.9758 | 2.5872 | 0.0333 | -3.2323 |
| 38 | 27.0 | -3.8032 | 2.4045 | 0.0025 | -3.0473 | -3.9524 | 2.5558 | 0.0303 | -3.2046 |
| 39 | 28.0 | -3.7753 | 2.3695 | -0.0017 | -3.0172 | -3.9223 | 2.5237 | 0.0259 | -3.1779 |
| 40 | 29.0 | -3.7526 | 2.3345 | -0.0068 | -2.9883 | -3.8929 | 2.4915 | 0.0203 | -3.1522 |
| 41 | 30.0 | -3.7289 | 2.2992 | -0.0127 | -2.9601 | -3.8729 | 2.4588 | 0.0134 | -3.1272 |
| 42 | 32.0 | -3.0787 | 1.8892 | -0.0739 | -2.4658 | -3.1582 | 2.0108 | -0.0546 | -2.5862 |
| 43 | 34.0 | -2.6048 | 1.4381 | -0.1415 | -1.9858 | -2.7235 | 1.6403 | -0.1094 | -2.1956 |
| 44 | 36.0 | -2.3842 | 1.2332 | -0.1653 | -1.7850 | -2.4329 | 1.3931 | -0.1343 | -1.9393 |
| 45 | 38.0 | -2.1652 | 1.0363 | -0.1783 | -1.5742 | -2.2206 | 1.2138 | -0.1450 | -1.7569 |
| 46 | 40.0 | -2.0483 | 0.9030 | -0.1880 | -1.4529 | -2.0619 | 1.0704 | -0.1521 | -1.6186 |
| 47 | 42.0 | -1.9250 | 0.7750 | -0.2010 | -1.3290 | -1.9453 | 0.9508 | -0.1605 | -1.5093 |
| 48 | 44.0 | -1.8566 | 0.6662 | -0.2164 | -1.2413 | -1.8668 | 0.8458 | -0.1722 | -1.4201 |
| 49 | 46.0 | -1.7816 | 0.5656 | -0.2356 | -1.1564 | -1.8157 | 0.7508 | -0.1867 | -1.3450 |
| 50 | 48.0 | -1.7414 | 0.4724 | -0.2564 | -1.0894 | -1.7691 | 0.6639 | -0.2036 | -1.2807 |
| 51 | 50.0 | -1.6943 | 0.3877 | -0.2794 | -1.0266 | -1.7211 | 0.5834 | -0.2224 | -1.2245 |
| 52 | 52.0 | -1.6712 | 0.3073 | -0.3031 | -0.9740 | -1.6824 | 0.5086 | -0.2424 | -1.1754 |
| 53 | 54.0 | -1.6413 | 0.2345 | -0.3278 | -0.9253 | -1.6570 | 0.4389 | -0.2633 | -1.1326 |
| 54 | 56.0 | -1.6293 | 0.1642 | -0.3526 | -0.8833 | -1.6418 | 0.3738 | -0.2847 | -1.0949 |

| | | | | | | | | | |
|-----|-------|---------|---------|---------|---------|---------|---------|---------|---------|
| 55 | 58.0 | -1.6103 | 0.0999 | -0.3775 | -0.8443 | -1.6264 | 0.3130 | -0.3058 | -1.0607 |
| 56 | 60.0 | -1.6053 | 0.0382 | -0.4022 | -0.8099 | -1.6092 | 0.2562 | -0.3263 | -1.0298 |
| 57 | 62.0 | -1.5934 | -0.0190 | -0.4286 | -0.7776 | -1.5954 | 0.2036 | -0.3467 | -1.0023 |
| 58 | 64.0 | -1.5926 | -0.0739 | -0.4505 | -0.7487 | -1.5903 | 0.1543 | -0.3671 | -0.9779 |
| 59 | 66.0 | -1.5856 | -0.1253 | -0.4739 | -0.7214 | -1.5918 | 0.1073 | -0.3876 | -0.9558 |
| 60 | 68.0 | -1.5873 | -0.1746 | -0.4968 | -0.6966 | -1.5902 | 0.0625 | -0.4078 | -0.9351 |
| 61 | 70.0 | -1.5834 | -0.2216 | -0.5192 | -0.6731 | -1.5836 | 0.0197 | -0.4276 | -0.9154 |
| 62 | 72.0 | -0.9750 | -0.6059 | -0.5878 | -0.2111 | -0.9224 | -0.4819 | -0.5131 | -0.3388 |
| 63 | 74.0 | -0.5349 | -1.0282 | -0.6597 | 0.2375 | -0.5485 | -0.8158 | -0.5702 | 0.0131 |
| 64 | 76.0 | -0.3475 | -1.2023 | -0.6848 | 0.4075 | -0.3155 | -1.0275 | -0.5955 | 0.2351 |
| 65 | 78.0 | -0.1558 | -1.3661 | -0.6966 | 0.5883 | -0.1568 | -1.1740 | -0.6072 | 0.3864 |
| 66 | 80.0 | -0.0668 | -1.4650 | -0.7030 | 0.6797 | -0.0434 | -1.2840 | -0.6150 | 0.4963 |
| 67 | 82.0 | 0.6455 | -1.8962 | -0.7578 | 1.2146 | 0.7054 | -1.8329 | -0.6887 | 1.1383 |
| 68 | 84.0 | 1.1287 | -2.3466 | -0.8170 | 1.7010 | 1.1445 | -2.2015 | -0.7359 | 1.5385 |
| 69 | 86.0 | 1.3763 | -2.5411 | -0.8323 | 1.9080 | 1.4272 | -2.4372 | -0.7527 | 1.7957 |
| 70 | 88.0 | 1.5877 | -2.7182 | -0.8354 | 2.1085 | 1.6231 | -2.6001 | -0.7573 | 1.9724 |
| 71 | 90.0 | 1.7121 | -2.8225 | -0.8346 | 2.2171 | 1.7655 | -2.7193 | -0.7590 | 2.0993 |
| 72 | 92.0 | 1.8191 | -2.9159 | -0.8357 | 2.3190 | 1.8736 | -2.8118 | -0.7612 | 2.1938 |
| 73 | 94.0 | 1.8846 | -2.9823 | -0.8379 | 2.3823 | 1.9496 | -2.8853 | -0.7651 | 2.2649 |
| 74 | 96.0 | 1.9387 | -3.0365 | -0.8422 | 2.4370 | 2.0019 | -2.9426 | -0.7701 | 2.3177 |
| 75 | 98.0 | 1.9703 | -3.0772 | -0.8470 | 2.4721 | 2.0411 | -2.9870 | -0.7754 | 2.3567 |
| 76 | 100.0 | 1.9945 | -3.1061 | -0.8523 | 2.4990 | 2.0714 | -3.0193 | -0.7807 | 2.3836 |
| 77 | 102.0 | 1.3943 | -2.7873 | -0.8103 | 2.0743 | 1.4322 | -2.5812 | -0.7195 | 1.8428 |
| 78 | 104.0 | 0.9627 | -2.4184 | -0.7638 | 1.6553 | 1.0717 | -2.3005 | -0.6860 | 1.5178 |
| 79 | 106.0 | 0.7704 | -2.2900 | -0.7624 | 1.5061 | 0.8426 | -2.1336 | -0.6834 | 1.3154 |
| 80 | 108.0 | 0.5756 | -2.1622 | -0.7726 | 1.3408 | 0.6736 | -2.0239 | -0.6929 | 1.1774 |
| 81 | 110.0 | 0.4741 | -2.0931 | -0.7863 | 1.2587 | 0.5329 | -1.9436 | -0.7049 | 1.0747 |
| 82 | 115.0 | -0.2368 | -1.6315 | -0.7676 | 0.6910 | -0.1612 | -1.4585 | -0.6781 | 0.5155 |
| 83 | 120.0 | -0.4818 | -1.3795 | -0.7666 | 0.4328 | -0.4078 | -1.2510 | -0.6909 | 0.2828 |
| 84 | 125.0 | -0.6051 | -1.3008 | -0.7800 | 0.3446 | -0.5171 | -1.1183 | -0.6936 | 0.1511 |
| 85 | 130.0 | -0.6893 | -1.1727 | -0.7641 | 0.2311 | -0.6355 | -1.0248 | -0.6898 | 0.0649 |
| 86 | 135.0 | -0.7183 | -1.1287 | -0.7518 | 0.2030 | -0.7150 | -0.9594 | -0.6822 | 0.0097 |
| 87 | 140.0 | -0.7463 | -1.0608 | -0.7361 | 0.1493 | -0.7047 | -0.9115 | -0.6716 | -0.0243 |
| 88 | 145.0 | -0.7490 | -1.0399 | -0.7238 | 0.1432 | -0.6802 | -0.8772 | -0.6610 | -0.0462 |
| 89 | 150.0 | -0.7568 | -1.0038 | -0.7128 | 0.1169 | -0.7215 | -0.8509 | -0.6519 | -0.0654 |
| 90 | 155.0 | -0.7537 | -0.9955 | -0.7044 | 0.1185 | -0.7567 | -0.8308 | -0.6438 | -0.0800 |
| 91 | 160.0 | -0.7543 | -0.9770 | -0.6979 | 0.1055 | -0.7207 | -0.8156 | -0.6353 | -0.0868 |
| 92 | 170.0 | -0.0234 | -1.4465 | -0.7393 | 0.6907 | -0.1251 | -1.2283 | -0.6610 | 0.4081 |
| 93 | 180.0 | -0.0363 | -1.4561 | -0.7019 | 0.7002 | -0.0169 | -1.2795 | -0.6381 | 0.4833 |
| 94 | 190.0 | -0.0044 | -1.4162 | -0.6842 | 0.6853 | 0.0044 | -1.2732 | -0.6250 | 0.4881 |
| 95 | 200.0 | -0.0062 | -1.4333 | -0.6889 | 0.7034 | -0.0025 | -1.2366 | -0.6107 | 0.4663 |
| 96 | 210.0 | -0.0380 | -1.3343 | -0.6586 | 0.6300 | 0.0236 | -1.1878 | -0.5932 | 0.4383 |
| 97 | 220.0 | -0.0270 | -1.3194 | -0.6470 | 0.6364 | -0.0471 | -1.1310 | -0.5738 | 0.4007 |
| 98 | 230.0 | -0.0608 | -1.2232 | -0.6162 | 0.5656 | -0.0778 | -1.0722 | -0.5520 | 0.3652 |
| 99 | 240.0 | -0.0446 | -1.1924 | -0.5956 | 0.5649 | -0.0390 | -1.0137 | -0.5279 | 0.3349 |
| 100 | 250.0 | -0.0726 | -1.1064 | -0.5661 | 0.5036 | -0.0171 | -0.9550 | -0.5029 | 0.3045 |
| 101 | 260.0 | -0.0550 | -1.0701 | -0.5425 | 0.4992 | -0.0702 | -0.8960 | -0.4781 | 0.2704 |
| 102 | 270.0 | -0.0782 | -0.9943 | -0.5149 | 0.4467 | -0.1025 | -0.8386 | -0.4528 | 0.2389 |
| 103 | 280.0 | -0.0605 | -0.9565 | -0.4910 | 0.4402 | -0.0661 | -0.7836 | -0.4268 | 0.2132 |
| 104 | 290.0 | -0.0793 | -0.8901 | -0.4654 | 0.3954 | -0.0385 | -0.7307 | -0.4016 | 0.1885 |
| 105 | 300.0 | -0.0625 | -0.8526 | -0.4424 | 0.3877 | -0.0680 | -0.6797 | -0.3780 | 0.1615 |

表7. 3(4) 評価断面3の応力テンソル成分4

F I N A S解と簡易計算値との比較 (ホットショック)

断面3の応力成分4

| ステップ | 時間(S) | F I N A S解 | | | | 簡易計算値 | | | |
|------|-------|------------|---------|---------|--------|--------|---------|---------|--------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.0040 | -0.0058 | -0.0079 | 0.0075 | 0.0045 | -0.0070 | -0.0090 | 0.0089 |
| 3 | 1.0 | 0.0089 | -0.0187 | -0.0264 | 0.0239 | 0.0092 | -0.0193 | -0.0277 | 0.0255 |
| 4 | 1.5 | 0.0129 | -0.0324 | -0.0480 | 0.0416 | 0.0135 | -0.0326 | -0.0493 | 0.0434 |
| 5 | 2.0 | 0.0165 | -0.0455 | -0.0696 | 0.0585 | 0.0172 | -0.0456 | -0.0709 | 0.0610 |
| 6 | 2.5 | 0.0195 | -0.0578 | -0.0900 | 0.0741 | 0.0204 | -0.0580 | -0.0914 | 0.0774 |
| 7 | 3.0 | 0.0223 | -0.0693 | -0.1088 | 0.0884 | 0.0233 | -0.0695 | -0.1104 | 0.0926 |
| 8 | 3.5 | 0.0248 | -0.0799 | -0.1260 | 0.1014 | 0.0260 | -0.0798 | -0.1278 | 0.1065 |
| 9 | 4.0 | 0.0271 | -0.0899 | -0.1417 | 0.1132 | 0.0282 | -0.0891 | -0.1437 | 0.1190 |
| 10 | 4.5 | 0.0291 | -0.0991 | -0.1561 | 0.1241 | 0.0303 | -0.0977 | -0.1581 | 0.1305 |
| 11 | 5.0 | 0.0311 | -0.1077 | -0.1692 | 0.1342 | 0.0324 | -0.1055 | -0.1714 | 0.1411 |
| 12 | 5.5 | 0.0328 | -0.1157 | -0.1812 | 0.1434 | 0.0342 | -0.1128 | -0.1835 | 0.1508 |
| 13 | 6.0 | 0.0345 | -0.1233 | -0.1923 | 0.1520 | 0.0360 | -0.1197 | -0.1948 | 0.1598 |
| 14 | 6.5 | 0.0360 | -0.1304 | -0.2026 | 0.1600 | 0.0376 | -0.1261 | -0.2052 | 0.1681 |
| 15 | 7.0 | 0.0375 | -0.1370 | -0.2121 | 0.1675 | 0.0392 | -0.1322 | -0.2148 | 0.1759 |
| 16 | 7.5 | 0.0388 | -0.1433 | -0.2210 | 0.1744 | 0.0406 | -0.1376 | -0.2239 | 0.1832 |
| 17 | 8.0 | 0.0401 | -0.1492 | -0.2293 | 0.1809 | 0.0419 | -0.1428 | -0.2324 | 0.1900 |
| 18 | 8.5 | 0.0413 | -0.1548 | -0.2371 | 0.1870 | 0.0431 | -0.1477 | -0.2403 | 0.1964 |
| 19 | 9.0 | 0.0425 | -0.1600 | -0.2444 | 0.1927 | 0.0444 | -0.1523 | -0.2477 | 0.2024 |
| 20 | 9.5 | 0.0435 | -0.1649 | -0.2513 | 0.1981 | 0.0455 | -0.1567 | -0.2549 | 0.2083 |
| 21 | 10.0 | 0.0444 | -0.1696 | -0.2577 | 0.2031 | 0.0466 | -0.1609 | -0.2616 | 0.2141 |
| 22 | 11.0 | 0.0420 | -0.1699 | -0.2578 | 0.2018 | 0.0443 | -0.1604 | -0.2615 | 0.2136 |
| 23 | 12.0 | 0.0393 | -0.1629 | -0.2455 | 0.1911 | 0.0420 | -0.1544 | -0.2512 | 0.2057 |
| 24 | 13.0 | 0.0379 | -0.1577 | -0.2346 | 0.1832 | 0.0403 | -0.1489 | -0.2412 | 0.1984 |
| 25 | 14.0 | 0.0366 | -0.1533 | -0.2261 | 0.1769 | 0.0390 | -0.1451 | -0.2331 | 0.1929 |
| 26 | 15.0 | 0.0356 | -0.1493 | -0.2192 | 0.1718 | 0.0379 | -0.1423 | -0.2267 | 0.1885 |
| 27 | 16.0 | 0.0347 | -0.1460 | -0.2135 | 0.1675 | 0.0368 | -0.1403 | -0.2214 | 0.1852 |
| 28 | 17.0 | 0.0340 | -0.1429 | -0.2085 | 0.1637 | 0.0359 | -0.1389 | -0.2167 | 0.1828 |
| 29 | 18.0 | 0.0333 | -0.1400 | -0.2039 | 0.1603 | 0.0351 | -0.1375 | -0.2124 | 0.1808 |
| 30 | 19.0 | 0.0328 | -0.1372 | -0.1995 | 0.1571 | 0.0343 | -0.1362 | -0.2083 | 0.1792 |
| 31 | 20.0 | 0.0322 | -0.1346 | -0.1951 | 0.1540 | 0.0336 | -0.1348 | -0.2043 | 0.1777 |
| 32 | 21.0 | 0.0318 | -0.1320 | -0.1907 | 0.1511 | 0.0328 | -0.1335 | -0.2002 | 0.1761 |
| 33 | 22.0 | 0.0314 | -0.1295 | -0.1862 | 0.1482 | 0.0321 | -0.1321 | -0.1961 | 0.1746 |
| 34 | 23.0 | 0.0310 | -0.1269 | -0.1817 | 0.1453 | 0.0315 | -0.1306 | -0.1919 | 0.1733 |
| 35 | 24.0 | 0.0307 | -0.1244 | -0.1771 | 0.1426 | 0.0310 | -0.1289 | -0.1876 | 0.1720 |
| 36 | 25.0 | 0.0305 | -0.1220 | -0.1724 | 0.1398 | 0.0305 | -0.1271 | -0.1833 | 0.1707 |
| 37 | 26.0 | 0.0302 | -0.1197 | -0.1677 | 0.1371 | 0.0301 | -0.1250 | -0.1788 | 0.1692 |
| 38 | 27.0 | 0.0300 | -0.1173 | -0.1629 | 0.1345 | 0.0297 | -0.1226 | -0.1744 | 0.1675 |
| 39 | 28.0 | 0.0298 | -0.1150 | -0.1581 | 0.1318 | 0.0293 | -0.1200 | -0.1698 | 0.1656 |
| 40 | 29.0 | 0.0297 | -0.1127 | -0.1533 | 0.1292 | 0.0290 | -0.1175 | -0.1651 | 0.1637 |
| 41 | 30.0 | 0.0296 | -0.1105 | -0.1484 | 0.1267 | 0.0287 | -0.1151 | -0.1604 | 0.1619 |
| 42 | 32.0 | 0.0254 | -0.0962 | -0.1237 | 0.1089 | 0.0239 | -0.0997 | -0.1350 | 0.1443 |
| 43 | 34.0 | 0.0222 | -0.0787 | -0.0923 | 0.0874 | 0.0207 | -0.0848 | -0.1077 | 0.1273 |
| 44 | 36.0 | 0.0206 | -0.0671 | -0.0706 | 0.0739 | 0.0183 | -0.0728 | -0.0857 | 0.1143 |
| 45 | 38.0 | 0.0190 | -0.0561 | -0.0515 | 0.0617 | 0.0163 | -0.0628 | -0.0671 | 0.1040 |
| 46 | 40.0 | 0.0180 | -0.0473 | -0.0347 | 0.0517 | 0.0143 | -0.0536 | -0.0506 | 0.0950 |
| 47 | 42.0 | 0.0171 | -0.0392 | -0.0194 | 0.0428 | 0.0127 | -0.0453 | -0.0356 | 0.0866 |
| 48 | 44.0 | 0.0166 | -0.0322 | -0.0053 | 0.0350 | 0.0113 | -0.0377 | -0.0217 | 0.0791 |
| 49 | 46.0 | 0.0162 | -0.0260 | 0.0076 | 0.0280 | 0.0104 | -0.0308 | -0.0090 | 0.0726 |
| 50 | 48.0 | 0.0160 | -0.0205 | 0.0196 | 0.0218 | 0.0095 | -0.0247 | 0.0026 | 0.0667 |
| 51 | 50.0 | 0.0158 | -0.0156 | 0.0306 | 0.0162 | 0.0087 | -0.0195 | 0.0134 | 0.0613 |
| 52 | 52.0 | 0.0157 | -0.0112 | 0.0407 | 0.0113 | 0.0080 | -0.0146 | 0.0234 | 0.0562 |
| 53 | 54.0 | 0.0157 | -0.0073 | 0.0501 | 0.0068 | 0.0074 | -0.0103 | 0.0326 | 0.0516 |
| 54 | 56.0 | 0.0157 | -0.0038 | 0.0589 | 0.0026 | 0.0070 | -0.0065 | 0.0411 | 0.0474 |

| | | | | | | | | | |
|-----|-------|---------|---------|--------|---------|---------|---------|--------|---------|
| 55 | 58.0 | 0.0158 | -0.0006 | 0.0671 | -0.0011 | 0.0066 | -0.0032 | 0.0489 | 0.0439 |
| 56 | 60.0 | 0.0159 | 0.0023 | 0.0747 | -0.0045 | 0.0062 | -0.0003 | 0.0563 | 0.0407 |
| 57 | 62.0 | 0.0160 | 0.0050 | 0.0819 | -0.0077 | 0.0059 | 0.0026 | 0.0632 | 0.0378 |
| 58 | 64.0 | 0.0161 | 0.0075 | 0.0886 | -0.0106 | 0.0056 | 0.0053 | 0.0698 | 0.0350 |
| 59 | 66.0 | 0.0162 | 0.0098 | 0.0950 | -0.0133 | 0.0054 | 0.0078 | 0.0759 | 0.0325 |
| 60 | 68.0 | 0.0164 | 0.0120 | 0.1010 | -0.0159 | 0.0053 | 0.0100 | 0.0818 | 0.0303 |
| 61 | 70.0 | 0.0165 | 0.0141 | 0.1067 | -0.0183 | 0.0051 | 0.0119 | 0.0873 | 0.0283 |
| 62 | 72.0 | 0.0127 | 0.0259 | 0.1272 | -0.0333 | 0.0006 | 0.0269 | 0.1133 | 0.0089 |
| 63 | 74.0 | 0.0099 | 0.0410 | 0.1539 | -0.0521 | -0.0022 | 0.0396 | 0.1365 | -0.0073 |
| 64 | 76.0 | 0.0085 | 0.0502 | 0.1708 | -0.0628 | -0.0042 | 0.0487 | 0.1541 | -0.0190 |
| 65 | 78.0 | 0.0071 | 0.0587 | 0.1849 | -0.0723 | -0.0057 | 0.0561 | 0.1681 | -0.0280 |
| 66 | 80.0 | 0.0063 | 0.0651 | 0.1965 | -0.0795 | -0.0068 | 0.0620 | 0.1799 | -0.0352 |
| 67 | 82.0 | 0.0016 | 0.0806 | 0.2215 | -0.0984 | -0.0122 | 0.0803 | 0.2108 | -0.0593 |
| 68 | 84.0 | -0.0018 | 0.0985 | 0.2516 | -0.1201 | -0.0156 | 0.0959 | 0.2378 | -0.0790 |
| 69 | 86.0 | -0.0038 | 0.1097 | 0.2709 | -0.1329 | -0.0179 | 0.1073 | 0.2581 | -0.0933 |
| 70 | 88.0 | -0.0055 | 0.1196 | 0.2865 | -0.1438 | -0.0196 | 0.1166 | 0.2738 | -0.1045 |
| 71 | 90.0 | -0.0066 | 0.1270 | 0.2987 | -0.1520 | -0.0210 | 0.1238 | 0.2866 | -0.1136 |
| 72 | 92.0 | -0.0075 | 0.1331 | 0.3087 | -0.1585 | -0.0221 | 0.1301 | 0.2972 | -0.1215 |
| 73 | 94.0 | -0.0081 | 0.1377 | 0.3166 | -0.1635 | -0.0227 | 0.1353 | 0.3056 | -0.1278 |
| 74 | 96.0 | -0.0085 | 0.1413 | 0.3227 | -0.1674 | -0.0232 | 0.1394 | 0.3122 | -0.1327 |
| 75 | 98.0 | -0.0088 | 0.1439 | 0.3273 | -0.1702 | -0.0235 | 0.1426 | 0.3171 | -0.1367 |
| 76 | 100.0 | -0.0090 | 0.1456 | 0.3303 | -0.1721 | -0.0237 | 0.1449 | 0.3206 | -0.1399 |
| 77 | 102.0 | -0.0051 | 0.1368 | 0.3173 | -0.1605 | -0.0193 | 0.1336 | 0.3023 | -0.1249 |
| 78 | 104.0 | -0.0021 | 0.1241 | 0.2965 | -0.1443 | -0.0167 | 0.1239 | 0.2853 | -0.1124 |
| 79 | 106.0 | -0.0006 | 0.1167 | 0.2843 | -0.1357 | -0.0147 | 0.1170 | 0.2729 | -0.1037 |
| 80 | 108.0 | 0.0010 | 0.1095 | 0.2739 | -0.1276 | -0.0131 | 0.1110 | 0.2628 | -0.0968 |
| 81 | 110.0 | 0.0020 | 0.1039 | 0.2651 | -0.1213 | -0.0116 | 0.1060 | 0.2540 | -0.0911 |
| 82 | 115.0 | 0.0072 | 0.0820 | 0.2304 | -0.0958 | -0.0060 | 0.0834 | 0.2155 | -0.0638 |
| 83 | 120.0 | 0.0094 | 0.0659 | 0.2027 | -0.0774 | -0.0033 | 0.0687 | 0.1918 | -0.0478 |
| 84 | 125.0 | 0.0105 | 0.0576 | 0.1883 | -0.0689 | -0.0017 | 0.0579 | 0.1745 | -0.0359 |
| 85 | 130.0 | 0.0111 | 0.0504 | 0.1742 | -0.0605 | -0.0004 | 0.0507 | 0.1621 | -0.0276 |
| 86 | 135.0 | 0.0112 | 0.0468 | 0.1662 | -0.0567 | 0.0005 | 0.0454 | 0.1529 | -0.0207 |
| 87 | 140.0 | 0.0114 | 0.0436 | 0.1594 | -0.0530 | 0.0006 | 0.0425 | 0.1466 | -0.0161 |
| 88 | 145.0 | 0.0113 | 0.0422 | 0.1554 | -0.0513 | 0.0005 | 0.0405 | 0.1419 | -0.0124 |
| 89 | 150.0 | 0.0113 | 0.0408 | 0.1522 | -0.0498 | 0.0006 | 0.0394 | 0.1386 | -0.0098 |
| 90 | 155.0 | 0.0112 | 0.0403 | 0.1504 | -0.0491 | 0.0005 | 0.0387 | 0.1362 | -0.0080 |
| 91 | 160.0 | 0.0112 | 0.0397 | 0.1490 | -0.0485 | -0.0001 | 0.0382 | 0.1345 | -0.0067 |
| 92 | 170.0 | 0.0060 | 0.0569 | 0.1746 | -0.0696 | -0.0053 | 0.0547 | 0.1608 | -0.0277 |
| 93 | 180.0 | 0.0055 | 0.0627 | 0.1825 | -0.0753 | -0.0070 | 0.0599 | 0.1669 | -0.0331 |
| 94 | 190.0 | 0.0052 | 0.0614 | 0.1783 | -0.0734 | -0.0075 | 0.0607 | 0.1659 | -0.0339 |
| 95 | 200.0 | 0.0052 | 0.0610 | 0.1769 | -0.0733 | -0.0078 | 0.0591 | 0.1612 | -0.0325 |
| 96 | 210.0 | 0.0052 | 0.0569 | 0.1671 | -0.0682 | -0.0079 | 0.0565 | 0.1547 | -0.0297 |
| 97 | 220.0 | 0.0050 | 0.0552 | 0.1617 | -0.0664 | -0.0076 | 0.0536 | 0.1470 | -0.0263 |
| 98 | 230.0 | 0.0051 | 0.0512 | 0.1520 | -0.0615 | -0.0075 | 0.0506 | 0.1393 | -0.0228 |
| 99 | 240.0 | 0.0048 | 0.0491 | 0.1455 | -0.0592 | -0.0078 | 0.0477 | 0.1317 | -0.0194 |
| 100 | 250.0 | 0.0048 | 0.0456 | 0.1368 | -0.0549 | -0.0081 | 0.0449 | 0.1241 | -0.0161 |
| 101 | 260.0 | 0.0045 | 0.0435 | 0.1301 | -0.0525 | -0.0080 | 0.0422 | 0.1165 | -0.0128 |
| 102 | 270.0 | 0.0044 | 0.0405 | 0.1223 | -0.0488 | -0.0080 | 0.0396 | 0.1092 | -0.0097 |
| 103 | 280.0 | 0.0041 | 0.0385 | 0.1159 | -0.0464 | -0.0083 | 0.0371 | 0.1023 | -0.0068 |
| 104 | 290.0 | 0.0041 | 0.0358 | 0.1090 | -0.0433 | -0.0087 | 0.0347 | 0.0957 | -0.0040 |
| 105 | 300.0 | 0.0038 | 0.0340 | 0.1031 | -0.0410 | -0.0087 | 0.0325 | 0.0893 | -0.0014 |

表7. 4 (1) 評価断面4の応力テンソル成分1

FINAS解と簡易計算値との比較 (ホットショック)

断面4の応力成分1

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|---------|---------|---------|---------|---------|---------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.0501 | -0.0015 | -0.0008 | -0.0054 | -0.0382 | -0.0015 | -0.0003 | -0.0042 |
| 3 | 1.0 | -0.0638 | -0.0050 | 0.0002 | -0.0128 | -0.0627 | -0.0049 | 0.0004 | -0.0128 |
| 4 | 1.5 | -0.0841 | -0.0107 | 0.0024 | -0.0240 | -0.0880 | -0.0116 | 0.0024 | -0.0238 |
| 5 | 2.0 | -0.0996 | -0.0183 | 0.0071 | -0.0356 | -0.1100 | -0.0206 | 0.0062 | -0.0357 |
| 6 | 2.5 | -0.1153 | -0.0276 | 0.0137 | -0.0480 | -0.1316 | -0.0308 | 0.0120 | -0.0482 |
| 7 | 3.0 | -0.1312 | -0.0382 | 0.0223 | -0.0605 | -0.1537 | -0.0417 | 0.0201 | -0.0613 |
| 8 | 3.5 | -0.1455 | -0.0496 | 0.0327 | -0.0730 | -0.1745 | -0.0533 | 0.0296 | -0.0740 |
| 9 | 4.0 | -0.1613 | -0.0616 | 0.0444 | -0.0856 | -0.1961 | -0.0655 | 0.0405 | -0.0869 |
| 10 | 4.5 | -0.1747 | -0.0739 | 0.0576 | -0.0979 | -0.2177 | -0.0780 | 0.0528 | -0.0999 |
| 11 | 5.0 | -0.1905 | -0.0863 | 0.0719 | -0.1103 | -0.2386 | -0.0907 | 0.0664 | -0.1127 |
| 12 | 5.5 | -0.2035 | -0.0988 | 0.0873 | -0.1223 | -0.2594 | -0.1031 | 0.0810 | -0.1256 |
| 13 | 6.0 | -0.2189 | -0.1117 | 0.1035 | -0.1342 | -0.2794 | -0.1158 | 0.0967 | -0.1385 |
| 14 | 6.5 | -0.2314 | -0.1246 | 0.1206 | -0.1457 | -0.2990 | -0.1291 | 0.1133 | -0.1512 |
| 15 | 7.0 | -0.2465 | -0.1373 | 0.1383 | -0.1572 | -0.3176 | -0.1421 | 0.1306 | -0.1639 |
| 16 | 7.5 | -0.2590 | -0.1500 | 0.1569 | -0.1683 | -0.3355 | -0.1549 | 0.1488 | -0.1765 |
| 17 | 8.0 | -0.2736 | -0.1631 | 0.1758 | -0.1793 | -0.3532 | -0.1679 | 0.1677 | -0.1889 |
| 18 | 8.5 | -0.2855 | -0.1757 | 0.1954 | -0.1899 | -0.3713 | -0.1813 | 0.1872 | -0.2010 |
| 19 | 9.0 | -0.3000 | -0.1886 | 0.2154 | -0.2004 | -0.3895 | -0.1947 | 0.2074 | -0.2127 |
| 20 | 9.5 | -0.3118 | -0.2011 | 0.2361 | -0.2106 | -0.4075 | -0.2078 | 0.2282 | -0.2244 |
| 21 | 10.0 | -0.3258 | -0.2138 | 0.2569 | -0.2208 | -0.4253 | -0.2206 | 0.2493 | -0.2359 |
| 22 | 11.0 | -0.3114 | -0.2368 | 0.2998 | -0.2337 | -0.4310 | -0.2434 | 0.2917 | -0.2530 |
| 23 | 12.0 | -0.3285 | -0.2553 | 0.3405 | -0.2418 | -0.4416 | -0.2597 | 0.3326 | -0.2641 |
| 24 | 13.0 | -0.3315 | -0.2705 | 0.3788 | -0.2468 | -0.4551 | -0.2743 | 0.3704 | -0.2731 |
| 25 | 14.0 | -0.3440 | -0.2833 | 0.4140 | -0.2521 | -0.4681 | -0.2881 | 0.4055 | -0.2810 |
| 26 | 15.0 | -0.3497 | -0.2955 | 0.4478 | -0.2562 | -0.4796 | -0.3013 | 0.4390 | -0.2879 |
| 27 | 16.0 | -0.3611 | -0.3073 | 0.4799 | -0.2608 | -0.4919 | -0.3149 | 0.4715 | -0.2943 |
| 28 | 17.0 | -0.3683 | -0.3186 | 0.5114 | -0.2649 | -0.5055 | -0.3271 | 0.5034 | -0.3006 |
| 29 | 18.0 | -0.3785 | -0.3300 | 0.5420 | -0.2692 | -0.5197 | -0.3384 | 0.5343 | -0.3064 |
| 30 | 19.0 | -0.3863 | -0.3412 | 0.5722 | -0.2732 | -0.5327 | -0.3492 | 0.5645 | -0.3117 |
| 31 | 20.0 | -0.3961 | -0.3522 | 0.6019 | -0.2774 | -0.5447 | -0.3606 | 0.5944 | -0.3165 |
| 32 | 21.0 | -0.4042 | -0.3634 | 0.6313 | -0.2814 | -0.5555 | -0.3723 | 0.6241 | -0.3209 |
| 33 | 22.0 | -0.4140 | -0.3745 | 0.6604 | -0.2855 | -0.5659 | -0.3839 | 0.6539 | -0.3253 |
| 34 | 23.0 | -0.4220 | -0.3855 | 0.6894 | -0.2895 | -0.5759 | -0.3949 | 0.6837 | -0.3299 |
| 35 | 24.0 | -0.4314 | -0.3963 | 0.7181 | -0.2936 | -0.5860 | -0.4054 | 0.7136 | -0.3347 |
| 36 | 25.0 | -0.4394 | -0.4072 | 0.7467 | -0.2976 | -0.5963 | -0.4154 | 0.7434 | -0.3396 |
| 37 | 26.0 | -0.4487 | -0.4180 | 0.7751 | -0.3016 | -0.6061 | -0.4252 | 0.7727 | -0.3444 |
| 38 | 27.0 | -0.4569 | -0.4287 | 0.8033 | -0.3056 | -0.6155 | -0.4356 | 0.8018 | -0.3489 |
| 39 | 28.0 | -0.4659 | -0.4397 | 0.8314 | -0.3095 | -0.6251 | -0.4468 | 0.8308 | -0.3532 |
| 40 | 29.0 | -0.4744 | -0.4502 | 0.8594 | -0.3134 | -0.6351 | -0.4582 | 0.8597 | -0.3574 |
| 41 | 30.0 | -0.4834 | -0.4606 | 0.8873 | -0.3174 | -0.6456 | -0.4695 | 0.8884 | -0.3616 |
| 42 | 32.0 | -0.4708 | -0.4778 | 0.9408 | -0.3169 | -0.6331 | -0.4877 | 0.9435 | -0.3618 |
| 43 | 34.0 | -0.4802 | -0.4885 | 0.9869 | -0.3114 | -0.6298 | -0.4992 | 0.9915 | -0.3574 |
| 44 | 36.0 | -0.4777 | -0.4963 | 1.0264 | -0.3065 | -0.6306 | -0.5093 | 1.0331 | -0.3527 |
| 45 | 38.0 | -0.4843 | -0.5041 | 1.0620 | -0.3028 | -0.6310 | -0.5171 | 1.0708 | -0.3481 |
| 46 | 40.0 | -0.4850 | -0.5122 | 1.0951 | -0.2994 | -0.6284 | -0.5245 | 1.1052 | -0.3440 |
| 47 | 42.0 | -0.4910 | -0.5199 | 1.1259 | -0.2972 | -0.6261 | -0.5322 | 1.1374 | -0.3398 |
| 48 | 44.0 | -0.4932 | -0.5276 | 1.1554 | -0.2952 | -0.6242 | -0.5391 | 1.1680 | -0.3360 |
| 49 | 46.0 | -0.4988 | -0.5351 | 1.1832 | -0.2939 | -0.6225 | -0.5455 | 1.1967 | -0.3327 |
| 50 | 48.0 | -0.5024 | -0.5427 | 1.2099 | -0.2928 | -0.6208 | -0.5521 | 1.2242 | -0.3298 |
| 51 | 50.0 | -0.5078 | -0.5502 | 1.2354 | -0.2923 | -0.6202 | -0.5587 | 1.2511 | -0.3273 |
| 52 | 52.0 | -0.5117 | -0.5574 | 1.2601 | -0.2920 | -0.6199 | -0.5647 | 1.2774 | -0.3251 |
| 53 | 54.0 | -0.5171 | -0.5647 | 1.2837 | -0.2921 | -0.6186 | -0.5706 | 1.3033 | -0.3229 |
| 54 | 56.0 | -0.5216 | -0.5719 | 1.3066 | -0.2922 | -0.6165 | -0.5760 | 1.3288 | -0.3207 |

| | | | | | | | | | |
|-----|-------|---------|---------|--------|---------|---------|---------|--------|---------|
| 55 | 58.0 | -0.5268 | -0.5788 | 1.3287 | -0.2927 | -0.6158 | -0.5808 | 1.3533 | -0.3190 |
| 56 | 60.0 | -0.5314 | -0.5859 | 1.3501 | -0.2932 | -0.6167 | -0.5849 | 1.3770 | -0.3180 |
| 57 | 62.0 | -0.5361 | -0.5926 | 1.3709 | -0.2939 | -0.6184 | -0.5887 | 1.3997 | -0.3172 |
| 58 | 64.0 | -0.5408 | -0.5993 | 1.3910 | -0.2947 | -0.6204 | -0.5925 | 1.4215 | -0.3163 |
| 59 | 66.0 | -0.5459 | -0.6058 | 1.4106 | -0.2956 | -0.6221 | -0.5966 | 1.4424 | -0.3154 |
| 60 | 68.0 | -0.5506 | -0.6124 | 1.4297 | -0.2965 | -0.6226 | -0.6008 | 1.4628 | -0.3144 |
| 61 | 70.0 | -0.5551 | -0.6187 | 1.4483 | -0.2976 | -0.6220 | -0.6051 | 1.4828 | -0.3135 |
| 62 | 72.0 | -0.5302 | -0.6208 | 1.4645 | -0.2905 | -0.5993 | -0.6037 | 1.5012 | -0.3027 |
| 63 | 74.0 | -0.5269 | -0.6165 | 1.4734 | -0.2786 | -0.5815 | -0.5962 | 1.5117 | -0.2896 |
| 64 | 76.0 | -0.5121 | -0.6092 | 1.4759 | -0.2674 | -0.5633 | -0.5869 | 1.5165 | -0.2766 |
| 65 | 78.0 | -0.5063 | -0.6026 | 1.4744 | -0.2575 | -0.5491 | -0.5777 | 1.5170 | -0.2644 |
| 66 | 80.0 | -0.4951 | -0.5957 | 1.4708 | -0.2481 | -0.5354 | -0.5683 | 1.5142 | -0.2540 |
| 67 | 82.0 | -0.4592 | -0.5845 | 1.4632 | -0.2317 | -0.4994 | -0.5549 | 1.5086 | -0.2340 |
| 68 | 84.0 | -0.4420 | -0.5672 | 1.4474 | -0.2108 | -0.4658 | -0.5359 | 1.4940 | -0.2121 |
| 69 | 86.0 | -0.4167 | -0.5475 | 1.4242 | -0.1915 | -0.4305 | -0.5153 | 1.4729 | -0.1905 |
| 70 | 88.0 | -0.3986 | -0.5278 | 1.3966 | -0.1739 | -0.3971 | -0.4950 | 1.4466 | -0.1691 |
| 71 | 90.0 | -0.3768 | -0.5086 | 1.3663 | -0.1572 | -0.3629 | -0.4736 | 1.4167 | -0.1494 |
| 72 | 92.0 | -0.3591 | -0.4893 | 1.3336 | -0.1423 | -0.3288 | -0.4528 | 1.3852 | -0.1302 |
| 73 | 94.0 | -0.3394 | -0.4704 | 1.2992 | -0.1281 | -0.2949 | -0.4322 | 1.3524 | -0.1124 |
| 74 | 96.0 | -0.3225 | -0.4517 | 1.2633 | -0.1150 | -0.2628 | -0.4113 | 1.3182 | -0.0960 |
| 75 | 98.0 | -0.3038 | -0.4332 | 1.2264 | -0.1025 | -0.2311 | -0.3914 | 1.2826 | -0.0805 |
| 76 | 100.0 | -0.2877 | -0.4149 | 1.1885 | -0.0910 | -0.2000 | -0.3713 | 1.2460 | -0.0668 |
| 77 | 102.0 | -0.2999 | -0.4009 | 1.1517 | -0.0880 | -0.1924 | -0.3562 | 1.2102 | -0.0639 |
| 78 | 104.0 | -0.2925 | -0.3935 | 1.1212 | -0.0909 | -0.1818 | -0.3470 | 1.1813 | -0.0640 |
| 79 | 106.0 | -0.2948 | -0.3886 | 1.0963 | -0.0933 | -0.1737 | -0.3392 | 1.1570 | -0.0648 |
| 80 | 108.0 | -0.2898 | -0.3838 | 1.0746 | -0.0950 | -0.1641 | -0.3315 | 1.1361 | -0.0659 |
| 81 | 110.0 | -0.2898 | -0.3790 | 1.0544 | -0.0965 | -0.1564 | -0.3239 | 1.1177 | -0.0668 |
| 82 | 115.0 | -0.3028 | -0.3746 | 1.0157 | -0.1080 | -0.1635 | -0.3144 | 1.0822 | -0.0825 |
| 83 | 120.0 | -0.3051 | -0.3766 | 0.9942 | -0.1206 | -0.1633 | -0.3071 | 1.0627 | -0.0989 |
| 84 | 125.0 | -0.3112 | -0.3773 | 0.9809 | -0.1276 | -0.1648 | -0.3001 | 1.0502 | -0.1134 |
| 85 | 130.0 | -0.3118 | -0.3774 | 0.9712 | -0.1335 | -0.1664 | -0.2959 | 1.0431 | -0.1235 |
| 86 | 135.0 | -0.3153 | -0.3782 | 0.9653 | -0.1373 | -0.1650 | -0.2949 | 1.0391 | -0.1313 |
| 87 | 140.0 | -0.3157 | -0.3785 | 0.9617 | -0.1404 | -0.1575 | -0.2962 | 1.0377 | -0.1384 |
| 88 | 145.0 | -0.3180 | -0.3791 | 0.9601 | -0.1426 | -0.1454 | -0.2983 | 1.0379 | -0.1446 |
| 89 | 150.0 | -0.3185 | -0.3799 | 0.9597 | -0.1442 | -0.1381 | -0.2987 | 1.0402 | -0.1495 |
| 90 | 155.0 | -0.3207 | -0.3811 | 0.9604 | -0.1456 | -0.1289 | -0.2981 | 1.0440 | -0.1527 |
| 91 | 160.0 | -0.3214 | -0.3821 | 0.9618 | -0.1467 | -0.1178 | -0.2983 | 1.0485 | -0.1546 |
| 92 | 170.0 | -0.2884 | -0.3656 | 0.9441 | -0.1277 | -0.0787 | -0.2709 | 1.0315 | -0.1295 |
| 93 | 180.0 | -0.2724 | -0.3396 | 0.8990 | -0.1094 | -0.0552 | -0.2444 | 0.9917 | -0.1056 |
| 94 | 190.0 | -0.2496 | -0.3207 | 0.8527 | -0.1001 | -0.0435 | -0.2235 | 0.9475 | -0.0904 |
| 95 | 200.0 | -0.2368 | -0.3002 | 0.8055 | -0.0899 | -0.0419 | -0.2052 | 0.9026 | -0.0817 |
| 96 | 210.0 | -0.2180 | -0.2820 | 0.7581 | -0.0831 | -0.0358 | -0.1878 | 0.8596 | -0.0745 |
| 97 | 220.0 | -0.2064 | -0.2641 | 0.7132 | -0.0759 | -0.0372 | -0.1655 | 0.8184 | -0.0699 |
| 98 | 230.0 | -0.1904 | -0.2471 | 0.6696 | -0.0704 | -0.0350 | -0.1426 | 0.7783 | -0.0647 |
| 99 | 240.0 | -0.1801 | -0.2315 | 0.6287 | -0.0647 | -0.0226 | -0.1209 | 0.7406 | -0.0584 |
| 100 | 250.0 | -0.1663 | -0.2169 | 0.5896 | -0.0599 | -0.0109 | -0.1020 | 0.7065 | -0.0555 |
| 101 | 260.0 | -0.1571 | -0.2032 | 0.5531 | -0.0553 | -0.0126 | -0.0868 | 0.6743 | -0.0568 |
| 102 | 270.0 | -0.1452 | -0.1900 | 0.5186 | -0.0512 | -0.0142 | -0.0747 | 0.6414 | -0.0578 |
| 103 | 280.0 | -0.1371 | -0.1782 | 0.4862 | -0.0473 | -0.0063 | -0.0655 | 0.6080 | -0.0565 |
| 104 | 290.0 | -0.1267 | -0.1667 | 0.4558 | -0.0438 | 0.0037 | -0.0572 | 0.5759 | -0.0531 |
| 105 | 300.0 | -0.1196 | -0.1558 | 0.4273 | -0.0406 | 0.0071 | -0.0490 | 0.5456 | -0.0494 |

表7. 4 (2) 評価断面4の応力テンソル成分2

FINAS解と簡易計算値との比較 (ホットショック)

断面4の応力成分2

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|----------|---------|---------|----------|----------|---------|---------|----------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.8216 | 0.1546 | -0.0066 | -0.2915 | -0.9409 | 0.1656 | -0.0074 | -0.3268 |
| 3 | 1.0 | -2.1214 | 0.5553 | -0.0199 | -0.9821 | -2.1853 | 0.5655 | -0.0206 | -1.0134 |
| 4 | 1.5 | -3.4541 | 1.1284 | -0.0360 | -1.8777 | -3.5511 | 1.1429 | -0.0371 | -1.9116 |
| 5 | 2.0 | -4.8938 | 1.8362 | -0.0539 | -2.9139 | -4.9764 | 1.8520 | -0.0553 | -2.9454 |
| 6 | 2.5 | -6.3349 | 2.6399 | -0.0727 | -4.0372 | -6.4368 | 2.6555 | -0.0747 | -4.0681 |
| 7 | 3.0 | -7.8186 | 3.5122 | -0.0921 | -5.2205 | -7.9170 | 3.5260 | -0.0947 | -5.2493 |
| 8 | 3.5 | -9.2911 | 4.4328 | -0.1118 | -6.4411 | -9.4054 | 4.4449 | -0.1151 | -6.4686 |
| 9 | 4.0 | -10.7807 | 5.3890 | -0.1317 | -7.6870 | -10.8950 | 5.3996 | -0.1356 | -7.7125 |
| 10 | 4.5 | -12.2530 | 6.3702 | -0.1516 | -8.9473 | -12.3820 | 6.3800 | -0.1561 | -8.9715 |
| 11 | 5.0 | -13.7306 | 7.3705 | -0.1715 | -10.2166 | -13.8620 | 7.3795 | -0.1767 | -10.2390 |
| 12 | 5.5 | -15.1882 | 8.3847 | -0.1912 | -11.4897 | -15.3340 | 8.3923 | -0.1971 | -11.5110 |
| 13 | 6.0 | -16.6452 | 9.4091 | -0.2109 | -12.7642 | -16.7960 | 9.4151 | -0.2173 | -12.7840 |
| 14 | 6.5 | -18.0824 | 10.4412 | -0.2304 | -14.0372 | -18.2450 | 10.4460 | -0.2374 | -14.0560 |
| 15 | 7.0 | -19.5155 | 11.4793 | -0.2498 | -15.3076 | -19.6810 | 11.4820 | -0.2572 | -15.3250 |
| 16 | 7.5 | -20.9292 | 12.5217 | -0.2689 | -16.5741 | -21.1030 | 12.5220 | -0.2769 | -16.5910 |
| 17 | 8.0 | -22.3372 | 13.5672 | -0.2880 | -17.8363 | -22.5130 | 13.5660 | -0.2962 | -17.8520 |
| 18 | 8.5 | -23.7270 | 14.6154 | -0.3068 | -19.0934 | -23.9100 | 14.6130 | -0.3155 | -19.1090 |
| 19 | 9.0 | -25.1103 | 15.6651 | -0.3255 | -20.3452 | -25.2950 | 15.6610 | -0.3346 | -20.3610 |
| 20 | 9.5 | -26.4767 | 16.7160 | -0.3440 | -21.5915 | -26.6680 | 16.7120 | -0.3535 | -21.6070 |
| 21 | 10.0 | -27.8363 | 17.7674 | -0.3624 | -22.8322 | -28.0290 | 17.7630 | -0.3722 | -22.8480 |
| 22 | 11.0 | -29.5262 | 19.6079 | -0.3895 | -24.8423 | -29.6760 | 19.5930 | -0.3995 | -24.8330 |
| 23 | 12.0 | -30.6989 | 21.0688 | -0.4078 | -26.2965 | -30.9310 | 21.0570 | -0.4189 | -26.3160 |
| 24 | 13.0 | -31.8642 | 22.3290 | -0.4239 | -27.5620 | -32.0700 | 22.3210 | -0.4356 | -27.5870 |
| 25 | 14.0 | -32.9182 | 23.4788 | -0.4387 | -28.7188 | -33.1530 | 23.4810 | -0.4510 | -28.7560 |
| 26 | 15.0 | -33.9813 | 24.5758 | -0.4531 | -29.8300 | -34.2050 | 24.5820 | -0.4656 | -29.8720 |
| 27 | 16.0 | -35.0034 | 25.6387 | -0.4671 | -30.9108 | -35.2430 | 25.6490 | -0.4799 | -30.9590 |
| 28 | 17.0 | -36.0372 | 26.6807 | -0.4812 | -31.9772 | -36.2730 | 26.6930 | -0.4940 | -32.0280 |
| 29 | 18.0 | -37.0503 | 27.7070 | -0.4951 | -33.0317 | -37.2990 | 27.7200 | -0.5083 | -33.0850 |
| 30 | 19.0 | -38.0735 | 28.7221 | -0.5090 | -34.0796 | -38.3220 | 28.7360 | -0.5225 | -34.1340 |
| 31 | 20.0 | -39.0840 | 29.7276 | -0.5229 | -35.1212 | -39.3430 | 29.7420 | -0.5365 | -35.1770 |
| 32 | 21.0 | -40.1014 | 30.7255 | -0.5369 | -36.1584 | -40.3600 | 30.7390 | -0.5504 | -36.2140 |
| 33 | 22.0 | -41.1099 | 31.7161 | -0.5509 | -37.1909 | -41.3750 | 31.7280 | -0.5640 | -37.2470 |
| 34 | 23.0 | -42.1227 | 32.7007 | -0.5647 | -38.2196 | -42.3860 | 32.7110 | -0.5776 | -38.2760 |
| 35 | 24.0 | -43.1280 | 33.6793 | -0.5786 | -39.2441 | -43.3940 | 33.6880 | -0.5909 | -39.3000 |
| 36 | 25.0 | -44.1358 | 34.6521 | -0.5925 | -40.2649 | -44.3990 | 34.6600 | -0.6042 | -40.3200 |
| 37 | 26.0 | -45.1366 | 35.6197 | -0.6063 | -41.2813 | -45.4010 | 35.6260 | -0.6176 | -41.3350 |
| 38 | 27.0 | -46.1385 | 36.5817 | -0.6201 | -42.2940 | -46.4010 | 36.5870 | -0.6309 | -42.3470 |
| 39 | 28.0 | -47.1339 | 37.5383 | -0.6339 | -43.3021 | -47.3990 | 37.5430 | -0.6441 | -43.3540 |
| 40 | 29.0 | -48.1291 | 38.4903 | -0.6476 | -44.3062 | -48.3940 | 38.4930 | -0.6573 | -44.3560 |
| 41 | 30.0 | -49.1180 | 39.4371 | -0.6613 | -45.3059 | -49.3850 | 39.4390 | -0.6706 | -45.3540 |
| 42 | 32.0 | -49.9416 | 40.8998 | -0.6763 | -46.6376 | -50.1250 | 40.8710 | -0.6841 | -46.6340 |
| 43 | 34.0 | -50.3260 | 41.8486 | -0.6826 | -47.3478 | -50.6010 | 41.8470 | -0.6908 | -47.4120 |
| 44 | 36.0 | -50.8336 | 42.6648 | -0.6897 | -48.0242 | -51.0610 | 42.6810 | -0.6972 | -48.0890 |
| 45 | 38.0 | -51.2900 | 43.4370 | -0.6966 | -48.6715 | -51.5450 | 43.4610 | -0.7042 | -48.7460 |
| 46 | 40.0 | -51.8323 | 44.1820 | -0.7043 | -49.3308 | -52.0580 | 44.2070 | -0.7119 | -49.4010 |
| 47 | 42.0 | -52.3583 | 44.9023 | -0.7122 | -49.9849 | -52.5950 | 44.9280 | -0.7199 | -50.0560 |
| 48 | 44.0 | -52.9363 | 45.6075 | -0.7205 | -50.6446 | -53.1530 | 45.6310 | -0.7276 | -50.7110 |
| 49 | 46.0 | -53.5015 | 46.2946 | -0.7288 | -51.2997 | -53.7240 | 46.3180 | -0.7354 | -51.3640 |
| 50 | 48.0 | -54.0992 | 46.9680 | -0.7373 | -51.9545 | -54.3040 | 46.9920 | -0.7430 | -52.0150 |
| 51 | 50.0 | -54.6826 | 47.6259 | -0.7457 | -52.6026 | -54.8900 | 47.6520 | -0.7503 | -52.6610 |
| 52 | 52.0 | -55.2855 | 48.2712 | -0.7543 | -53.2465 | -55.4790 | 48.3010 | -0.7575 | -53.3010 |
| 53 | 54.0 | -55.8733 | 48.9026 | -0.7628 | -53.8819 | -56.0680 | 48.9360 | -0.7646 | -53.9350 |
| 54 | 56.0 | -56.4726 | 49.5212 | -0.7713 | -54.5106 | -56.6560 | 49.5600 | -0.7717 | -54.5610 |

| | | | | | | | | | |
|-----|-------|----------|---------|---------|----------|----------|---------|---------|----------|
| 55 | 58.0 | -57.0557 | 50.1274 | -0.7796 | -55.1299 | -57.2410 | 50.1710 | -0.7790 | -55.1800 |
| 56 | 60.0 | -57.6453 | 50.7213 | -0.7880 | -55.7410 | -57.8240 | 50.7690 | -0.7867 | -55.7900 |
| 57 | 62.0 | -58.2187 | 51.3036 | -0.7961 | -56.3424 | -58.4040 | 51.3540 | -0.7947 | -56.3910 |
| 58 | 64.0 | -58.7952 | 51.8745 | -0.8043 | -56.9347 | -58.9790 | 51.9280 | -0.8029 | -56.9830 |
| 59 | 66.0 | -59.3561 | 52.4342 | -0.8122 | -57.5172 | -59.5490 | 52.4890 | -0.8113 | -57.5650 |
| 60 | 68.0 | -59.9177 | 52.9831 | -0.8201 | -58.0908 | -60.1100 | 53.0410 | -0.8190 | -58.1380 |
| 61 | 70.0 | -60.4638 | 53.5219 | -0.8278 | -58.6548 | -60.6600 | 53.5830 | -0.8260 | -58.7010 |
| 62 | 72.0 | -59.8633 | 53.6356 | -0.8233 | -58.5559 | -59.8880 | 53.6220 | -0.8173 | -58.4490 |
| 63 | 74.0 | -58.8283 | 53.2461 | -0.8101 | -57.8452 | -58.9390 | 53.2500 | -0.8033 | -57.7920 |
| 64 | 76.0 | -57.9307 | 52.7356 | -0.7979 | -57.1119 | -57.9870 | 52.7590 | -0.7887 | -57.0590 |
| 65 | 78.0 | -56.9898 | 52.1920 | -0.7857 | -56.3609 | -57.0780 | 52.2250 | -0.7750 | -56.3190 |
| 66 | 80.0 | -56.1504 | 51.6343 | -0.7744 | -55.6347 | -56.2130 | 51.6710 | -0.7621 | -55.5900 |
| 67 | 82.0 | -54.1579 | 50.6499 | -0.7512 | -54.2624 | -54.0740 | 50.6100 | -0.7347 | -54.0690 |
| 68 | 84.0 | -51.8145 | 49.1697 | -0.7200 | -52.3070 | -51.7980 | 49.1420 | -0.7028 | -52.1650 |
| 69 | 86.0 | -49.6083 | 47.5724 | -0.6901 | -50.3468 | -49.5580 | 47.5610 | -0.6710 | -50.2050 |
| 70 | 88.0 | -47.4220 | 45.9524 | -0.6608 | -48.3924 | -47.3880 | 45.9480 | -0.6405 | -48.2610 |
| 71 | 90.0 | -45.3372 | 44.3250 | -0.6326 | -46.4787 | -45.2870 | 44.3250 | -0.6112 | -46.3450 |
| 72 | 92.0 | -43.2962 | 42.6952 | -0.6052 | -44.5923 | -43.2500 | 42.7010 | -0.5828 | -44.4610 |
| 73 | 94.0 | -41.3241 | 41.0718 | -0.5785 | -42.7399 | -41.2670 | 41.0800 | -0.5551 | -42.6080 |
| 74 | 96.0 | -39.3918 | 39.4532 | -0.5524 | -40.9135 | -39.3330 | 39.4650 | -0.5282 | -40.7820 |
| 75 | 98.0 | -37.5082 | 37.8443 | -0.5269 | -39.1146 | -37.4410 | 37.8590 | -0.5018 | -38.9840 |
| 76 | 100.0 | -35.6592 | 36.2437 | -0.5019 | -37.3390 | -35.5860 | 36.2610 | -0.4758 | -37.2090 |
| 77 | 102.0 | -34.9934 | 35.0691 | -0.4894 | -36.2404 | -35.0800 | 35.1690 | -0.4653 | -36.2630 |
| 78 | 104.0 | -34.7769 | 34.3986 | -0.4859 | -35.7652 | -34.7750 | 34.4900 | -0.4603 | -35.7360 |
| 79 | 106.0 | -34.4506 | 33.8520 | -0.4816 | -35.3247 | -34.4930 | 33.9340 | -0.4561 | -35.2970 |
| 80 | 108.0 | -34.1800 | 33.3407 | -0.4776 | -34.9122 | -34.1890 | 33.4230 | -0.4514 | -34.8760 |
| 81 | 110.0 | -33.8309 | 32.8477 | -0.4729 | -34.4859 | -33.8620 | 32.9350 | -0.4463 | -34.4540 |
| 82 | 115.0 | -34.2471 | 32.3224 | -0.4757 | -34.3293 | -34.4380 | 32.6130 | -0.4526 | -34.5420 |
| 83 | 120.0 | -34.7737 | 32.3419 | -0.4832 | -34.6456 | -34.8810 | 32.5450 | -0.4575 | -34.7260 |
| 84 | 125.0 | -35.0237 | 32.2952 | -0.4857 | -34.7301 | -35.1880 | 32.5300 | -0.4607 | -34.8660 |
| 85 | 130.0 | -35.2494 | 32.3044 | -0.4885 | -34.8547 | -35.4160 | 32.5430 | -0.4626 | -34.9780 |
| 86 | 135.0 | -35.3929 | 32.3345 | -0.4900 | -34.9374 | -35.5930 | 32.5780 | -0.4640 | -35.0770 |
| 87 | 140.0 | -35.5385 | 32.3826 | -0.4918 | -35.0369 | -35.7360 | 32.6260 | -0.4655 | -35.1740 |
| 88 | 145.0 | -35.6581 | 32.4517 | -0.4932 | -35.1309 | -35.8620 | 32.6880 | -0.4668 | -35.2720 |
| 89 | 150.0 | -35.7855 | 32.5320 | -0.4948 | -35.2374 | -35.9850 | 32.7570 | -0.4674 | -35.3760 |
| 90 | 155.0 | -35.9046 | 32.6240 | -0.4963 | -35.3445 | -36.1010 | 32.8560 | -0.4680 | -35.4850 |
| 91 | 160.0 | -36.0285 | 32.7232 | -0.4979 | -35.4594 | -36.2070 | 32.9510 | -0.4691 | -35.5960 |
| 92 | 170.0 | -33.5874 | 31.3315 | -0.4671 | -33.5908 | -33.5380 | 31.2810 | -0.4326 | -33.4040 |
| 93 | 180.0 | -31.1069 | 29.2072 | -0.4319 | -31.1526 | -31.2280 | 29.4230 | -0.3999 | -31.2590 |
| 94 | 190.0 | -29.2191 | 27.5356 | -0.4070 | -29.3583 | -29.1720 | 27.6290 | -0.3706 | -29.2760 |
| 95 | 200.0 | -27.2599 | 25.7457 | -0.3796 | -27.4010 | -27.2750 | 25.9000 | -0.3433 | -27.4120 |
| 96 | 210.0 | -25.5710 | 24.1486 | -0.3565 | -25.7184 | -25.4970 | 24.2570 | -0.3173 | -25.6610 |
| 97 | 220.0 | -23.8715 | 22.5828 | -0.3329 | -24.0258 | -23.8340 | 22.7080 | -0.2920 | -24.0090 |
| 98 | 230.0 | -22.3674 | 21.1385 | -0.3121 | -22.5055 | -22.2720 | 21.2630 | -0.2673 | -22.4590 |
| 99 | 240.0 | -20.8828 | 19.7683 | -0.2915 | -21.0309 | -20.8010 | 19.9170 | -0.2430 | -21.0090 |
| 100 | 250.0 | -19.5575 | 18.4903 | -0.2730 | -19.6842 | -19.4230 | 18.6500 | -0.2199 | -19.6500 |
| 101 | 260.0 | -18.2614 | 17.2931 | -0.2551 | -18.3986 | -18.1450 | 17.4500 | -0.1989 | -18.3750 |
| 102 | 270.0 | -17.1001 | 16.1724 | -0.2388 | -17.2153 | -16.9520 | 16.3170 | -0.1809 | -17.1770 |
| 103 | 280.0 | -15.9685 | 15.1253 | -0.2232 | -16.0933 | -15.8300 | 15.2540 | -0.1652 | -16.0520 |
| 104 | 290.0 | -14.9522 | 14.1446 | -0.2089 | -15.0566 | -14.7710 | 14.2620 | -0.1504 | -14.9980 |
| 105 | 300.0 | -13.9637 | 13.2292 | -0.1953 | -14.0769 | -13.7800 | 13.3370 | -0.1365 | -14.0150 |

表7. 4 (3) 評価断面4の応力テンソル成分3

FINAS解と簡易計算値との比較 (ホットショック)

断面4の応力成分3

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|----------|---------|---------|----------|----------|---------|---------|----------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.7688 | 0.1205 | 0.0099 | -0.2421 | -0.8837 | 0.1292 | 0.0114 | -0.2728 |
| 3 | 1.0 | -1.9297 | 0.4322 | 0.0369 | -0.8073 | -1.9889 | 0.4407 | 0.0385 | -0.8346 |
| 4 | 1.5 | -3.0588 | 0.8776 | 0.0770 | -1.5248 | -3.1503 | 0.8899 | 0.0789 | -1.5536 |
| 5 | 2.0 | -4.2377 | 1.4263 | 0.1309 | -2.3371 | -4.3149 | 1.4396 | 0.1324 | -2.3635 |
| 6 | 2.5 | -5.3685 | 2.0442 | 0.1971 | -3.1980 | -5.4651 | 2.0566 | 0.1982 | -3.2232 |
| 7 | 3.0 | -6.4970 | 2.7080 | 0.2752 | -4.0844 | -6.5911 | 2.7174 | 0.2759 | -4.1075 |
| 8 | 3.5 | -7.5744 | 3.4001 | 0.3643 | -4.9781 | -7.6857 | 3.4067 | 0.3641 | -4.9995 |
| 9 | 4.0 | -8.6330 | 4.1102 | 0.4633 | -5.8699 | -8.7467 | 4.1134 | 0.4621 | -5.8892 |
| 10 | 4.5 | -9.6424 | 4.8303 | 0.5715 | -6.7526 | -9.7721 | 4.8297 | 0.5693 | -6.7700 |
| 11 | 5.0 | -10.6281 | 5.5559 | 0.6882 | -7.6230 | -10.7630 | 5.5498 | 0.6844 | -7.6377 |
| 12 | 5.5 | -11.5678 | 6.2836 | 0.8129 | -8.4779 | -11.7200 | 6.2723 | 0.8077 | -8.4908 |
| 13 | 6.0 | -12.4827 | 7.0110 | 0.9449 | -9.3168 | -12.6410 | 6.9942 | 0.9384 | -9.3277 |
| 14 | 6.5 | -13.3555 | 7.7370 | 1.0840 | -10.1385 | -13.5290 | 7.7146 | 1.0759 | -10.1480 |
| 15 | 7.0 | -14.2040 | 8.4605 | 1.2293 | -10.9434 | -14.3840 | 8.4329 | 1.2200 | -10.9520 |
| 16 | 7.5 | -15.0144 | 9.1810 | 1.3809 | -11.7312 | -15.2060 | 9.1483 | 1.3702 | -11.7390 |
| 17 | 8.0 | -15.8016 | 9.8982 | 1.5382 | -12.5025 | -15.9980 | 9.8603 | 1.5263 | -12.5100 |
| 18 | 8.5 | -16.5541 | 10.6122 | 1.7012 | -13.2575 | -16.7620 | 10.5690 | 1.6882 | -13.2640 |
| 19 | 9.0 | -17.2849 | 11.3223 | 1.8693 | -13.9969 | -17.4980 | 11.2730 | 1.8555 | -14.0030 |
| 20 | 9.5 | -17.9841 | 12.0287 | 2.0427 | -14.7210 | -18.2080 | 11.9740 | 2.0279 | -14.7270 |
| 21 | 10.0 | -18.6628 | 12.7317 | 2.2209 | -15.4307 | -18.8920 | 12.6710 | 2.2051 | -15.4370 |
| 22 | 11.0 | -19.0450 | 13.9233 | 2.5736 | -16.4375 | -19.2440 | 13.8410 | 2.5542 | -16.4230 |
| 23 | 12.0 | -19.0052 | 14.8097 | 2.9145 | -16.9790 | -19.2910 | 14.7180 | 2.8932 | -16.9900 |
| 24 | 13.0 | -19.0137 | 15.5388 | 3.2480 | -17.3817 | -19.2790 | 15.4400 | 3.2243 | -17.3990 |
| 25 | 14.0 | -18.9541 | 16.1916 | 3.5748 | -17.7153 | -19.2510 | 16.0920 | 3.5499 | -17.7430 |
| 26 | 15.0 | -18.9326 | 16.8173 | 3.8984 | -18.0305 | -19.2200 | 16.7130 | 3.8731 | -18.0620 |
| 27 | 16.0 | -18.8912 | 17.4297 | 4.2200 | -18.3365 | -19.1930 | 17.3210 | 4.1954 | -18.3720 |
| 28 | 17.0 | -18.8763 | 18.0378 | 4.5413 | -18.6437 | -19.1750 | 17.9230 | 4.5169 | -18.6810 |
| 29 | 18.0 | -18.8519 | 18.6446 | 4.8628 | -18.9519 | -19.1650 | 18.5230 | 4.8380 | -18.9910 |
| 30 | 19.0 | -18.8459 | 19.2522 | 5.1854 | -19.2636 | -19.1600 | 19.1250 | 5.1600 | -19.3020 |
| 31 | 20.0 | -18.8340 | 19.8610 | 5.5089 | -19.5778 | -19.1590 | 19.7280 | 5.4833 | -19.6160 |
| 32 | 21.0 | -18.8347 | 20.4714 | 5.8335 | -19.8949 | -19.1620 | 20.3330 | 5.8074 | -19.9330 |
| 33 | 22.0 | -18.8313 | 21.0829 | 6.1592 | -20.2139 | -19.1680 | 20.9380 | 6.1327 | -20.2530 |
| 34 | 23.0 | -18.8370 | 21.6957 | 6.4858 | -20.5352 | -19.1750 | 21.5450 | 6.4588 | -20.5740 |
| 35 | 24.0 | -18.8393 | 22.3092 | 6.8131 | -20.8575 | -19.1840 | 22.1530 | 6.7858 | -20.8970 |
| 36 | 25.0 | -18.8480 | 22.9230 | 7.1411 | -21.1812 | -19.1940 | 22.7600 | 7.1132 | -21.2210 |
| 37 | 26.0 | -18.8540 | 23.5371 | 7.4694 | -21.5054 | -19.2070 | 23.3670 | 7.4406 | -21.5450 |
| 38 | 27.0 | -18.8648 | 24.1506 | 7.7980 | -21.8302 | -19.2200 | 23.9740 | 7.7684 | -21.8700 |
| 39 | 28.0 | -18.8730 | 24.7636 | 8.1267 | -22.1549 | -19.2350 | 24.5800 | 8.0971 | -22.1940 |
| 40 | 29.0 | -18.8850 | 25.3761 | 8.4554 | -22.4796 | -19.2500 | 25.1840 | 8.4257 | -22.5180 |
| 41 | 30.0 | -18.8946 | 25.9874 | 8.7839 | -22.8038 | -19.2660 | 25.7880 | 8.7541 | -22.8410 |
| 42 | 32.0 | -17.9261 | 26.8853 | 9.4081 | -22.9310 | -18.2260 | 26.6450 | 9.3777 | -22.9240 |
| 43 | 34.0 | -16.7566 | 27.4085 | 9.9792 | -22.6317 | -17.1450 | 27.1760 | 9.9495 | -22.6860 |
| 44 | 36.0 | -15.8555 | 27.8704 | 10.5096 | -22.4064 | -16.1990 | 27.6460 | 10.4810 | -22.4610 |
| 45 | 38.0 | -15.0134 | 28.3398 | 11.0077 | -22.2341 | -15.3790 | 28.1120 | 10.9820 | -22.2930 |
| 46 | 40.0 | -14.3395 | 28.8157 | 11.4800 | -22.1316 | -14.6730 | 28.5820 | 11.4570 | -22.1840 |
| 47 | 42.0 | -13.7204 | 29.2928 | 11.9287 | -22.0733 | -14.0640 | 29.0550 | 11.9060 | -22.1240 |
| 48 | 44.0 | -13.2138 | 29.7733 | 12.3561 | -22.0603 | -13.5390 | 29.5290 | 12.3340 | -22.1060 |
| 49 | 46.0 | -12.7489 | 30.2502 | 12.7633 | -22.0777 | -13.0800 | 30.0020 | 12.7410 | -22.1210 |
| 50 | 48.0 | -12.3645 | 30.7244 | 13.1521 | -22.1247 | -12.6820 | 30.4700 | 13.1290 | -22.1630 |
| 51 | 50.0 | -12.0099 | 31.1918 | 13.5232 | -22.1920 | -12.3340 | 30.9330 | 13.5000 | -22.2270 |
| 52 | 52.0 | -11.7142 | 31.6533 | 13.8783 | -22.2784 | -12.0270 | 31.3900 | 13.8560 | -22.3090 |
| 53 | 54.0 | -11.4399 | 32.1067 | 14.2182 | -22.3781 | -11.7560 | 31.8400 | 14.1970 | -22.4040 |
| 54 | 56.0 | -11.2098 | 32.5521 | 14.5444 | -22.4902 | -11.5160 | 32.2840 | 14.5250 | -22.5110 |

| | | | | | | | | | |
|-----|-------|----------|---------|---------|----------|----------|---------|---------|----------|
| 55 | 58.0 | -10.9943 | 32.9890 | 14.8576 | -22.6106 | -11.3030 | 32.7200 | 14.8410 | -22.6270 |
| 56 | 60.0 | -10.8127 | 33.4173 | 15.1589 | -22.7388 | -11.1130 | 33.1480 | 15.1450 | -22.7500 |
| 57 | 62.0 | -10.6406 | 33.8370 | 15.4493 | -22.8719 | -10.9460 | 33.5680 | 15.4380 | -22.8800 |
| 58 | 64.0 | -10.4952 | 34.2482 | 15.7295 | -23.0097 | -10.7990 | 33.9780 | 15.7200 | -23.0140 |
| 59 | 66.0 | -10.3559 | 34.6508 | 16.0003 | -23.1502 | -10.6690 | 34.3800 | 15.9930 | -23.1520 |
| 60 | 68.0 | -10.2375 | 35.0453 | 16.2625 | -23.2935 | -10.5510 | 34.7720 | 16.2570 | -23.2920 |
| 61 | 70.0 | -10.1221 | 35.4321 | 16.5167 | -23.4379 | -10.4440 | 35.1560 | 16.5120 | -23.4340 |
| 62 | 72.0 | -9.0315 | 35.4910 | 16.7321 | -23.0643 | -9.2044 | 35.1480 | 16.7270 | -22.9250 |
| 63 | 74.0 | -7.7440 | 35.1747 | 16.8894 | -22.2678 | -8.0045 | 34.8420 | 16.8850 | -22.1780 |
| 64 | 76.0 | -6.7370 | 34.7980 | 17.0028 | -21.5503 | -6.9464 | 34.4830 | 17.0010 | -21.4610 |
| 65 | 78.0 | -5.7933 | 34.4307 | 17.0814 | -20.8909 | -6.0314 | 34.1220 | 17.0830 | -20.8090 |
| 66 | 80.0 | -5.0284 | 34.0740 | 17.1329 | -20.3069 | -5.2389 | 33.7670 | 17.1360 | -20.2200 |
| 67 | 82.0 | -3.3295 | 33.4025 | 17.1284 | -19.2535 | -3.4101 | 33.0340 | 17.1320 | -19.0350 |
| 68 | 84.0 | -1.5544 | 32.3719 | 17.0516 | -17.8286 | -1.7003 | 32.0150 | 17.0570 | -17.6590 |
| 69 | 86.0 | -0.0911 | 31.2896 | 16.9173 | -16.5190 | -0.2014 | 30.9540 | 16.9260 | -16.3510 |
| 70 | 88.0 | 1.2204 | 30.2280 | 16.7368 | -15.3039 | 1.1009 | 29.9020 | 16.7490 | -15.1420 |
| 71 | 90.0 | 2.3318 | 29.1830 | 16.5185 | -14.1912 | 2.2353 | 28.8650 | 16.5330 | -14.0250 |
| 72 | 92.0 | 3.3172 | 28.1511 | 16.2665 | -13.1552 | 3.2254 | 27.8420 | 16.2840 | -12.9880 |
| 73 | 94.0 | 4.1664 | 27.1333 | 15.9852 | -12.1912 | 4.0923 | 26.8290 | 16.0060 | -12.0200 |
| 74 | 96.0 | 4.9179 | 26.1230 | 15.6770 | -11.2837 | 4.8513 | 25.8250 | 15.7010 | -11.1110 |
| 75 | 98.0 | 5.5726 | 25.1218 | 15.3454 | -10.4279 | 5.5205 | 24.8300 | 15.3720 | -10.2520 |
| 76 | 100.0 | 6.1522 | 24.1257 | 14.9927 | -9.6144 | 6.1110 | 23.8410 | 15.0210 | -9.4388 |
| 77 | 102.0 | 5.6686 | 23.4556 | 14.6530 | -9.3583 | 5.4919 | 23.2430 | 14.6850 | -9.3148 |
| 78 | 104.0 | 4.9288 | 23.1576 | 14.3479 | -9.5574 | 4.8447 | 22.9420 | 14.3830 | -9.4612 |
| 79 | 106.0 | 4.4036 | 22.9179 | 14.0663 | -9.7066 | 4.2798 | 22.6920 | 14.1020 | -9.6076 |
| 80 | 108.0 | 3.8965 | 22.6661 | 13.8014 | -9.8225 | 3.8044 | 22.4420 | 13.8360 | -9.7138 |
| 81 | 110.0 | 3.5173 | 22.4021 | 13.5476 | -9.8849 | 3.4038 | 22.1820 | 13.5830 | -9.7784 |
| 82 | 115.0 | 1.7258 | 22.1991 | 13.0197 | -10.5892 | 1.5069 | 22.1390 | 13.0640 | -10.6740 |
| 83 | 120.0 | 0.3451 | 22.2929 | 12.6374 | -11.3764 | 0.1990 | 22.1520 | 12.6830 | -11.3370 |
| 84 | 125.0 | -0.5015 | 22.2505 | 12.3520 | -11.7683 | -0.7077 | 22.1370 | 12.3980 | -11.7860 |
| 85 | 130.0 | -1.1334 | 22.2272 | 12.1420 | -12.0844 | -1.3407 | 22.1140 | 12.1920 | -12.0910 |
| 86 | 135.0 | -1.5443 | 22.2139 | 11.9946 | -12.2828 | -1.7851 | 22.0960 | 12.0460 | -12.3070 |
| 87 | 140.0 | -1.8512 | 22.2130 | 11.8959 | -12.4406 | -2.0910 | 22.0860 | 11.9480 | -12.4660 |
| 88 | 145.0 | -2.0561 | 22.2334 | 11.8342 | -12.5543 | -2.3066 | 22.0900 | 11.8840 | -12.5890 |
| 89 | 150.0 | -2.2106 | 22.2653 | 11.8006 | -12.6505 | -2.4665 | 22.1140 | 11.8480 | -12.6900 |
| 90 | 155.0 | -2.3164 | 22.3113 | 11.7878 | -12.7277 | -2.5812 | 22.1510 | 11.8310 | -12.7740 |
| 91 | 160.0 | -2.3961 | 22.3657 | 11.7905 | -12.7972 | -2.6565 | 22.1980 | 11.8300 | -12.8460 |
| 92 | 170.0 | -0.6390 | 21.3391 | 11.6228 | -11.4788 | -0.8187 | 20.9570 | 11.6280 | -11.3110 |
| 93 | 180.0 | 0.3882 | 19.9276 | 11.2301 | -10.1562 | 0.0738 | 19.7430 | 11.2370 | -10.2220 |
| 94 | 190.0 | 0.7168 | 18.9070 | 10.7571 | -9.4965 | 0.5202 | 18.5960 | 10.7530 | -9.3948 |
| 95 | 200.0 | 1.0225 | 17.7426 | 10.2298 | -8.7111 | 0.7496 | 17.4900 | 10.2230 | -8.7046 |
| 96 | 210.0 | 1.0785 | 16.7137 | 9.6861 | -8.1593 | 0.8762 | 16.4300 | 9.6816 | -8.0953 |
| 97 | 220.0 | 1.1893 | 15.6796 | 9.1488 | -7.5577 | 0.9262 | 15.4210 | 9.1411 | -7.5407 |
| 98 | 230.0 | 1.1756 | 14.7234 | 8.6263 | -7.0687 | 0.9471 | 14.4650 | 8.6169 | -7.0284 |
| 99 | 240.0 | 1.2169 | 13.8081 | 8.1255 | -6.5711 | 0.9594 | 13.5620 | 8.1157 | -6.5536 |
| 100 | 250.0 | 1.1795 | 12.9496 | 7.6481 | -6.1412 | 0.9581 | 12.7070 | 7.6394 | -6.1175 |
| 101 | 260.0 | 1.1894 | 12.1425 | 7.1952 | -5.7187 | 0.9339 | 11.8950 | 7.1860 | -5.7161 |
| 102 | 270.0 | 1.1420 | 11.3823 | 6.7668 | -5.3431 | 0.9010 | 11.1260 | 6.7534 | -5.3391 |
| 103 | 280.0 | 1.1353 | 10.6711 | 6.3616 | -4.9804 | 0.8699 | 10.3990 | 6.3409 | -4.9838 |
| 104 | 290.0 | 1.0836 | 10.0008 | 5.9796 | -4.6533 | 0.8437 | 9.7151 | 5.9501 | -4.6495 |
| 105 | 300.0 | 1.0676 | 9.3746 | 5.6189 | -4.3400 | 0.8191 | 9.0776 | 5.5826 | -4.3378 |

表7. 4(4) 評価断面4の応力テンソル成分4

F I N A S解と簡易計算値との比較 (ホットショック)

断面4の応力成分4

| ステップ | 時間(S) | F I N A S解 | | | | 簡易計算値 | | | |
|------|-------|------------|--------|---------|--------|--------|--------|---------|--------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.0673 | 0.0025 | -0.0092 | 0.0223 | 0.0787 | 0.0028 | -0.0098 | 0.0254 |
| 3 | 1.0 | 0.1798 | 0.0092 | -0.0328 | 0.0750 | 0.1851 | 0.0093 | -0.0334 | 0.0780 |
| 4 | 1.5 | 0.2943 | 0.0186 | -0.0672 | 0.1420 | 0.3024 | 0.0191 | -0.0678 | 0.1460 |
| 5 | 2.0 | 0.4184 | 0.0303 | -0.1108 | 0.2188 | 0.4248 | 0.0308 | -0.1113 | 0.2231 |
| 6 | 2.5 | 0.5424 | 0.0436 | -0.1620 | 0.3014 | 0.5501 | 0.0443 | -0.1624 | 0.3065 |
| 7 | 3.0 | 0.6700 | 0.0579 | -0.2196 | 0.3881 | 0.6773 | 0.0586 | -0.2199 | 0.3941 |
| 8 | 3.5 | 0.7966 | 0.0730 | -0.2826 | 0.4774 | 0.8054 | 0.0736 | -0.2828 | 0.4847 |
| 9 | 4.0 | 0.9244 | 0.0888 | -0.3502 | 0.5685 | 0.9336 | 0.0894 | -0.3503 | 0.5771 |
| 10 | 4.5 | 1.0508 | 0.1049 | -0.4218 | 0.6607 | 1.0613 | 0.1055 | -0.4219 | 0.6708 |
| 11 | 5.0 | 1.1775 | 0.1215 | -0.4968 | 0.7535 | 1.1886 | 0.1218 | -0.4967 | 0.7651 |
| 12 | 5.5 | 1.3026 | 0.1382 | -0.5748 | 0.8466 | 1.3152 | 0.1388 | -0.5744 | 0.8597 |
| 13 | 6.0 | 1.4274 | 0.1553 | -0.6553 | 0.9397 | 1.4409 | 0.1559 | -0.6547 | 0.9543 |
| 14 | 6.5 | 1.5507 | 0.1724 | -0.7380 | 1.0327 | 1.5655 | 0.1733 | -0.7373 | 1.0489 |
| 15 | 7.0 | 1.6733 | 0.1897 | -0.8227 | 1.1255 | 1.6890 | 0.1907 | -0.8218 | 1.1431 |
| 16 | 7.5 | 1.7945 | 0.2070 | -0.9090 | 1.2179 | 1.8113 | 0.2081 | -0.9080 | 1.2367 |
| 17 | 8.0 | 1.9149 | 0.2245 | -0.9968 | 1.3099 | 1.9325 | 0.2258 | -0.9957 | 1.3299 |
| 18 | 8.5 | 2.0340 | 0.2420 | -1.0860 | 1.4014 | 2.0525 | 0.2437 | -1.0847 | 1.4229 |
| 19 | 9.0 | 2.1522 | 0.2596 | -1.1763 | 1.4926 | 2.1716 | 0.2617 | -1.1750 | 1.5156 |
| 20 | 9.5 | 2.2691 | 0.2771 | -1.2677 | 1.5831 | 2.2896 | 0.2799 | -1.2663 | 1.6078 |
| 21 | 10.0 | 2.3853 | 0.2947 | -1.3599 | 1.6732 | 2.4067 | 0.2982 | -1.3586 | 1.6996 |
| 22 | 11.0 | 2.5313 | 0.3258 | -1.5312 | 1.8172 | 2.5496 | 0.3308 | -1.5294 | 1.8450 |
| 23 | 12.0 | 2.6294 | 0.3505 | -1.6816 | 1.9198 | 2.6572 | 0.3572 | -1.6803 | 1.9531 |
| 24 | 13.0 | 2.7286 | 0.3721 | -1.8192 | 2.0096 | 2.7543 | 0.3804 | -1.8180 | 2.0459 |
| 25 | 14.0 | 2.8173 | 0.3920 | -1.9473 | 2.0914 | 2.8462 | 0.4018 | -1.9467 | 2.1307 |
| 26 | 15.0 | 2.9077 | 0.4111 | -2.0691 | 2.1695 | 2.9357 | 0.4223 | -2.0690 | 2.2114 |
| 27 | 16.0 | 2.9940 | 0.4296 | -2.1861 | 2.2449 | 3.0240 | 0.4419 | -2.1868 | 2.2893 |
| 28 | 17.0 | 3.0817 | 0.4477 | -2.2999 | 2.3190 | 3.1118 | 0.4607 | -2.3010 | 2.3656 |
| 29 | 18.0 | 3.1674 | 0.4656 | -2.4110 | 2.3920 | 3.1993 | 0.4784 | -2.4127 | 2.4408 |
| 30 | 19.0 | 3.2543 | 0.4833 | -2.5204 | 2.4645 | 3.2865 | 0.4956 | -2.5223 | 2.5151 |
| 31 | 20.0 | 3.3399 | 0.5009 | -2.6283 | 2.5364 | 3.3733 | 0.5123 | -2.6306 | 2.5885 |
| 32 | 21.0 | 3.4262 | 0.5183 | -2.7351 | 2.6079 | 3.4599 | 0.5281 | -2.7377 | 2.6615 |
| 33 | 22.0 | 3.5117 | 0.5356 | -2.8411 | 2.6791 | 3.5464 | 0.5435 | -2.8439 | 2.7341 |
| 34 | 23.0 | 3.5977 | 0.5528 | -2.9463 | 2.7500 | 3.6328 | 0.5589 | -2.9494 | 2.8066 |
| 35 | 24.0 | 3.6829 | 0.5698 | -3.0510 | 2.8207 | 3.7190 | 0.5744 | -3.0543 | 2.8786 |
| 36 | 25.0 | 3.7684 | 0.5867 | -3.1552 | 2.8910 | 3.8048 | 0.5900 | -3.1586 | 2.9503 |
| 37 | 26.0 | 3.8533 | 0.6037 | -3.2589 | 2.9612 | 3.8900 | 0.6059 | -3.2625 | 3.0218 |
| 38 | 27.0 | 3.9383 | 0.6204 | -3.3622 | 3.0311 | 3.9747 | 0.6221 | -3.3660 | 3.0929 |
| 39 | 28.0 | 4.0227 | 0.6371 | -3.4652 | 3.1006 | 4.0593 | 0.6388 | -3.4692 | 3.1637 |
| 40 | 29.0 | 4.1071 | 0.6538 | -3.5678 | 3.1699 | 4.1435 | 0.6555 | -3.5720 | 3.2342 |
| 41 | 30.0 | 4.1909 | 0.6703 | -3.6700 | 3.2389 | 4.2275 | 0.6723 | -3.6744 | 3.3045 |
| 42 | 32.0 | 4.2606 | 0.6963 | -3.8477 | 3.3270 | 4.2902 | 0.6987 | -3.8512 | 3.3911 |
| 43 | 34.0 | 4.2904 | 0.7138 | -3.9893 | 3.3704 | 4.3289 | 0.7173 | -3.9940 | 3.4414 |
| 44 | 36.0 | 4.3325 | 0.7290 | -4.1132 | 3.4127 | 4.3661 | 0.7339 | -4.1186 | 3.4839 |
| 45 | 38.0 | 4.3695 | 0.7434 | -4.2263 | 3.4525 | 4.4057 | 0.7489 | -4.2324 | 3.5258 |
| 46 | 40.0 | 4.4147 | 0.7572 | -4.3327 | 3.4938 | 4.4483 | 0.7630 | -4.3390 | 3.5680 |
| 47 | 42.0 | 4.4580 | 0.7706 | -4.4339 | 3.5353 | 4.4932 | 0.7767 | -4.4402 | 3.6100 |
| 48 | 44.0 | 4.5063 | 0.7836 | -4.5313 | 3.5778 | 4.5401 | 0.7904 | -4.5373 | 3.6519 |
| 49 | 46.0 | 4.5532 | 0.7963 | -4.6254 | 3.6204 | 4.5881 | 0.8042 | -4.6312 | 3.6939 |
| 50 | 48.0 | 4.6033 | 0.8086 | -4.7167 | 3.6636 | 4.6370 | 0.8183 | -4.7220 | 3.7361 |
| 51 | 50.0 | 4.6519 | 0.8207 | -4.8052 | 3.7066 | 4.6864 | 0.8329 | -4.8104 | 3.7785 |
| 52 | 52.0 | 4.7025 | 0.8324 | -4.8913 | 3.7497 | 4.7363 | 0.8475 | -4.8963 | 3.8213 |
| 53 | 54.0 | 4.7516 | 0.8438 | -4.9751 | 3.7926 | 4.7864 | 0.8617 | -4.9800 | 3.8645 |
| 54 | 56.0 | 4.8019 | 0.8551 | -5.0566 | 3.8352 | 4.8366 | 0.8751 | -5.0616 | 3.9080 |

| | | | | | | | | | |
|-----|-------|--------|--------|---------|--------|--------|--------|---------|--------|
| 55 | 58.0 | 4.8507 | 0.8661 | -5.1361 | 3.8773 | 4.8869 | 0.8877 | -5.1411 | 3.9512 |
| 56 | 60.0 | 4.9003 | 0.8768 | -5.2135 | 3.9191 | 4.9372 | 0.8994 | -5.2186 | 3.9941 |
| 57 | 62.0 | 4.9484 | 0.8873 | -5.2890 | 3.9603 | 4.9872 | 0.9107 | -5.2942 | 4.0365 |
| 58 | 64.0 | 4.9969 | 0.8976 | -5.3627 | 4.0011 | 5.0365 | 0.9217 | -5.3679 | 4.0787 |
| 59 | 66.0 | 5.0440 | 0.9077 | -5.4346 | 4.0412 | 5.0851 | 0.9325 | -5.4400 | 4.1205 |
| 60 | 68.0 | 5.0912 | 0.9176 | -5.5048 | 4.0808 | 5.1328 | 0.9435 | -5.5104 | 4.1612 |
| 61 | 70.0 | 5.1371 | 0.9273 | -5.5735 | 4.1198 | 5.1794 | 0.9549 | -5.5792 | 4.2007 |
| 62 | 72.0 | 5.0856 | 0.9300 | -5.6149 | 4.1092 | 5.1125 | 0.9581 | -5.6173 | 4.1784 |
| 63 | 74.0 | 4.9947 | 0.9243 | -5.6202 | 4.0545 | 5.0304 | 0.9543 | -5.6228 | 4.1278 |
| 64 | 76.0 | 4.9174 | 0.9166 | -5.6081 | 3.9994 | 4.9489 | 0.9480 | -5.6110 | 4.0717 |
| 65 | 78.0 | 4.8356 | 0.9082 | -5.5852 | 3.9427 | 4.8708 | 0.9403 | -5.5888 | 4.0159 |
| 66 | 80.0 | 4.7634 | 0.8994 | -5.5560 | 3.8882 | 4.7965 | 0.9311 | -5.5598 | 3.9610 |
| 67 | 82.0 | 4.5928 | 0.8834 | -5.4965 | 3.7857 | 4.6124 | 0.9129 | -5.4970 | 3.8459 |
| 68 | 84.0 | 4.3905 | 0.8593 | -5.3991 | 3.6417 | 4.4165 | 0.8889 | -5.3997 | 3.7040 |
| 69 | 86.0 | 4.2015 | 0.8331 | -5.2830 | 3.4988 | 4.2236 | 0.8630 | -5.2837 | 3.5579 |
| 70 | 88.0 | 4.0137 | 0.8063 | -5.1554 | 3.3563 | 4.0365 | 0.8371 | -5.1566 | 3.4138 |
| 71 | 90.0 | 3.8354 | 0.7792 | -5.0210 | 3.2176 | 3.8555 | 0.8108 | -5.0224 | 3.2724 |
| 72 | 92.0 | 3.6606 | 0.7519 | -4.8816 | 3.0815 | 3.6802 | 0.7843 | -4.8832 | 3.1338 |
| 73 | 94.0 | 3.4921 | 0.7246 | -4.7389 | 2.9487 | 3.5103 | 0.7576 | -4.7406 | 2.9983 |
| 74 | 96.0 | 3.3269 | 0.6973 | -4.5934 | 2.8183 | 3.3448 | 0.7301 | -4.5952 | 2.8655 |
| 75 | 98.0 | 3.1661 | 0.6701 | -4.4460 | 2.6905 | 3.1830 | 0.7027 | -4.4479 | 2.7357 |
| 76 | 100.0 | 3.0083 | 0.6429 | -4.2969 | 2.5647 | 3.0244 | 0.6750 | -4.2989 | 2.6087 |
| 77 | 102.0 | 2.9513 | 0.6227 | -4.1723 | 2.4901 | 2.9820 | 0.6560 | -4.1779 | 2.5450 |
| 78 | 104.0 | 2.9348 | 0.6107 | -4.0813 | 2.4608 | 2.9572 | 0.6437 | -4.0870 | 2.5110 |
| 79 | 106.0 | 2.9073 | 0.6007 | -4.0057 | 2.4330 | 2.9343 | 0.6337 | -4.0113 | 2.4841 |
| 80 | 108.0 | 2.8853 | 0.5914 | -3.9389 | 2.4081 | 2.9101 | 0.6242 | -3.9441 | 2.4583 |
| 81 | 110.0 | 2.8559 | 0.5825 | -3.8769 | 2.3817 | 2.8838 | 0.6157 | -3.8820 | 2.4326 |
| 82 | 115.0 | 2.8932 | 0.5720 | -3.7779 | 2.3818 | 2.9367 | 0.6099 | -3.7935 | 2.4529 |
| 83 | 120.0 | 2.9401 | 0.5709 | -3.7348 | 2.4130 | 2.9774 | 0.6044 | -3.7480 | 2.4790 |
| 84 | 125.0 | 2.9622 | 0.5691 | -3.7045 | 2.4251 | 3.0043 | 0.5995 | -3.7185 | 2.4998 |
| 85 | 130.0 | 2.9826 | 0.5686 | -3.6837 | 2.4381 | 3.0231 | 0.5975 | -3.6988 | 2.5158 |
| 86 | 135.0 | 2.9953 | 0.5685 | -3.6696 | 2.4461 | 3.0371 | 0.5960 | -3.6860 | 2.5283 |
| 87 | 140.0 | 3.0083 | 0.5689 | -3.6615 | 2.4548 | 3.0480 | 0.5943 | -3.6787 | 2.5398 |
| 88 | 145.0 | 3.0188 | 0.5697 | -3.6582 | 2.4622 | 3.0577 | 0.5926 | -3.6759 | 2.5501 |
| 89 | 150.0 | 3.0300 | 0.5709 | -3.6588 | 2.4702 | 3.0679 | 0.5920 | -3.6769 | 2.5598 |
| 90 | 155.0 | 3.0403 | 0.5723 | -3.6625 | 2.4779 | 3.0779 | 0.5923 | -3.6808 | 2.5698 |
| 91 | 160.0 | 3.0511 | 0.5739 | -3.6685 | 2.4860 | 3.0874 | 0.5939 | -3.6868 | 2.5792 |
| 92 | 170.0 | 2.8421 | 0.5507 | -3.5641 | 2.3480 | 2.8582 | 0.5675 | -3.5616 | 2.4200 |
| 93 | 180.0 | 2.6298 | 0.5149 | -3.3728 | 2.1723 | 2.6626 | 0.5371 | -3.3863 | 2.2645 |
| 94 | 190.0 | 2.4698 | 0.4860 | -3.1975 | 2.0457 | 2.4872 | 0.5062 | -3.2064 | 2.1206 |
| 95 | 200.0 | 2.3028 | 0.4551 | -3.0169 | 1.9089 | 2.3251 | 0.4761 | -3.0277 | 1.9846 |
| 96 | 210.0 | 2.1600 | 0.4273 | -2.8427 | 1.7920 | 2.1768 | 0.4467 | -2.8539 | 1.8581 |
| 97 | 220.0 | 2.0156 | 0.3999 | -2.6734 | 1.6741 | 2.0385 | 0.4170 | -2.6854 | 1.7399 |
| 98 | 230.0 | 1.8886 | 0.3746 | -2.5123 | 1.5687 | 1.9080 | 0.3908 | -2.5244 | 1.6292 |
| 99 | 240.0 | 1.7626 | 0.3505 | -2.3589 | 1.4659 | 1.7836 | 0.3670 | -2.3721 | 1.5257 |
| 100 | 250.0 | 1.6508 | 0.3281 | -2.2141 | 1.3725 | 1.6656 | 0.3428 | -2.2283 | 1.4285 |
| 101 | 260.0 | 1.5409 | 0.3070 | -2.0774 | 1.2828 | 1.5534 | 0.3192 | -2.0923 | 1.3366 |
| 102 | 270.0 | 1.4430 | 0.2872 | -1.9488 | 1.2007 | 1.4486 | 0.2996 | -1.9634 | 1.2501 |
| 103 | 280.0 | 1.3471 | 0.2688 | -1.8277 | 1.1224 | 1.3512 | 0.2832 | -1.8414 | 1.1686 |
| 104 | 290.0 | 1.2615 | 0.2514 | -1.7140 | 1.0504 | 1.2599 | 0.2674 | -1.7267 | 1.0917 |
| 105 | 300.0 | 1.1778 | 0.2352 | -1.6070 | 0.9821 | 1.1743 | 0.2522 | -1.6193 | 1.0189 |

表7. 5 (1) 評価断面5の応力テンソル成分1

FINAS解と簡易計算値との比較 (ホットショック)

断面5の応力成分1

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|----------|--------|---------|----------|----------|--------|---------|----------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.4617 | 0.0019 | -0.0237 | -0.1070 | -0.5518 | 0.0020 | -0.0271 | -0.1234 |
| 3 | 1.0 | -1.1143 | 0.0067 | -0.0702 | -0.3267 | -1.1440 | 0.0069 | -0.0717 | -0.3372 |
| 4 | 1.5 | -1.6872 | 0.0135 | -0.1269 | -0.5888 | -1.7475 | 0.0134 | -0.1294 | -0.6017 |
| 5 | 2.0 | -2.3190 | 0.0223 | -0.1955 | -0.8879 | -2.3516 | 0.0213 | -0.1975 | -0.8970 |
| 6 | 2.5 | -2.9145 | 0.0324 | -0.2713 | -1.2034 | -2.9544 | 0.0298 | -0.2733 | -1.2119 |
| 7 | 3.0 | -3.5281 | 0.0435 | -0.3537 | -1.5326 | -3.5539 | 0.0389 | -0.3555 | -1.5387 |
| 8 | 3.5 | -4.1201 | 0.0557 | -0.4401 | -1.8679 | -4.1480 | 0.0490 | -0.4421 | -1.8732 |
| 9 | 4.0 | -4.7158 | 0.0688 | -0.5299 | -2.2083 | -4.7337 | 0.0604 | -0.5318 | -2.2116 |
| 10 | 4.5 | -5.2964 | 0.0825 | -0.6218 | -2.5504 | -5.3134 | 0.0723 | -0.6238 | -2.5526 |
| 11 | 5.0 | -5.8759 | 0.0967 | -0.7153 | -2.8940 | -5.8846 | 0.0856 | -0.7168 | -2.8948 |
| 12 | 5.5 | -6.4435 | 0.1120 | -0.8096 | -3.2374 | -6.4484 | 0.1000 | -0.8106 | -3.2372 |
| 13 | 6.0 | -7.0080 | 0.1276 | -0.9045 | -3.5805 | -7.0049 | 0.1152 | -0.9050 | -3.5793 |
| 14 | 6.5 | -7.5626 | 0.1437 | -0.9994 | -3.9225 | -7.5552 | 0.1312 | -0.9994 | -3.9206 |
| 15 | 7.0 | -8.1136 | 0.1604 | -1.0941 | -4.2635 | -8.0994 | 0.1479 | -1.0937 | -4.2605 |
| 16 | 7.5 | -8.6559 | 0.1775 | -1.1884 | -4.6029 | -8.6380 | 0.1650 | -1.1877 | -4.5989 |
| 17 | 8.0 | -9.1943 | 0.1952 | -1.2821 | -4.9409 | -9.1710 | 0.1824 | -1.2811 | -4.9357 |
| 18 | 8.5 | -9.7254 | 0.2131 | -1.3751 | -5.2771 | -9.6985 | 0.2002 | -1.3738 | -5.2710 |
| 19 | 9.0 | -10.2523 | 0.2311 | -1.4673 | -5.6116 | -10.2210 | 0.2182 | -1.4655 | -5.6045 |
| 20 | 9.5 | -10.7725 | 0.2497 | -1.5586 | -5.9442 | -10.7370 | 0.2360 | -1.5563 | -5.9360 |
| 21 | 10.0 | -11.2890 | 0.2684 | -1.6489 | -6.2752 | -11.2490 | 0.2532 | -1.6462 | -6.2657 |
| 22 | 11.0 | -11.7871 | 0.3035 | -1.7931 | -6.7806 | -11.6960 | 0.2853 | -1.7880 | -6.7596 |
| 23 | 12.0 | -12.1317 | 0.3349 | -1.9016 | -7.1396 | -12.0820 | 0.3146 | -1.8970 | -7.1291 |
| 24 | 13.0 | -12.5371 | 0.3641 | -1.9916 | -7.4611 | -12.4530 | 0.3440 | -1.9848 | -7.4505 |
| 25 | 14.0 | -12.8806 | 0.3920 | -2.0655 | -7.7544 | -12.8170 | 0.3724 | -2.0585 | -7.7487 |
| 26 | 15.0 | -13.2677 | 0.4186 | -2.1313 | -8.0414 | -13.1820 | 0.4003 | -2.1231 | -8.0352 |
| 27 | 16.0 | -13.6202 | 0.4441 | -2.1894 | -8.3181 | -13.5470 | 0.4269 | -2.1810 | -8.3142 |
| 28 | 17.0 | -13.9989 | 0.4688 | -2.2433 | -8.5931 | -13.9120 | 0.4518 | -2.2335 | -8.5884 |
| 29 | 18.0 | -14.3560 | 0.4930 | -2.2927 | -8.8630 | -14.2760 | 0.4745 | -2.2822 | -8.8595 |
| 30 | 19.0 | -14.7285 | 0.5165 | -2.3393 | -9.1318 | -14.6380 | 0.4954 | -2.3278 | -9.1279 |
| 31 | 20.0 | -15.0862 | 0.5396 | -2.3829 | -9.3975 | -14.9990 | 0.5164 | -2.3709 | -9.3939 |
| 32 | 21.0 | -15.4532 | 0.5622 | -2.4244 | -9.6621 | -15.3580 | 0.5380 | -2.4118 | -9.6578 |
| 33 | 22.0 | -15.8098 | 0.5848 | -2.4639 | -9.9245 | -15.7140 | 0.5596 | -2.4509 | -9.9196 |
| 34 | 23.0 | -16.1717 | 0.6069 | -2.5017 | -10.1858 | -16.0690 | 0.5813 | -2.4883 | -10.1800 |
| 35 | 24.0 | -16.5261 | 0.6288 | -2.5378 | -10.4453 | -16.4230 | 0.6028 | -2.5241 | -10.4390 |
| 36 | 25.0 | -16.8838 | 0.6507 | -2.5727 | -10.7038 | -16.7740 | 0.6230 | -2.5585 | -10.6970 |
| 37 | 26.0 | -17.2352 | 0.6724 | -2.6061 | -10.9606 | -17.1240 | 0.6416 | -2.5917 | -10.9540 |
| 38 | 27.0 | -17.5885 | 0.6938 | -2.6386 | -11.2161 | -17.4710 | 0.6597 | -2.6237 | -11.2090 |
| 39 | 28.0 | -17.9365 | 0.7148 | -2.6699 | -11.4701 | -17.8170 | 0.6786 | -2.6542 | -11.4630 |
| 40 | 29.0 | -18.2853 | 0.7359 | -2.7003 | -11.7230 | -18.1610 | 0.6981 | -2.6833 | -11.7160 |
| 41 | 30.0 | -18.6297 | 0.7567 | -2.7297 | -11.9743 | -18.5020 | 0.7173 | -2.7113 | -11.9660 |
| 42 | 32.0 | -18.7602 | 0.7932 | -2.7408 | -12.2716 | -18.5910 | 0.7506 | -2.7156 | -12.2480 |
| 43 | 34.0 | -18.8004 | 0.8225 | -2.7089 | -12.4150 | -18.6640 | 0.7773 | -2.6835 | -12.4110 |
| 44 | 36.0 | -18.9181 | 0.8481 | -2.6656 | -12.5615 | -18.7530 | 0.8028 | -2.6383 | -12.5540 |
| 45 | 38.0 | -19.0096 | 0.8708 | -2.6180 | -12.6992 | -18.8560 | 0.8269 | -2.5903 | -12.6930 |
| 46 | 40.0 | -19.1553 | 0.8921 | -2.5725 | -12.8436 | -18.9740 | 0.8516 | -2.5432 | -12.8330 |
| 47 | 42.0 | -19.2777 | 0.9114 | -2.5280 | -12.9851 | -19.1050 | 0.8746 | -2.4988 | -12.9750 |
| 48 | 44.0 | -19.4387 | 0.9300 | -2.4873 | -13.1314 | -19.2450 | 0.8947 | -2.4574 | -13.1160 |
| 49 | 46.0 | -19.5802 | 0.9478 | -2.4488 | -13.2756 | -19.3930 | 0.9123 | -2.4190 | -13.2590 |
| 50 | 48.0 | -19.7506 | 0.9647 | -2.4141 | -13.4228 | -19.5450 | 0.9300 | -2.3838 | -13.4010 |
| 51 | 50.0 | -19.9038 | 0.9809 | -2.3817 | -13.5676 | -19.6970 | 0.9487 | -2.3513 | -13.5430 |
| 52 | 52.0 | -20.0784 | 0.9965 | -2.3528 | -13.7139 | -19.8520 | 0.9674 | -2.3215 | -13.6850 |
| 53 | 54.0 | -20.2385 | 1.0116 | -2.3262 | -13.8579 | -20.0080 | 0.9859 | -2.2943 | -13.8270 |
| 54 | 56.0 | -20.4145 | 1.0263 | -2.3024 | -14.0022 | -20.1650 | 1.0049 | -2.2702 | -13.9670 |

| | | | | | | | | | |
|-----|-------|----------|--------|---------|----------|----------|--------|---------|----------|
| 55 | 58.0 | -20.5781 | 1.0406 | -2.2804 | -14.1440 | -20.3240 | 1.0225 | -2.2485 | -14.1060 |
| 56 | 60.0 | -20.7534 | 1.0549 | -2.2609 | -14.2855 | -20.4830 | 1.0377 | -2.2292 | -14.2450 |
| 57 | 62.0 | -20.9175 | 1.0683 | -2.2430 | -14.4244 | -20.6430 | 1.0507 | -2.2121 | -14.3820 |
| 58 | 64.0 | -21.0908 | 1.0816 | -2.2270 | -14.5625 | -20.8030 | 1.0616 | -2.1967 | -14.5170 |
| 59 | 66.0 | -21.2541 | 1.0946 | -2.2123 | -14.6981 | -20.9640 | 1.0707 | -2.1830 | -14.6500 |
| 60 | 68.0 | -21.4244 | 1.1073 | -2.1991 | -14.8326 | -21.1260 | 1.0800 | -2.1708 | -14.7820 |
| 61 | 70.0 | -21.5863 | 1.1198 | -2.1871 | -14.9648 | -21.2880 | 1.0899 | -2.1600 | -14.9130 |
| 62 | 72.0 | -21.1973 | 1.1271 | -2.1310 | -14.8941 | -20.8490 | 1.0944 | -2.0988 | -14.7990 |
| 63 | 74.0 | -20.7209 | 1.1275 | -2.0359 | -14.6729 | -20.4120 | 1.0961 | -2.0054 | -14.5960 |
| 64 | 76.0 | -20.3327 | 1.1246 | -1.9331 | -14.4591 | -20.0010 | 1.0935 | -1.9041 | -14.3790 |
| 65 | 78.0 | -19.9218 | 1.1189 | -1.8293 | -14.2401 | -19.6130 | 1.0875 | -1.8029 | -14.1640 |
| 66 | 80.0 | -19.5750 | 1.1118 | -1.7307 | -14.0321 | -19.2430 | 1.0795 | -1.7054 | -13.9530 |
| 67 | 82.0 | -18.6533 | 1.0986 | -1.5904 | -13.6237 | -18.2900 | 1.0653 | -1.5609 | -13.5060 |
| 68 | 84.0 | -17.7005 | 1.0778 | -1.4168 | -13.0763 | -17.3560 | 1.0460 | -1.3882 | -12.9740 |
| 69 | 86.0 | -16.8170 | 1.0532 | -1.2390 | -12.5395 | -16.4630 | 1.0200 | -1.2115 | -12.4360 |
| 70 | 88.0 | -15.9553 | 1.0260 | -1.0656 | -12.0071 | -15.6100 | 0.9910 | -1.0398 | -11.9050 |
| 71 | 90.0 | -15.1431 | 0.9970 | -0.9010 | -11.4890 | -14.7900 | 0.9614 | -0.8763 | -11.3850 |
| 72 | 92.0 | -14.3474 | 0.9666 | -0.7450 | -10.9801 | -14.0000 | 0.9318 | -0.7217 | -10.8750 |
| 73 | 94.0 | -13.5887 | 0.9353 | -0.5987 | -10.4834 | -13.2390 | 0.9007 | -0.5766 | -10.3760 |
| 74 | 96.0 | -12.8447 | 0.9038 | -0.4612 | -9.9956 | -12.4990 | 0.8687 | -0.4403 | -9.8870 |
| 75 | 98.0 | -12.1292 | 0.8719 | -0.3326 | -9.5181 | -11.7790 | 0.8378 | -0.3129 | -9.4073 |
| 76 | 100.0 | -11.4263 | 0.8398 | -0.2122 | -9.0485 | -11.0760 | 0.8083 | -0.1937 | -8.9368 |
| 77 | 102.0 | -11.3020 | 0.8126 | -0.1449 | -8.7893 | -10.9910 | 0.7845 | -0.1336 | -8.7173 |
| 78 | 104.0 | -11.2687 | 0.7918 | -0.1246 | -8.6850 | -10.9180 | 0.7636 | -0.1139 | -8.5939 |
| 79 | 106.0 | -11.1698 | 0.7740 | -0.1198 | -8.5799 | -10.8330 | 0.7476 | -0.1099 | -8.4891 |
| 80 | 108.0 | -11.0976 | 0.7586 | -0.1229 | -8.4842 | -10.7360 | 0.7345 | -0.1131 | -8.3879 |
| 81 | 110.0 | -10.9801 | 0.7445 | -0.1274 | -8.3829 | -10.6300 | 0.7223 | -0.1195 | -8.2869 |
| 82 | 115.0 | -11.2870 | 0.7223 | -0.2068 | -8.3961 | -10.9410 | 0.7033 | -0.2172 | -8.3553 |
| 83 | 120.0 | -11.5340 | 0.7129 | -0.3199 | -8.5129 | -11.1650 | 0.6934 | -0.3236 | -8.4355 |
| 84 | 125.0 | -11.6997 | 0.7075 | -0.4115 | -8.5651 | -11.3290 | 0.6848 | -0.4142 | -8.5003 |
| 85 | 130.0 | -11.8321 | 0.7046 | -0.4863 | -8.6238 | -11.4600 | 0.6752 | -0.4866 | -8.5544 |
| 86 | 135.0 | -11.9386 | 0.7032 | -0.5467 | -8.6658 | -11.5680 | 0.6670 | -0.5445 | -8.5995 |
| 87 | 140.0 | -12.0272 | 0.7031 | -0.5947 | -8.7083 | -11.6560 | 0.6619 | -0.5907 | -8.6384 |
| 88 | 145.0 | -12.1077 | 0.7039 | -0.6333 | -8.7464 | -11.7310 | 0.6596 | -0.6279 | -8.6737 |
| 89 | 150.0 | -12.1774 | 0.7050 | -0.6644 | -8.7845 | -11.7970 | 0.6597 | -0.6577 | -8.7082 |
| 90 | 155.0 | -12.2453 | 0.7068 | -0.6897 | -8.8212 | -11.8590 | 0.6617 | -0.6822 | -8.7416 |
| 91 | 160.0 | -12.3052 | 0.7088 | -0.7103 | -8.8577 | -11.9260 | 0.6642 | -0.7022 | -8.7745 |
| 92 | 170.0 | -11.3005 | 0.6890 | -0.5942 | -8.3432 | -10.9070 | 0.6451 | -0.5596 | -8.1804 |
| 93 | 180.0 | -10.4231 | 0.6507 | -0.4340 | -7.7124 | -10.0620 | 0.6091 | -0.4235 | -7.6161 |
| 94 | 190.0 | -9.7245 | 0.6139 | -0.3453 | -7.2493 | -9.3153 | 0.5647 | -0.3249 | -7.1007 |
| 95 | 200.0 | -9.0382 | 0.5769 | -0.2707 | -6.7526 | -8.6384 | 0.5226 | -0.2548 | -6.6275 |
| 96 | 210.0 | -8.4533 | 0.5420 | -0.2210 | -6.3332 | -8.0185 | 0.4852 | -0.2025 | -6.1911 |
| 97 | 220.0 | -7.8723 | 0.5079 | -0.1801 | -5.9098 | -7.4457 | 0.4513 | -0.1624 | -5.7829 |
| 98 | 230.0 | -7.3664 | 0.4762 | -0.1495 | -5.5354 | -6.9070 | 0.4233 | -0.1286 | -5.4021 |
| 99 | 240.0 | -6.8664 | 0.4462 | -0.1243 | -5.1698 | -6.3973 | 0.3973 | -0.1014 | -5.0463 |
| 100 | 250.0 | -6.4285 | 0.4180 | -0.1043 | -4.8400 | -5.9214 | 0.3738 | -0.0799 | -4.7131 |
| 101 | 260.0 | -5.9953 | 0.3916 | -0.0874 | -4.5229 | -5.4815 | 0.3554 | -0.0616 | -4.4018 |
| 102 | 270.0 | -5.6156 | 0.3667 | -0.0740 | -4.2339 | -5.0781 | 0.3409 | -0.0454 | -4.1117 |
| 103 | 280.0 | -5.2387 | 0.3437 | -0.0621 | -3.9578 | -4.7014 | 0.3273 | -0.0313 | -3.8405 |
| 104 | 290.0 | -4.9089 | 0.3217 | -0.0528 | -3.7048 | -4.3498 | 0.3080 | -0.0197 | -3.5830 |
| 105 | 300.0 | -4.5802 | 0.3011 | -0.0443 | -3.4642 | -4.0264 | 0.2817 | -0.0100 | -3.3388 |

表7. 5(2) 評価断面5の応力テンソル成分2

FINAS解と簡易計算値との比較 (ホットショック)

断面5の応力成分2

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|----------|---------|---------|----------|----------|---------|---------|----------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.4889 | 0.1270 | -0.0067 | -0.1608 | -0.5854 | 0.1370 | -0.0081 | -0.1808 |
| 3 | 1.0 | -1.2388 | 0.4559 | -0.0162 | -0.5359 | -1.2715 | 0.4633 | -0.0170 | -0.5511 |
| 4 | 1.5 | -1.9311 | 0.9302 | -0.0229 | -1.0233 | -1.9882 | 0.9370 | -0.0240 | -1.0391 |
| 5 | 2.0 | -2.6814 | 1.5297 | -0.0273 | -1.5962 | -2.7122 | 1.5335 | -0.0283 | -1.6096 |
| 6 | 2.5 | -3.4034 | 2.2308 | -0.0288 | -2.2271 | -3.4364 | 2.2319 | -0.0300 | -2.2392 |
| 7 | 3.0 | -4.1403 | 3.0174 | -0.0277 | -2.9027 | -4.1578 | 3.0146 | -0.0290 | -2.9126 |
| 8 | 3.5 | -4.8577 | 3.8748 | -0.0239 | -3.6107 | -4.8719 | 3.8684 | -0.0250 | -3.6189 |
| 9 | 4.0 | -5.5761 | 4.7919 | -0.0179 | -4.3443 | -5.5776 | 4.7817 | -0.0186 | -4.3505 |
| 10 | 4.5 | -6.2798 | 5.7588 | -0.0097 | -5.0969 | -6.2752 | 5.7460 | -0.0098 | -5.1015 |
| 11 | 5.0 | -6.9807 | 6.7684 | 0.0004 | -5.8652 | -6.9627 | 6.7546 | 0.0011 | -5.8672 |
| 12 | 5.5 | -7.6693 | 7.8156 | 0.0125 | -6.6453 | -7.6412 | 7.8003 | 0.0138 | -6.6450 |
| 13 | 6.0 | -8.3534 | 8.8945 | 0.0260 | -7.4351 | -8.3113 | 8.8787 | 0.0282 | -7.4327 |
| 14 | 6.5 | -9.0267 | 10.0017 | 0.0412 | -8.2324 | -8.9743 | 9.9863 | 0.0442 | -8.2282 |
| 15 | 7.0 | -9.6958 | 11.1339 | 0.0576 | -9.0362 | -9.6299 | 11.1200 | 0.0618 | -9.0298 |
| 16 | 7.5 | -10.3553 | 12.2883 | 0.0755 | -9.8447 | -10.2790 | 12.2760 | 0.0806 | -9.8364 |
| 17 | 8.0 | -11.0099 | 13.4621 | 0.0944 | -10.6573 | -10.9220 | 13.4520 | 0.1007 | -10.6470 |
| 18 | 8.5 | -11.6564 | 14.6541 | 0.1145 | -11.4732 | -11.5580 | 14.6470 | 0.1218 | -11.4620 |
| 19 | 9.0 | -12.2981 | 15.8615 | 0.1355 | -12.2917 | -12.1880 | 15.8580 | 0.1440 | -12.2790 |
| 20 | 9.5 | -12.9323 | 17.0835 | 0.1576 | -13.1123 | -12.8130 | 17.0840 | 0.1672 | -13.0980 |
| 21 | 10.0 | -13.5619 | 18.3190 | 0.1805 | -13.9346 | -13.4310 | 18.3220 | 0.1911 | -13.9200 |
| 22 | 11.0 | -14.2316 | 20.6079 | 0.2360 | -15.3340 | -14.0390 | 20.6100 | 0.2490 | -15.3050 |
| 23 | 12.0 | -14.6692 | 22.6152 | 0.2940 | -16.4434 | -14.5190 | 22.6310 | 0.3084 | -16.4290 |
| 24 | 13.0 | -15.1703 | 24.4555 | 0.3478 | -17.4449 | -14.9770 | 24.4840 | 0.3653 | -17.4320 |
| 25 | 14.0 | -15.6079 | 26.1777 | 0.3995 | -18.3738 | -15.4290 | 26.2250 | 0.4194 | -18.3680 |
| 26 | 15.0 | -16.0866 | 27.8256 | 0.4487 | -19.2671 | -15.8810 | 27.8920 | 0.4709 | -19.2660 |
| 27 | 16.0 | -16.5346 | 29.4208 | 0.4964 | -20.1333 | -16.3340 | 29.5070 | 0.5207 | -20.1390 |
| 28 | 17.0 | -17.0051 | 30.9796 | 0.5427 | -20.9844 | -16.7860 | 31.0820 | 0.5689 | -20.9930 |
| 29 | 18.0 | -17.4576 | 32.5106 | 0.5882 | -21.8230 | -17.2370 | 32.6240 | 0.6158 | -21.8350 |
| 30 | 19.0 | -17.9223 | 34.0216 | 0.6330 | -22.6539 | -17.6860 | 34.1420 | 0.6618 | -22.6680 |
| 31 | 20.0 | -18.3745 | 35.5158 | 0.6774 | -23.4778 | -18.1330 | 35.6450 | 0.7074 | -23.4940 |
| 32 | 21.0 | -18.8340 | 36.9973 | 0.7213 | -24.2971 | -18.5790 | 37.1350 | 0.7525 | -24.3150 |
| 33 | 22.0 | -19.2848 | 38.4684 | 0.7650 | -25.1120 | -19.0210 | 38.6120 | 0.7972 | -25.1310 |
| 34 | 23.0 | -19.7394 | 39.9302 | 0.8084 | -25.9233 | -19.4610 | 40.0800 | 0.8415 | -25.9430 |
| 35 | 24.0 | -20.1872 | 41.3839 | 0.8517 | -26.7312 | -19.8990 | 41.5390 | 0.8855 | -26.7510 |
| 36 | 25.0 | -20.6371 | 42.8303 | 0.8947 | -27.5362 | -20.3330 | 42.9880 | 0.9294 | -27.5560 |
| 37 | 26.0 | -21.0815 | 44.2702 | 0.9376 | -28.3381 | -20.7660 | 44.4290 | 0.9732 | -28.3570 |
| 38 | 27.0 | -21.5268 | 45.7040 | 0.9804 | -29.1373 | -21.1970 | 45.8640 | 1.0169 | -29.1560 |
| 39 | 28.0 | -21.9672 | 47.1312 | 1.0231 | -29.9334 | -21.6260 | 47.2940 | 1.0607 | -29.9530 |
| 40 | 29.0 | -22.4075 | 48.5528 | 1.0656 | -30.7267 | -22.0530 | 48.7190 | 1.1044 | -30.7460 |
| 41 | 30.0 | -22.8435 | 49.9682 | 1.1080 | -31.5170 | -22.4780 | 50.1370 | 1.1480 | -31.5370 |
| 42 | 32.0 | -23.0782 | 52.4282 | 1.1983 | -32.7263 | -22.6490 | 52.5860 | 1.2421 | -32.7210 |
| 43 | 34.0 | -23.1571 | 54.3953 | 1.2816 | -33.5688 | -22.7680 | 54.5770 | 1.3257 | -33.5970 |
| 44 | 36.0 | -23.3389 | 56.1307 | 1.3532 | -34.3420 | -22.9080 | 56.3290 | 1.3997 | -34.3710 |
| 45 | 38.0 | -23.4874 | 57.7233 | 1.4190 | -35.0607 | -23.0670 | 57.9400 | 1.4668 | -35.0970 |
| 46 | 40.0 | -23.6959 | 59.2246 | 1.4792 | -35.7593 | -23.2430 | 59.4530 | 1.5286 | -35.7940 |
| 47 | 42.0 | -23.8801 | 60.6488 | 1.5357 | -36.4332 | -23.4330 | 60.8850 | 1.5859 | -36.4680 |
| 48 | 44.0 | -24.1032 | 62.0142 | 1.5887 | -37.0935 | -23.6340 | 62.2540 | 1.6398 | -37.1250 |
| 49 | 46.0 | -24.3082 | 63.3258 | 1.6390 | -37.7360 | -23.8450 | 63.5680 | 1.6908 | -37.7670 |
| 50 | 48.0 | -24.5403 | 64.5914 | 1.6866 | -38.3659 | -24.0600 | 64.8340 | 1.7395 | -38.3940 |
| 51 | 50.0 | -24.7568 | 65.8138 | 1.7322 | -38.9801 | -24.2740 | 66.0600 | 1.7865 | -39.0070 |
| 52 | 52.0 | -24.9922 | 66.9973 | 1.7754 | -39.5816 | -24.4880 | 67.2480 | 1.8318 | -39.6060 |
| 53 | 54.0 | -25.2143 | 68.1441 | 1.8170 | -40.1687 | -24.7030 | 68.4010 | 1.8752 | -40.1930 |
| 54 | 56.0 | -25.4497 | 69.2572 | 1.8567 | -40.7432 | -24.9160 | 69.5220 | 1.9169 | -40.7670 |

| | | | | | | | | | |
|-----|-------|----------|---------|--------|----------|----------|---------|--------|----------|
| 55 | 58.0 | -25.6735 | 70.3384 | 1.8950 | -41.3043 | -25.1300 | 70.6120 | 1.9566 | -41.3290 |
| 56 | 60.0 | -25.9066 | 71.3900 | 1.9318 | -41.8535 | -25.3430 | 71.6710 | 1.9944 | -41.8780 |
| 57 | 62.0 | -26.1291 | 72.4126 | 1.9674 | -42.3899 | -25.5560 | 72.7000 | 2.0305 | -42.4140 |
| 58 | 64.0 | -26.3585 | 73.4092 | 2.0016 | -42.9151 | -25.7680 | 73.7010 | 2.0649 | -42.9390 |
| 59 | 66.0 | -26.5782 | 74.3804 | 2.0348 | -43.4285 | -25.9800 | 74.6750 | 2.0978 | -43.4530 |
| 60 | 68.0 | -26.8027 | 75.3282 | 2.0669 | -43.9316 | -26.1920 | 75.6250 | 2.1296 | -43.9570 |
| 61 | 70.0 | -27.0190 | 76.2533 | 2.0980 | -44.4239 | -26.4040 | 76.5520 | 2.1604 | -44.4500 |
| 62 | 72.0 | -26.6043 | 76.8036 | 2.1344 | -44.5444 | -25.9080 | 77.0550 | 2.1986 | -44.4990 |
| 63 | 74.0 | -26.0385 | 76.8644 | 2.1632 | -44.3011 | -25.3960 | 77.1200 | 2.2258 | -44.2800 |
| 64 | 76.0 | -25.5866 | 76.6984 | 2.1803 | -43.9930 | -24.9130 | 76.9580 | 2.2431 | -43.9710 |
| 65 | 78.0 | -25.1058 | 76.3963 | 2.1914 | -43.6353 | -24.4580 | 76.6600 | 2.2532 | -43.6210 |
| 66 | 80.0 | -24.6951 | 76.0109 | 2.1969 | -43.2639 | -24.0230 | 76.2700 | 2.2578 | -43.2480 |
| 67 | 82.0 | -23.6326 | 75.2044 | 2.2048 | -42.5123 | -22.9020 | 75.4100 | 2.2662 | -42.4260 |
| 68 | 84.0 | -22.4760 | 73.8801 | 2.2026 | -41.4010 | -21.7870 | 74.0830 | 2.2604 | -41.3380 |
| 69 | 86.0 | -21.4185 | 72.3063 | 2.1869 | -40.2240 | -20.7220 | 72.5040 | 2.2426 | -40.1600 |
| 70 | 88.0 | -20.3761 | 70.5821 | 2.1634 | -39.0027 | -19.7030 | 70.7760 | 2.2163 | -38.9450 |
| 71 | 90.0 | -19.3937 | 68.7624 | 2.1331 | -37.7692 | -18.7200 | 68.9490 | 2.1835 | -37.7110 |
| 72 | 92.0 | -18.4274 | 66.8683 | 2.0980 | -36.5233 | -17.7710 | 67.0510 | 2.1459 | -36.4670 |
| 73 | 94.0 | -17.5033 | 64.9203 | 2.0585 | -35.2743 | -16.8520 | 65.0970 | 2.1042 | -35.2180 |
| 74 | 96.0 | -16.5949 | 62.9284 | 2.0157 | -34.0210 | -15.9580 | 63.0990 | 2.0594 | -33.9650 |
| 75 | 98.0 | -15.7180 | 60.9028 | 1.9699 | -32.7677 | -15.0900 | 61.0690 | 2.0118 | -32.7130 |
| 76 | 100.0 | -14.8557 | 58.8489 | 1.9216 | -31.5136 | -14.2420 | 59.0140 | 1.9617 | -31.4600 |
| 77 | 102.0 | -14.6518 | 57.1279 | 1.8650 | -30.6233 | -14.1180 | 57.3410 | 1.9015 | -30.6440 |
| 78 | 104.0 | -14.6047 | 55.8589 | 1.8133 | -30.0882 | -14.0250 | 56.0670 | 1.8497 | -30.0860 |
| 79 | 106.0 | -14.4664 | 54.7849 | 1.7710 | -29.6122 | -13.9160 | 54.9890 | 1.8055 | -29.6130 |
| 80 | 108.0 | -14.3622 | 53.8198 | 1.7326 | -29.1799 | -13.7900 | 54.0180 | 1.7663 | -29.1750 |
| 81 | 110.0 | -14.2066 | 52.9153 | 1.6980 | -28.7578 | -13.6520 | 53.1160 | 1.7306 | -28.7550 |
| 82 | 115.0 | -14.5186 | 51.4371 | 1.6196 | -28.2770 | -13.9980 | 51.7850 | 1.6513 | -28.4030 |
| 83 | 120.0 | -14.7997 | 50.7395 | 1.5687 | -28.1815 | -14.2410 | 51.0490 | 1.6018 | -28.2480 |
| 84 | 125.0 | -14.9649 | 50.2404 | 1.5355 | -28.0565 | -14.4170 | 50.5620 | 1.5673 | -28.1470 |
| 85 | 130.0 | -15.1125 | 49.9067 | 1.5109 | -27.9960 | -14.5510 | 50.2380 | 1.5428 | -28.0840 |
| 86 | 135.0 | -15.2204 | 49.6911 | 1.4948 | -27.9534 | -14.6610 | 50.0330 | 1.5254 | -28.0530 |
| 87 | 140.0 | -15.3200 | 49.5698 | 1.4839 | -27.9483 | -14.7490 | 49.9180 | 1.5142 | -28.0470 |
| 88 | 145.0 | -15.4053 | 49.5212 | 1.4777 | -27.9635 | -14.8300 | 49.8780 | 1.5076 | -28.0640 |
| 89 | 150.0 | -15.4866 | 49.5304 | 1.4745 | -28.0027 | -14.9070 | 49.9010 | 1.5055 | -28.1040 |
| 90 | 155.0 | -15.5622 | 49.5819 | 1.4739 | -28.0558 | -14.9810 | 49.9690 | 1.5062 | -28.1600 |
| 91 | 160.0 | -15.6342 | 49.6672 | 1.4750 | -28.1229 | -15.0560 | 50.0680 | 1.5087 | -28.2290 |
| 92 | 170.0 | -14.4335 | 48.2583 | 1.4670 | -27.0041 | -13.8140 | 48.4100 | 1.4984 | -26.9200 |
| 93 | 180.0 | -13.3417 | 45.6850 | 1.4141 | -25.3551 | -12.7750 | 46.0450 | 1.4490 | -25.4330 |
| 94 | 190.0 | -12.4834 | 43.2896 | 1.3497 | -23.9875 | -11.8500 | 43.5650 | 1.3862 | -23.9680 |
| 95 | 200.0 | -11.6150 | 40.7911 | 1.2827 | -22.5278 | -10.9990 | 41.0840 | 1.3173 | -22.5450 |
| 96 | 210.0 | -10.8817 | 38.3948 | 1.2119 | -21.1954 | -10.2180 | 38.6760 | 1.2479 | -21.1860 |
| 97 | 220.0 | -10.1402 | 36.0657 | 1.1442 | -19.8743 | -9.4984 | 36.3560 | 1.1803 | -19.8850 |
| 98 | 230.0 | -9.4987 | 33.8560 | 1.0773 | -18.6531 | -8.8228 | 34.1490 | 1.1170 | -18.6500 |
| 99 | 240.0 | -8.8587 | 31.7575 | 1.0145 | -17.4776 | -8.1808 | 32.0640 | 1.0574 | -17.4850 |
| 100 | 250.0 | -8.2995 | 29.7799 | 0.9538 | -16.3873 | -7.5815 | 30.0980 | 1.0007 | -16.3890 |
| 101 | 260.0 | -7.7439 | 27.9163 | 0.8973 | -15.3501 | -7.0296 | 28.2460 | 0.9470 | -15.3590 |
| 102 | 270.0 | -7.2566 | 26.1658 | 0.8431 | -14.3863 | -6.5191 | 26.4970 | 0.8960 | -14.3890 |
| 103 | 280.0 | -6.7730 | 24.5201 | 0.7926 | -13.4739 | -6.0392 | 24.8470 | 0.8476 | -13.4750 |
| 104 | 290.0 | -6.3483 | 22.9765 | 0.7444 | -12.6249 | -5.5855 | 23.2880 | 0.8009 | -12.6140 |
| 105 | 300.0 | -5.9263 | 21.5265 | 0.6995 | -11.8231 | -5.1608 | 21.8190 | 0.7559 | -11.8030 |

表7. 5(3) 評価断面5の応力テンソル成分3

FINAS解と簡易計算値との比較 (ホットショック)

断面5の応力成分3

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|----------|---------|---------|----------|----------|---------|---------|----------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.7798 | 0.1064 | -0.0058 | -0.2281 | -0.9423 | 0.1145 | -0.0071 | -0.2579 |
| 3 | 1.0 | -2.0408 | 0.3827 | -0.0133 | -0.7565 | -2.1106 | 0.3886 | -0.0139 | -0.7806 |
| 4 | 1.5 | -3.2373 | 0.7821 | -0.0182 | -1.4362 | -3.3468 | 0.7890 | -0.0192 | -1.4634 |
| 5 | 2.0 | -4.5277 | 1.2874 | -0.0218 | -2.2284 | -4.6059 | 1.2935 | -0.0227 | -2.2537 |
| 6 | 2.5 | -5.7814 | 1.8770 | -0.0229 | -3.0912 | -5.8698 | 1.8819 | -0.0237 | -3.1169 |
| 7 | 3.0 | -7.0557 | 2.5348 | -0.0211 | -4.0054 | -7.1300 | 2.5365 | -0.0224 | -4.0299 |
| 8 | 3.5 | -8.3008 | 3.2457 | -0.0160 | -4.9524 | -8.3791 | 3.2437 | -0.0183 | -4.9770 |
| 9 | 4.0 | -9.5425 | 3.9990 | -0.0072 | -5.9229 | -9.6125 | 3.9924 | -0.0106 | -5.9466 |
| 10 | 4.5 | -10.7585 | 4.7855 | 0.0057 | -6.9075 | -10.8290 | 4.7748 | 0.0010 | -6.9310 |
| 11 | 5.0 | -11.9628 | 5.5987 | 0.0229 | -7.9015 | -12.0270 | 5.5831 | 0.0164 | -7.9240 |
| 12 | 5.5 | -13.1432 | 6.4341 | 0.0446 | -8.8997 | -13.2060 | 6.4131 | 0.0363 | -8.9219 |
| 13 | 6.0 | -14.3084 | 7.2872 | 0.0708 | -9.9000 | -14.3640 | 7.2611 | 0.0606 | -9.9216 |
| 14 | 6.5 | -15.4509 | 8.1550 | 0.1018 | -10.8992 | -15.5040 | 8.1238 | 0.0894 | -10.9200 |
| 15 | 7.0 | -16.5775 | 9.0355 | 0.1374 | -11.8964 | -16.6250 | 8.9990 | 0.1228 | -11.9160 |
| 16 | 7.5 | -17.6831 | 9.9263 | 0.1777 | -12.8898 | -17.7270 | 9.8847 | 0.1608 | -12.9090 |
| 17 | 8.0 | -18.7723 | 10.8257 | 0.2227 | -13.8789 | -18.8120 | 10.7800 | 0.2035 | -13.8970 |
| 18 | 8.5 | -19.8418 | 11.7329 | 0.2723 | -14.8627 | -19.8790 | 11.6820 | 0.2511 | -14.8800 |
| 19 | 9.0 | -20.8953 | 12.6464 | 0.3263 | -15.8410 | -20.9280 | 12.5920 | 0.3033 | -15.8570 |
| 20 | 9.5 | -21.9304 | 13.5656 | 0.3848 | -16.8132 | -21.9600 | 13.5070 | 0.3598 | -16.8280 |
| 21 | 10.0 | -22.9501 | 14.4899 | 0.4476 | -17.7795 | -22.9750 | 14.4260 | 0.4208 | -17.7930 |
| 22 | 11.0 | -24.0038 | 16.1685 | 0.5918 | -19.3424 | -23.9460 | 16.0890 | 0.5625 | -19.3340 |
| 23 | 12.0 | -24.5846 | 17.5890 | 0.7510 | -20.4769 | -24.6220 | 17.5060 | 0.7182 | -20.4890 |
| 24 | 13.0 | -25.2403 | 18.8528 | 0.9197 | -21.4526 | -25.2230 | 18.7640 | 0.8851 | -21.4650 |
| 25 | 14.0 | -25.7750 | 20.0105 | 1.0970 | -22.3247 | -25.7900 | 19.9260 | 1.0607 | -22.3460 |
| 26 | 15.0 | -26.3564 | 21.1077 | 1.2794 | -23.1488 | -26.3400 | 21.0280 | 1.2427 | -23.1710 |
| 27 | 16.0 | -26.8820 | 22.1654 | 1.4659 | -23.9367 | -26.8800 | 22.0910 | 1.4288 | -23.9630 |
| 28 | 17.0 | -27.4349 | 23.1973 | 1.6546 | -24.7062 | -27.4130 | 23.1270 | 1.6175 | -24.7330 |
| 29 | 18.0 | -27.9569 | 24.2105 | 1.8451 | -25.4598 | -27.9410 | 24.1400 | 1.8075 | -25.4890 |
| 30 | 19.0 | -28.4945 | 25.2105 | 2.0366 | -26.2043 | -28.4650 | 25.1380 | 1.9985 | -26.2340 |
| 31 | 20.0 | -29.0120 | 26.1992 | 2.2290 | -26.9401 | -28.9840 | 26.1270 | 2.1902 | -26.9720 |
| 32 | 21.0 | -29.5385 | 27.1793 | 2.4217 | -27.6700 | -29.4990 | 27.1080 | 2.3819 | -27.7030 |
| 33 | 22.0 | -30.0513 | 28.1519 | 2.6145 | -28.3939 | -30.0100 | 28.0790 | 2.5735 | -28.4270 |
| 34 | 23.0 | -30.5684 | 29.1176 | 2.8073 | -29.1131 | -30.5180 | 29.0420 | 2.7650 | -29.1470 |
| 35 | 24.0 | -31.0752 | 30.0770 | 2.9999 | -29.8272 | -31.0230 | 30.0000 | 2.9564 | -29.8620 |
| 36 | 25.0 | -31.5840 | 31.0307 | 3.1922 | -30.5372 | -31.5240 | 30.9500 | 3.1474 | -30.5720 |
| 37 | 26.0 | -32.0846 | 31.9786 | 3.3839 | -31.2424 | -32.0230 | 31.8930 | 3.3377 | -31.2790 |
| 38 | 27.0 | -32.5854 | 32.9209 | 3.5751 | -31.9435 | -32.5180 | 32.8310 | 3.5279 | -31.9810 |
| 39 | 28.0 | -33.0787 | 33.8575 | 3.7656 | -32.6399 | -33.0100 | 33.7640 | 3.7181 | -32.6790 |
| 40 | 29.0 | -33.5711 | 34.7888 | 3.9555 | -33.3323 | -33.4980 | 34.6930 | 3.9079 | -33.3730 |
| 41 | 30.0 | -34.0572 | 35.7144 | 4.1445 | -34.0200 | -33.9820 | 35.6150 | 4.0970 | -34.0620 |
| 42 | 32.0 | -33.9615 | 37.2529 | 4.5245 | -34.8795 | -33.8020 | 37.1300 | 4.4785 | -34.8860 |
| 43 | 34.0 | -33.5544 | 38.3828 | 4.8926 | -35.2566 | -33.4950 | 38.2670 | 4.8454 | -35.3140 |
| 44 | 36.0 | -33.3461 | 39.3421 | 5.2407 | -35.5880 | -33.2310 | 39.2350 | 5.1924 | -35.6470 |
| 45 | 38.0 | -33.1042 | 40.2180 | 5.5668 | -35.8906 | -33.0240 | 40.1220 | 5.5175 | -35.9610 |
| 46 | 40.0 | -32.9923 | 41.0468 | 5.8693 | -36.2066 | -32.8740 | 40.9550 | 5.8187 | -36.2750 |
| 47 | 42.0 | -32.8726 | 41.8327 | 6.1507 | -36.5234 | -32.7770 | 41.7460 | 6.0976 | -36.5960 |
| 48 | 44.0 | -32.8423 | 42.5881 | 6.4118 | -36.8525 | -32.7240 | 42.5000 | 6.3566 | -36.9230 |
| 49 | 46.0 | -32.8095 | 43.3137 | 6.6550 | -37.1840 | -32.7080 | 43.2250 | 6.5982 | -37.2550 |
| 50 | 48.0 | -32.8405 | 44.0140 | 6.8815 | -37.5229 | -32.7230 | 43.9240 | 6.8225 | -37.5920 |
| 51 | 50.0 | -32.8693 | 44.6899 | 7.0932 | -37.8621 | -32.7020 | 44.6000 | 7.0318 | -37.9320 |
| 52 | 52.0 | -32.9445 | 45.3441 | 7.2913 | -38.2049 | -32.8210 | 45.2550 | 7.2276 | -38.2740 |
| 53 | 54.0 | -33.0172 | 45.9777 | 7.4773 | -38.5463 | -32.8970 | 45.8920 | 7.4111 | -38.6170 |
| 54 | 56.0 | -33.1239 | 46.5927 | 7.6523 | -38.8884 | -32.9880 | 46.5100 | 7.5835 | -38.9590 |

| | | | | | | | | | |
|-----|-------|----------|---------|--------|----------|----------|---------|--------|----------|
| 55 | 58.0 | -33.2277 | 47.1898 | 7.8177 | -39.2279 | -33.0920 | 47.1100 | 7.7459 | -39.2990 |
| 56 | 60.0 | -33.3567 | 47.7707 | 7.9742 | -39.5663 | -33.2070 | 47.6920 | 7.8992 | -39.6380 |
| 57 | 62.0 | -33.4821 | 48.3354 | 8.1227 | -39.9013 | -33.3320 | 48.2560 | 8.0446 | -39.9740 |
| 58 | 64.0 | -33.6264 | 48.8861 | 8.2642 | -40.2341 | -33.4650 | 48.8040 | 8.1834 | -40.3060 |
| 59 | 66.0 | -33.7666 | 49.4231 | 8.3993 | -40.5629 | -33.6050 | 49.3370 | 8.3161 | -40.6350 |
| 60 | 68.0 | -33.9210 | 49.9477 | 8.5288 | -40.8890 | -33.7500 | 49.8570 | 8.4432 | -40.9610 |
| 61 | 70.0 | -34.0712 | 50.4601 | 8.6530 | -41.2110 | -33.9000 | 50.3650 | 8.5652 | -41.2830 |
| 62 | 72.0 | -33.1716 | 50.6652 | 8.7774 | -41.0270 | -32.8410 | 50.5220 | 8.6889 | -40.9890 |
| 63 | 74.0 | -31.9743 | 50.4732 | 8.8895 | -40.3746 | -31.7430 | 50.3260 | 8.8000 | -40.3720 |
| 64 | 76.0 | -30.9975 | 50.1233 | 8.9819 | -39.6910 | -30.7120 | 49.9820 | 8.8920 | -39.6850 |
| 65 | 78.0 | -29.9998 | 49.7028 | 9.0532 | -38.9929 | -29.7590 | 49.5660 | 8.9624 | -38.9990 |
| 66 | 80.0 | -29.1513 | 49.2490 | 9.1023 | -38.3231 | -28.8760 | 49.1070 | 9.0107 | -38.3280 |
| 67 | 82.0 | -27.2475 | 48.4707 | 9.1367 | -37.1657 | -26.8460 | 48.2820 | 9.0450 | -37.0670 |
| 68 | 84.0 | -25.1578 | 47.2895 | 9.1446 | -35.5710 | -24.8300 | 47.0930 | 9.0535 | -35.5050 |
| 69 | 86.0 | -23.2899 | 45.9454 | 9.1211 | -33.9653 | -22.9290 | 45.7510 | 9.0314 | -33.8980 |
| 70 | 88.0 | -21.4857 | 44.5307 | 9.0656 | -32.3711 | -21.1520 | 44.3380 | 8.9775 | -32.3120 |
| 71 | 90.0 | -19.8346 | 43.0825 | 8.9790 | -30.8232 | -19.4850 | 42.8860 | 8.8927 | -30.7610 |
| 72 | 92.0 | -18.2538 | 41.6086 | 8.8647 | -29.3122 | -17.9200 | 41.4110 | 8.7798 | -29.2520 |
| 73 | 94.0 | -16.7846 | 40.1214 | 8.7257 | -27.8443 | -16.4450 | 39.9210 | 8.6422 | -27.7810 |
| 74 | 96.0 | -15.3771 | 38.6240 | 8.5651 | -26.4115 | -15.0490 | 38.4210 | 8.4828 | -26.3480 |
| 75 | 98.0 | -14.0538 | 37.1217 | 8.3857 | -25.0150 | -13.7260 | 36.9190 | 8.3046 | -24.9500 |
| 76 | 100.0 | -12.7826 | 35.6166 | 8.1903 | -23.6493 | -12.4650 | 35.4160 | 8.1099 | -23.5850 |
| 77 | 102.0 | -12.6371 | 34.4087 | 7.9764 | -22.8170 | -12.4740 | 34.2540 | 7.8951 | -22.8620 |
| 78 | 104.0 | -12.8284 | 33.5896 | 7.7587 | -22.4760 | -12.5770 | 33.4380 | 7.6773 | -22.4860 |
| 79 | 106.0 | -12.8594 | 32.9228 | 7.5473 | -22.1894 | -12.6600 | 32.7640 | 7.4647 | -22.2020 |
| 80 | 108.0 | -12.9437 | 32.3233 | 7.3455 | -21.9373 | -12.7070 | 32.1560 | 7.2616 | -21.9390 |
| 81 | 110.0 | -12.9272 | 31.7559 | 7.1560 | -21.6771 | -12.7200 | 31.5880 | 7.0701 | -21.6800 |
| 82 | 115.0 | -14.0075 | 30.9389 | 6.7354 | -21.7296 | -13.8960 | 30.9000 | 6.6439 | -21.9120 |
| 83 | 120.0 | -14.9643 | 30.6835 | 6.4128 | -22.1462 | -14.7770 | 30.5900 | 6.3256 | -22.2270 |
| 84 | 125.0 | -15.5760 | 30.5024 | 6.1857 | -22.3708 | -15.4200 | 30.4110 | 6.1013 | -22.4820 |
| 85 | 130.0 | -16.0716 | 30.4079 | 6.0329 | -22.5871 | -15.8910 | 30.3160 | 5.9526 | -22.6880 |
| 86 | 135.0 | -16.4166 | 30.3795 | 5.9343 | -22.7505 | -16.2470 | 30.2810 | 5.8571 | -22.8600 |
| 87 | 140.0 | -16.7008 | 30.3966 | 5.8760 | -22.9044 | -16.5200 | 30.2910 | 5.8000 | -23.0100 |
| 88 | 145.0 | -16.9117 | 30.4501 | 5.8465 | -23.0380 | -16.7390 | 30.3360 | 5.7693 | -23.1440 |
| 89 | 150.0 | -17.0904 | 30.5289 | 5.8374 | -23.1665 | -16.9180 | 30.4090 | 5.7573 | -23.2690 |
| 90 | 155.0 | -17.2315 | 30.6245 | 5.8424 | -23.2842 | -17.0700 | 30.5030 | 5.7576 | -23.3870 |
| 91 | 160.0 | -17.3543 | 30.7328 | 5.8570 | -23.3982 | -17.2040 | 30.6120 | 5.7677 | -23.4990 |
| 92 | 170.0 | -15.3059 | 29.6707 | 5.8574 | -21.9825 | -15.0530 | 29.3330 | 5.7612 | -21.8260 |
| 93 | 180.0 | -13.5596 | 27.8126 | 5.7266 | -20.1197 | -13.4480 | 27.6690 | 5.6095 | -20.2070 |
| 94 | 190.0 | -12.4178 | 26.2241 | 5.4870 | -18.8183 | -12.1740 | 25.9770 | 5.3703 | -18.7610 |
| 95 | 200.0 | -11.2997 | 24.5609 | 5.2107 | -17.4394 | -11.1070 | 24.3140 | 5.0909 | -17.4440 |
| 96 | 210.0 | -10.4549 | 23.0162 | 4.9221 | -16.2804 | -10.1960 | 22.7280 | 4.8003 | -16.2400 |
| 97 | 220.0 | -9.5960 | 21.5343 | 4.6380 | -15.1368 | -9.3954 | 21.2300 | 4.5105 | -15.1250 |
| 98 | 230.0 | -8.9080 | 20.1480 | 4.3655 | -14.1239 | -8.6606 | 19.8350 | 4.2361 | -14.0950 |
| 99 | 240.0 | -8.2045 | 18.8483 | 4.1069 | -13.1516 | -7.9717 | 18.5410 | 3.9791 | -13.1410 |
| 100 | 250.0 | -7.6277 | 17.6317 | 3.8633 | -12.2728 | -7.3423 | 17.3360 | 3.7363 | -12.2560 |
| 101 | 260.0 | -7.0372 | 16.4966 | 3.6343 | -11.4385 | -6.7744 | 16.2130 | 3.5060 | -11.4350 |
| 102 | 270.0 | -6.5486 | 15.4348 | 3.4189 | -10.6771 | -6.2567 | 15.1650 | 3.2882 | -10.6700 |
| 103 | 280.0 | -6.0478 | 14.4436 | 3.2167 | -9.9575 | -5.7771 | 14.1860 | 3.0827 | -9.9580 |
| 104 | 290.0 | -5.6322 | 13.5167 | 3.0263 | -9.2974 | -5.3286 | 13.2650 | 2.8889 | -9.2917 |
| 105 | 300.0 | -5.2050 | 12.6499 | 2.8476 | -8.6747 | -4.9147 | 12.3940 | 2.7070 | -8.6692 |

表7. 5(4) 評価断面5の応力テンソル成分4

FINAS解と簡易計算値との比較 (ホットショック)

断面5の応力成分4

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|----------|--------|---------|----------|----------|--------|---------|----------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.3321 | 0.0092 | -0.0035 | -0.0968 | -0.3999 | 0.0099 | -0.0033 | -0.1080 |
| 3 | 1.0 | -0.9204 | 0.0330 | -0.0136 | -0.3266 | -0.9547 | 0.0335 | -0.0137 | -0.3367 |
| 4 | 1.5 | -1.5133 | 0.0674 | -0.0302 | -0.6263 | -1.5611 | 0.0681 | -0.0302 | -0.6379 |
| 5 | 2.0 | -2.1509 | 0.1110 | -0.0519 | -0.9742 | -2.1880 | 0.1112 | -0.0519 | -0.9852 |
| 6 | 2.5 | -2.7818 | 0.1619 | -0.0779 | -1.3508 | -2.8226 | 0.1617 | -0.0779 | -1.3620 |
| 7 | 3.0 | -3.4225 | 0.2189 | -0.1076 | -1.7474 | -3.4582 | 0.2182 | -0.1076 | -1.7578 |
| 8 | 3.5 | -4.0547 | 0.2809 | -0.1405 | -2.1559 | -4.0908 | 0.2794 | -0.1405 | -2.1658 |
| 9 | 4.0 | -4.6862 | 0.3468 | -0.1761 | -2.5726 | -4.7186 | 0.3448 | -0.1760 | -2.5816 |
| 10 | 4.5 | -5.3091 | 0.4160 | -0.2141 | -2.9937 | -5.3412 | 0.4138 | -0.2139 | -3.0025 |
| 11 | 5.0 | -5.9278 | 0.4878 | -0.2542 | -3.4174 | -5.9573 | 0.4857 | -0.2539 | -3.4257 |
| 12 | 5.5 | -6.5385 | 0.5619 | -0.2962 | -3.8421 | -6.5667 | 0.5599 | -0.2958 | -3.8497 |
| 13 | 6.0 | -7.1437 | 0.6377 | -0.3399 | -4.2668 | -7.1695 | 0.6359 | -0.3393 | -4.2736 |
| 14 | 6.5 | -7.7420 | 0.7152 | -0.3850 | -4.6906 | -7.7659 | 0.7131 | -0.3844 | -4.6967 |
| 15 | 7.0 | -8.3343 | 0.7941 | -0.4315 | -5.1132 | -8.3564 | 0.7917 | -0.4307 | -5.1184 |
| 16 | 7.5 | -8.9201 | 0.8741 | -0.4792 | -5.5339 | -8.9412 | 0.8716 | -0.4783 | -5.5385 |
| 17 | 8.0 | -9.5001 | 0.9550 | -0.5280 | -5.9526 | -9.5203 | 0.9524 | -0.5270 | -5.9567 |
| 18 | 8.5 | -10.0742 | 1.0370 | -0.5779 | -6.3690 | -10.0940 | 1.0340 | -0.5767 | -6.3728 |
| 19 | 9.0 | -10.6428 | 1.1196 | -0.6286 | -6.7831 | -10.6620 | 1.1165 | -0.6274 | -6.7864 |
| 20 | 9.5 | -11.2058 | 1.2030 | -0.6802 | -7.1946 | -11.2250 | 1.1999 | -0.6789 | -7.1975 |
| 21 | 10.0 | -11.7634 | 1.2870 | -0.7326 | -7.6035 | -11.7820 | 1.2838 | -0.7313 | -7.6061 |
| 22 | 11.0 | -12.4440 | 1.4408 | -0.8328 | -8.2623 | -12.4310 | 1.4367 | -0.8314 | -8.2560 |
| 23 | 12.0 | -12.8621 | 1.5730 | -0.9235 | -8.7314 | -12.8970 | 1.5684 | -0.9219 | -8.7330 |
| 24 | 13.0 | -13.3062 | 1.6919 | -1.0072 | -9.1329 | -13.3250 | 1.6875 | -1.0059 | -9.1362 |
| 25 | 14.0 | -13.7047 | 1.8016 | -1.0867 | -9.4960 | -13.7400 | 1.7987 | -1.0856 | -9.5033 |
| 26 | 15.0 | -14.1211 | 1.9058 | -1.1631 | -9.8417 | -14.1490 | 1.9041 | -1.1624 | -9.8500 |
| 27 | 16.0 | -14.5193 | 2.0062 | -1.2374 | -10.1744 | -14.5550 | 2.0057 | -1.2371 | -10.1850 |
| 28 | 17.0 | -14.9276 | 2.1041 | -1.3102 | -10.5003 | -14.9580 | 2.1047 | -1.3102 | -10.5110 |
| 29 | 18.0 | -15.3253 | 2.2002 | -1.3818 | -10.8200 | -15.3590 | 2.2018 | -1.3820 | -10.8310 |
| 30 | 19.0 | -15.7284 | 2.2949 | -1.4525 | -11.1359 | -15.7580 | 2.2975 | -1.4529 | -11.1460 |
| 31 | 20.0 | -16.1242 | 2.3886 | -1.5227 | -11.4478 | -16.1560 | 2.3923 | -1.5232 | -11.4580 |
| 32 | 21.0 | -16.5227 | 2.4815 | -1.5924 | -11.7573 | -16.5500 | 2.4864 | -1.5930 | -11.7670 |
| 33 | 22.0 | -16.9159 | 2.5737 | -1.6616 | -12.0638 | -16.9420 | 2.5796 | -1.6623 | -12.0730 |
| 34 | 23.0 | -17.3103 | 2.6653 | -1.7306 | -12.3683 | -17.3330 | 2.6720 | -1.7313 | -12.3770 |
| 35 | 24.0 | -17.7001 | 2.7564 | -1.7993 | -12.6703 | -17.7220 | 2.7636 | -1.7999 | -12.6780 |
| 36 | 25.0 | -18.0903 | 2.8470 | -1.8677 | -12.9706 | -18.1080 | 2.8546 | -1.8682 | -12.9770 |
| 37 | 26.0 | -18.4766 | 2.9372 | -1.9359 | -13.2687 | -18.4930 | 2.9453 | -1.9363 | -13.2750 |
| 38 | 27.0 | -18.8624 | 3.0270 | -2.0039 | -13.5650 | -18.8760 | 3.0356 | -2.0043 | -13.5700 |
| 39 | 28.0 | -19.2450 | 3.1165 | -2.0716 | -13.8595 | -19.2570 | 3.1250 | -2.0720 | -13.8640 |
| 40 | 29.0 | -19.6266 | 3.2055 | -2.1392 | -14.1522 | -19.6360 | 3.2138 | -2.1396 | -14.1560 |
| 41 | 30.0 | -20.0052 | 3.2942 | -2.2065 | -14.4430 | -20.0130 | 3.3016 | -2.2070 | -14.4460 |
| 42 | 32.0 | -20.2608 | 3.4448 | -2.3285 | -14.8009 | -20.2260 | 3.4495 | -2.3287 | -14.7860 |
| 43 | 34.0 | -20.3139 | 3.5601 | -2.4304 | -14.9493 | -20.3310 | 3.5654 | -2.4310 | -14.9560 |
| 44 | 36.0 | -20.4573 | 3.6599 | -2.5212 | -15.0869 | -20.4470 | 3.6660 | -2.5222 | -15.0950 |
| 45 | 38.0 | -20.5751 | 3.7514 | -2.6051 | -15.2170 | -20.5790 | 3.7593 | -2.6062 | -15.2290 |
| 46 | 40.0 | -20.7375 | 3.8383 | -2.6836 | -15.3524 | -20.7250 | 3.8475 | -2.6849 | -15.3640 |
| 47 | 42.0 | -20.8885 | 3.9211 | -2.7581 | -15.4891 | -20.8830 | 3.9316 | -2.7594 | -15.5020 |
| 48 | 44.0 | -21.0661 | 4.0010 | -2.8292 | -15.6308 | -21.0510 | 4.0117 | -2.8303 | -15.6440 |
| 49 | 46.0 | -21.2367 | 4.0781 | -2.8973 | -15.7743 | -21.2260 | 4.0883 | -2.8984 | -15.7880 |
| 50 | 48.0 | -21.4243 | 4.1529 | -2.9627 | -15.9211 | -21.4060 | 4.1625 | -2.9637 | -15.9350 |
| 51 | 50.0 | -21.6061 | 4.2254 | -3.0256 | -16.0688 | -21.5890 | 4.2350 | -3.0265 | -16.0830 |
| 52 | 52.0 | -21.7988 | 4.2960 | -3.0862 | -16.2182 | -21.7730 | 4.3059 | -3.0871 | -16.2330 |
| 53 | 54.0 | -21.9862 | 4.3645 | -3.1447 | -16.3677 | -21.9590 | 4.3756 | -3.1455 | -16.3830 |
| 54 | 56.0 | -22.1809 | 4.4313 | -3.2013 | -16.5179 | -22.1450 | 4.4436 | -3.2019 | -16.5330 |

| | | | | | | | | | |
|-----|-------|----------|--------|---------|----------|----------|--------|---------|----------|
| 55 | 58.0 | -22.3705 | 4.4963 | -3.2560 | -16.6673 | -22.3320 | 4.5099 | -3.2565 | -16.6830 |
| 56 | 60.0 | -22.5646 | 4.5597 | -3.3091 | -16.8166 | -22.5190 | 4.5747 | -3.3094 | -16.8330 |
| 57 | 62.0 | -22.7536 | 4.6216 | -3.3605 | -16.9646 | -22.7060 | 4.6377 | -3.3607 | -16.9810 |
| 58 | 64.0 | -22.9456 | 4.6819 | -3.4104 | -17.1119 | -22.8910 | 4.6990 | -3.4106 | -17.1290 |
| 59 | 66.0 | -23.1328 | 4.7409 | -3.4589 | -17.2577 | -23.0750 | 4.7585 | -3.4592 | -17.2750 |
| 60 | 68.0 | -23.3215 | 4.7986 | -3.5061 | -17.4024 | -23.2570 | 4.8167 | -3.5064 | -17.4190 |
| 61 | 70.0 | -23.5059 | 4.8549 | -3.5521 | -17.5455 | -23.4380 | 4.8741 | -3.5524 | -17.5620 |
| 62 | 72.0 | -23.1945 | 4.8845 | -3.5849 | -17.4688 | -23.0300 | 4.9015 | -3.5837 | -17.4340 |
| 63 | 74.0 | -22.6860 | 4.8791 | -3.5976 | -17.1880 | -22.5740 | 4.8986 | -3.5962 | -17.1720 |
| 64 | 76.0 | -22.2762 | 4.8585 | -3.5991 | -16.9021 | -22.1380 | 4.8808 | -3.5979 | -16.8870 |
| 65 | 78.0 | -21.8464 | 4.8304 | -3.5938 | -16.6142 | -21.7250 | 4.8556 | -3.5927 | -16.6030 |
| 66 | 80.0 | -21.4697 | 4.7982 | -3.5834 | -16.3372 | -21.3310 | 4.8254 | -3.5824 | -16.3260 |
| 67 | 82.0 | -20.5916 | 4.7370 | -3.5572 | -15.8488 | -20.3660 | 4.7628 | -3.5545 | -15.7870 |
| 68 | 84.0 | -19.5550 | 4.6400 | -3.5090 | -15.1686 | -19.3710 | 4.6675 | -3.5060 | -15.1250 |
| 69 | 86.0 | -18.6167 | 4.5270 | -3.4480 | -14.4919 | -18.4120 | 4.5555 | -3.4452 | -14.4500 |
| 70 | 88.0 | -17.6875 | 4.4061 | -3.3790 | -13.8239 | -17.4930 | 4.4360 | -3.3763 | -13.7870 |
| 71 | 90.0 | -16.8124 | 4.2808 | -3.3040 | -13.1749 | -16.6080 | 4.3117 | -3.3014 | -13.1390 |
| 72 | 92.0 | -15.9546 | 4.1522 | -3.2244 | -12.5417 | -15.7550 | 4.1843 | -3.2219 | -12.5080 |
| 73 | 94.0 | -15.1337 | 4.0214 | -3.1412 | -11.9263 | -14.9280 | 4.0542 | -3.1387 | -11.8940 |
| 74 | 96.0 | -14.3301 | 3.8888 | -3.0549 | -11.3258 | -14.1260 | 3.9216 | -3.0524 | -11.2950 |
| 75 | 98.0 | -13.5541 | 3.7551 | -2.9661 | -10.7404 | -13.3460 | 3.7884 | -2.9636 | -10.7110 |
| 76 | 100.0 | -12.7940 | 3.6205 | -2.8752 | -10.1683 | -12.5860 | 3.6551 | -2.8726 | -10.1400 |
| 77 | 102.0 | -12.5518 | 3.5109 | -2.7946 | -9.8274 | -12.4320 | 3.5507 | -2.7934 | -9.8524 |
| 78 | 104.0 | -12.5168 | 3.4345 | -2.7315 | -9.7004 | -12.3410 | 3.4754 | -2.7305 | -9.7091 |
| 79 | 106.0 | -12.4005 | 3.3719 | -2.6774 | -9.5881 | -12.2460 | 3.4138 | -2.6760 | -9.5979 |
| 80 | 108.0 | -12.3132 | 3.3159 | -2.6281 | -9.4864 | -12.1390 | 3.3580 | -2.6265 | -9.4940 |
| 81 | 110.0 | -12.1874 | 3.2630 | -2.5823 | -9.3819 | -12.0230 | 3.3062 | -2.5803 | -9.3910 |
| 82 | 115.0 | -12.4426 | 3.1832 | -2.4994 | -9.4229 | -12.3400 | 3.2400 | -2.5026 | -9.5154 |
| 83 | 120.0 | -12.7302 | 3.1535 | -2.4531 | -9.6148 | -12.5740 | 3.2089 | -2.4550 | -9.6601 |
| 84 | 125.0 | -12.8808 | 3.1315 | -2.4201 | -9.7149 | -12.7440 | 3.1903 | -2.4222 | -9.7759 |
| 85 | 130.0 | -13.0310 | 3.1170 | -2.3971 | -9.8144 | -12.8730 | 3.1797 | -2.3999 | -9.8657 |
| 86 | 135.0 | -13.1298 | 3.1084 | -2.3819 | -9.8867 | -12.9770 | 3.1734 | -2.3852 | -9.9391 |
| 87 | 140.0 | -13.2286 | 3.1043 | -2.3726 | -9.9539 | -13.0680 | 3.1716 | -2.3763 | -10.0020 |
| 88 | 145.0 | -13.3053 | 3.1038 | -2.3680 | -10.0113 | -13.1490 | 3.1718 | -2.3718 | -10.0590 |
| 89 | 150.0 | -13.3829 | 3.1064 | -2.3670 | -10.0658 | -13.2220 | 3.1751 | -2.3706 | -10.1140 |
| 90 | 155.0 | -13.4497 | 3.1111 | -2.3688 | -10.1158 | -13.2880 | 3.1799 | -2.3720 | -10.1640 |
| 91 | 160.0 | -13.5168 | 3.1175 | -2.3724 | -10.1640 | -13.3490 | 3.1857 | -2.3752 | -10.2100 |
| 92 | 170.0 | -12.4955 | 3.0185 | -2.3183 | -9.5558 | -12.2400 | 3.0689 | -2.3090 | -9.4887 |
| 93 | 180.0 | -11.5030 | 2.8452 | -2.2085 | -8.7688 | -11.3150 | 2.9177 | -2.2061 | -8.8036 |
| 94 | 190.0 | -10.7680 | 2.6927 | -2.0996 | -8.2217 | -10.5040 | 2.7595 | -2.0945 | -8.1949 |
| 95 | 200.0 | -9.9993 | 2.5336 | -1.9847 | -7.6353 | -9.7687 | 2.6006 | -1.9799 | -7.6428 |
| 96 | 210.0 | -9.3702 | 2.3829 | -1.8719 | -7.1487 | -9.0919 | 2.4489 | -1.8663 | -7.1369 |
| 97 | 220.0 | -8.7222 | 2.2369 | -1.7620 | -6.6604 | -8.4620 | 2.3030 | -1.7553 | -6.6659 |
| 98 | 230.0 | -8.1713 | 2.0987 | -1.6568 | -6.2302 | -7.8790 | 2.1667 | -1.6494 | -6.2281 |
| 99 | 240.0 | -7.6155 | 1.9678 | -1.5568 | -5.8130 | -7.3419 | 2.0389 | -1.5493 | -5.8214 |
| 100 | 250.0 | -7.1344 | 1.8446 | -1.4622 | -5.4362 | -6.8440 | 1.9183 | -1.4547 | -5.4431 |
| 101 | 260.0 | -6.6545 | 1.7287 | -1.3729 | -5.0765 | -6.3787 | 1.8054 | -1.3649 | -5.0903 |
| 102 | 270.0 | -6.2346 | 1.6197 | -1.2888 | -4.7475 | -5.9429 | 1.7008 | -1.2799 | -4.7604 |
| 103 | 280.0 | -5.8182 | 1.5174 | -1.2097 | -4.4357 | -5.5345 | 1.6042 | -1.1995 | -4.4522 |
| 104 | 290.0 | -5.4517 | 1.4215 | -1.1351 | -4.1486 | -5.1530 | 1.5121 | -1.1239 | -4.1633 |
| 105 | 300.0 | -5.0895 | 1.3315 | -1.0652 | -3.8775 | -4.7972 | 1.4231 | -1.0533 | -3.8932 |

表7. 6(1) 評価断面6の応力テンソル成分1

FINAS解と簡易計算値との比較 (ホットショック)

断面6の応力成分1

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|---------|---------|--------|---------|---------|---------|--------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.2194 | -0.0002 | 0.0060 | -0.0072 | -0.2539 | -0.0002 | 0.0051 | -0.0107 |
| 3 | 1.0 | -0.3926 | -0.0006 | 0.0310 | -0.0041 | -0.3902 | -0.0006 | 0.0314 | -0.0043 |
| 4 | 1.5 | -0.4586 | -0.0012 | 0.0726 | 0.0124 | -0.4847 | -0.0012 | 0.0724 | 0.0111 |
| 5 | 2.0 | -0.5534 | -0.0020 | 0.1239 | 0.0303 | -0.5559 | -0.0020 | 0.1241 | 0.0304 |
| 6 | 2.5 | -0.5985 | -0.0030 | 0.1841 | 0.0507 | -0.6157 | -0.0030 | 0.1840 | 0.0503 |
| 7 | 3.0 | -0.6607 | -0.0041 | 0.2509 | 0.0701 | -0.6644 | -0.0040 | 0.2508 | 0.0703 |
| 8 | 3.5 | -0.6985 | -0.0053 | 0.3239 | 0.0892 | -0.7086 | -0.0053 | 0.3236 | 0.0892 |
| 9 | 4.0 | -0.7449 | -0.0068 | 0.4018 | 0.1064 | -0.7487 | -0.0066 | 0.4016 | 0.1067 |
| 10 | 4.5 | -0.7793 | -0.0085 | 0.4843 | 0.1221 | -0.7853 | -0.0084 | 0.4842 | 0.1222 |
| 11 | 5.0 | -0.8170 | -0.0101 | 0.5705 | 0.1355 | -0.8187 | -0.0108 | 0.5709 | 0.1355 |
| 12 | 5.5 | -0.8482 | -0.0121 | 0.6600 | 0.1469 | -0.8502 | -0.0136 | 0.6604 | 0.1466 |
| 13 | 6.0 | -0.8807 | -0.0140 | 0.7522 | 0.1558 | -0.8802 | -0.0168 | 0.7525 | 0.1555 |
| 14 | 6.5 | -0.9101 | -0.0162 | 0.8467 | 0.1624 | -0.9089 | -0.0202 | 0.8467 | 0.1620 |
| 15 | 7.0 | -0.9394 | -0.0188 | 0.9431 | 0.1668 | -0.9359 | -0.0234 | 0.9426 | 0.1659 |
| 16 | 7.5 | -0.9667 | -0.0211 | 1.0407 | 0.1689 | -0.9616 | -0.0265 | 1.0399 | 0.1674 |
| 17 | 8.0 | -0.9935 | -0.0233 | 1.1394 | 0.1687 | -0.9857 | -0.0298 | 1.1380 | 0.1667 |
| 18 | 8.5 | -1.0186 | -0.0259 | 1.2389 | 0.1664 | -1.0084 | -0.0333 | 1.2366 | 0.1638 |
| 19 | 9.0 | -1.0437 | -0.0286 | 1.3388 | 0.1621 | -1.0308 | -0.0369 | 1.3358 | 0.1588 |
| 20 | 9.5 | -1.0678 | -0.0314 | 1.4389 | 0.1559 | -1.0528 | -0.0404 | 1.4352 | 0.1518 |
| 21 | 10.0 | -1.0909 | -0.0342 | 1.5391 | 0.1479 | -1.0742 | -0.0441 | 1.5344 | 0.1431 |
| 22 | 11.0 | -0.9428 | -0.0392 | 1.7238 | 0.1293 | -0.9625 | -0.0523 | 1.7170 | 0.1236 |
| 23 | 12.0 | -0.8949 | -0.0439 | 1.8753 | 0.0869 | -0.8574 | -0.0615 | 1.8666 | 0.0784 |
| 24 | 13.0 | -0.8972 | -0.0478 | 2.0056 | 0.0328 | -0.8417 | -0.0701 | 1.9963 | 0.0251 |
| 25 | 14.0 | -0.8765 | -0.0515 | 2.1221 | -0.0205 | -0.8375 | -0.0783 | 2.1106 | -0.0310 |
| 26 | 15.0 | -0.8921 | -0.0544 | 2.2249 | -0.0763 | -0.8395 | -0.0855 | 2.2122 | -0.0872 |
| 27 | 16.0 | -0.8818 | -0.0566 | 2.3177 | -0.1294 | -0.8446 | -0.0914 | 2.3035 | -0.1420 |
| 28 | 17.0 | -0.8977 | -0.0581 | 2.4013 | -0.1818 | -0.8512 | -0.0934 | 2.3864 | -0.1950 |
| 29 | 18.0 | -0.8940 | -0.0588 | 2.4780 | -0.2311 | -0.8600 | -0.1010 | 2.4624 | -0.2459 |
| 30 | 19.0 | -0.9085 | -0.0594 | 2.5487 | -0.2790 | -0.8691 | -0.1046 | 2.5330 | -0.2946 |
| 31 | 20.0 | -0.9087 | -0.0594 | 2.6148 | -0.3243 | -0.8785 | -0.1071 | 2.5990 | -0.3417 |
| 32 | 21.0 | -0.9215 | -0.0591 | 2.6769 | -0.3680 | -0.8886 | -0.1080 | 2.6615 | -0.3873 |
| 33 | 22.0 | -0.9240 | -0.0586 | 2.7360 | -0.4097 | -0.8982 | -0.1075 | 2.7208 | -0.4311 |
| 34 | 23.0 | -0.9353 | -0.0575 | 2.7924 | -0.4501 | -0.9070 | -0.1067 | 2.7777 | -0.4732 |
| 35 | 24.0 | -0.9395 | -0.0564 | 2.8467 | -0.4891 | -0.9146 | -0.1059 | 2.8325 | -0.5135 |
| 36 | 25.0 | -0.9499 | -0.0551 | 2.8990 | -0.5271 | -0.9211 | -0.1051 | 2.8855 | -0.5523 |
| 37 | 26.0 | -0.9554 | -0.0536 | 2.9499 | -0.5639 | -0.9269 | -0.1043 | 2.9368 | -0.5901 |
| 38 | 27.0 | -0.9650 | -0.0519 | 2.9993 | -0.5999 | -0.9325 | -0.1035 | 2.9869 | -0.6267 |
| 39 | 28.0 | -0.9709 | -0.0507 | 3.0476 | -0.6350 | -0.9377 | -0.1020 | 3.0358 | -0.6619 |
| 40 | 29.0 | -0.9801 | -0.0491 | 3.0947 | -0.6695 | -0.9430 | -0.1004 | 3.0835 | -0.6963 |
| 41 | 30.0 | -0.9866 | -0.0476 | 3.1410 | -0.7033 | -0.9482 | -0.0990 | 3.1301 | -0.7299 |
| 42 | 32.0 | -0.8497 | -0.0436 | 3.2032 | -0.7736 | -0.8103 | -0.0959 | 3.1920 | -0.8001 |
| 43 | 34.0 | -0.8302 | -0.0387 | 3.2187 | -0.8595 | -0.7685 | -0.0914 | 3.2100 | -0.8842 |
| 44 | 36.0 | -0.8134 | -0.0333 | 3.2153 | -0.9357 | -0.7469 | -0.0849 | 3.2059 | -0.9623 |
| 45 | 38.0 | -0.7938 | -0.0275 | 3.2003 | -0.9999 | -0.7337 | -0.0778 | 3.1895 | -1.0308 |
| 46 | 40.0 | -0.7919 | -0.0212 | 3.1788 | -1.0561 | -0.7256 | -0.0706 | 3.1680 | -1.0893 |
| 47 | 42.0 | -0.7753 | -0.0148 | 3.1566 | -1.1024 | -0.7184 | -0.0629 | 3.1455 | -1.1393 |
| 48 | 44.0 | -0.7783 | -0.0085 | 3.1345 | -1.1442 | -0.7128 | -0.0553 | 3.1235 | -1.1820 |
| 49 | 46.0 | -0.7650 | -0.0026 | 3.1149 | -1.1799 | -0.7073 | -0.0482 | 3.1033 | -1.2191 |
| 50 | 48.0 | -0.7696 | 0.0031 | 3.0973 | -1.2130 | -0.7030 | -0.0423 | 3.0860 | -1.2521 |
| 51 | 50.0 | -0.7591 | 0.0081 | 3.0827 | -1.2423 | -0.7005 | -0.0383 | 3.0714 | -1.2820 |
| 52 | 52.0 | -0.7645 | 0.0129 | 3.0702 | -1.2702 | -0.6989 | -0.0361 | 3.0591 | -1.3093 |
| 53 | 54.0 | -0.7565 | 0.0169 | 3.0604 | -1.2955 | -0.6976 | -0.0353 | 3.0492 | -1.3346 |
| 54 | 56.0 | -0.7622 | 0.0210 | 3.0525 | -1.3200 | -0.6965 | -0.0354 | 3.0414 | -1.3583 |

| | | | | | | | | | |
|-----|-------|---------|--------|--------|---------|---------|---------|--------|---------|
| 55 | 58.0 | -0.7561 | 0.0247 | 3.0469 | -1.3428 | -0.6944 | -0.0358 | 3.0354 | -1.3806 |
| 56 | 60.0 | -0.7616 | 0.0283 | 3.0428 | -1.3649 | -0.6909 | -0.0365 | 3.0310 | -1.4014 |
| 57 | 62.0 | -0.7572 | 0.0314 | 3.0405 | -1.3858 | -0.6873 | -0.0374 | 3.0280 | -1.4211 |
| 58 | 64.0 | -0.7624 | 0.0343 | 3.0396 | -1.4062 | -0.6842 | -0.0386 | 3.0263 | -1.4402 |
| 59 | 66.0 | -0.7591 | 0.0368 | 3.0399 | -1.4256 | -0.6811 | -0.0399 | 3.0258 | -1.4588 |
| 60 | 68.0 | -0.7639 | 0.0395 | 3.0413 | -1.4448 | -0.6770 | -0.0416 | 3.0263 | -1.4770 |
| 61 | 70.0 | -0.7616 | 0.0418 | 3.0438 | -1.4632 | -0.6723 | -0.0437 | 3.0273 | -1.4952 |
| 62 | 72.0 | -0.6133 | 0.0444 | 3.0193 | -1.4854 | -0.5561 | -0.0455 | 2.9943 | -1.5251 |
| 63 | 74.0 | -0.5784 | 0.0477 | 2.9522 | -1.5246 | -0.5053 | -0.0468 | 2.9262 | -1.5626 |
| 64 | 76.0 | -0.5501 | 0.0513 | 2.8694 | -1.5552 | -0.4682 | -0.0467 | 2.8402 | -1.5921 |
| 65 | 78.0 | -0.5162 | 0.0552 | 2.7783 | -1.5746 | -0.4368 | -0.0462 | 2.7465 | -1.6115 |
| 66 | 80.0 | -0.5032 | 0.0595 | 2.6835 | -1.5870 | -0.4087 | -0.0452 | 2.6506 | -1.6215 |
| 67 | 82.0 | -0.3200 | 0.0642 | 2.5628 | -1.5944 | -0.2723 | -0.0423 | 2.5221 | -1.6362 |
| 68 | 84.0 | -0.2791 | 0.0694 | 2.4010 | -1.6155 | -0.2033 | -0.0389 | 2.3612 | -1.6530 |
| 69 | 86.0 | -0.2203 | 0.0745 | 2.2280 | -1.6226 | -0.1498 | -0.0340 | 2.1862 | -1.6580 |
| 70 | 88.0 | -0.1815 | 0.0799 | 2.0499 | -1.6173 | -0.1053 | -0.0288 | 2.0076 | -1.6504 |
| 71 | 90.0 | -0.1420 | 0.0853 | 1.8729 | -1.6018 | -0.0676 | -0.0232 | 1.8309 | -1.6318 |
| 72 | 92.0 | -0.1082 | 0.0904 | 1.7012 | -1.5768 | -0.0340 | -0.0170 | 1.6598 | -1.6046 |
| 73 | 94.0 | -0.0775 | 0.0948 | 1.5363 | -1.5459 | -0.0036 | -0.0116 | 1.4953 | -1.5712 |
| 74 | 96.0 | -0.0476 | 0.0984 | 1.3796 | -1.5096 | 0.0245 | -0.0064 | 1.3381 | -1.5333 |
| 75 | 98.0 | -0.0220 | 0.1016 | 1.2306 | -1.4702 | 0.0516 | -0.0010 | 1.1892 | -1.4916 |
| 76 | 100.0 | 0.0045 | 0.1041 | 1.0895 | -1.4278 | 0.0781 | 0.0046 | 1.0481 | -1.4470 |
| 77 | 102.0 | -0.1263 | 0.1052 | 0.9833 | -1.3797 | -0.0070 | 0.0092 | 0.9489 | -1.3879 |
| 78 | 104.0 | -0.1363 | 0.1052 | 0.9277 | -1.3124 | -0.0289 | 0.0124 | 0.8922 | -1.3199 |
| 79 | 106.0 | -0.1491 | 0.1041 | 0.8947 | -1.2527 | -0.0387 | 0.0140 | 0.8602 | -1.2587 |
| 80 | 108.0 | -0.1612 | 0.1020 | 0.8768 | -1.2028 | -0.0448 | 0.0138 | 0.8424 | -1.2067 |
| 81 | 110.0 | -0.1601 | 0.0993 | 0.8683 | -1.1595 | -0.0497 | 0.0115 | 0.8324 | -1.1634 |
| 82 | 115.0 | -0.2751 | 0.0903 | 0.9093 | -1.0704 | -0.1132 | -0.0019 | 0.8845 | -1.0593 |
| 83 | 120.0 | -0.2689 | 0.0799 | 1.0057 | -1.0028 | -0.1404 | -0.0172 | 0.9751 | -0.9952 |
| 84 | 125.0 | -0.3078 | 0.0703 | 1.0927 | -0.9753 | -0.1569 | -0.0304 | 1.0607 | -0.9609 |
| 85 | 130.0 | -0.3065 | 0.0625 | 1.1673 | -0.9590 | -0.1692 | -0.0409 | 1.1312 | -0.9435 |
| 86 | 135.0 | -0.3269 | 0.0571 | 1.2249 | -0.9529 | -0.1798 | -0.0465 | 1.1880 | -0.9363 |
| 87 | 140.0 | -0.3258 | 0.0530 | 1.2722 | -0.9492 | -0.1937 | -0.0494 | 1.2345 | -0.9344 |
| 88 | 145.0 | -0.3382 | 0.0499 | 1.3100 | -0.9490 | -0.2063 | -0.0500 | 1.2736 | -0.9342 |
| 89 | 150.0 | -0.3370 | 0.0478 | 1.3413 | -0.9497 | -0.2192 | -0.0507 | 1.3059 | -0.9346 |
| 90 | 155.0 | -0.3456 | 0.0461 | 1.3671 | -0.9517 | -0.2290 | -0.0514 | 1.3335 | -0.9348 |
| 91 | 160.0 | -0.3441 | 0.0451 | 1.3888 | -0.9542 | -0.2329 | -0.0524 | 1.3568 | -0.9345 |
| 92 | 170.0 | -0.2126 | 0.0466 | 1.2901 | -0.9719 | -0.1569 | -0.0537 | 1.2320 | -0.9548 |
| 93 | 180.0 | -0.2254 | 0.0507 | 1.1053 | -0.9534 | -0.1181 | -0.0570 | 1.0720 | -0.9148 |
| 94 | 190.0 | -0.1743 | 0.0524 | 0.9815 | -0.8890 | -0.0861 | -0.0709 | 0.9403 | -0.8585 |
| 95 | 200.0 | -0.1756 | 0.0510 | 0.8814 | -0.8397 | -0.0642 | -0.0869 | 0.8365 | -0.8012 |
| 96 | 210.0 | -0.1480 | 0.0486 | 0.8020 | -0.7841 | -0.0425 | -0.0985 | 0.7531 | -0.7462 |
| 97 | 220.0 | -0.1440 | 0.0459 | 0.7318 | -0.7355 | -0.0233 | -0.1082 | 0.6804 | -0.6933 |
| 98 | 230.0 | -0.1273 | 0.0427 | 0.6736 | -0.6870 | -0.0070 | -0.1162 | 0.6178 | -0.6435 |
| 99 | 240.0 | -0.1203 | 0.0397 | 0.6202 | -0.6432 | 0.0080 | -0.1219 | 0.5647 | -0.5967 |
| 100 | 250.0 | -0.1098 | 0.0370 | 0.5741 | -0.6009 | 0.0232 | -0.1264 | 0.5178 | -0.5534 |
| 101 | 260.0 | -0.1018 | 0.0345 | 0.5314 | -0.5622 | 0.0412 | -0.1306 | 0.4752 | -0.5122 |
| 102 | 270.0 | -0.0951 | 0.0321 | 0.4935 | -0.5256 | 0.0568 | -0.1358 | 0.4374 | -0.4705 |
| 103 | 280.0 | -0.0863 | 0.0301 | 0.4584 | -0.4915 | 0.0703 | -0.1408 | 0.4039 | -0.4273 |
| 104 | 290.0 | -0.0824 | 0.0279 | 0.4266 | -0.4596 | 0.0874 | -0.1444 | 0.3730 | -0.3862 |
| 105 | 300.0 | -0.0735 | 0.0260 | 0.3972 | -0.4295 | 0.1089 | -0.1461 | 0.3446 | -0.3497 |

表 7. 6 (2) 評価断面6の応力テンソル成分2

FINAS解と簡易計算値との比較 (ホットショック)

断面6の応力成分2

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|----------|---------|---------|----------|----------|---------|---------|----------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.8225 | -0.0186 | -0.0052 | -0.0480 | -0.9783 | -0.0197 | -0.0063 | -0.0544 |
| 3 | 1.0 | -2.1476 | -0.0674 | -0.0149 | -0.1580 | -2.2121 | -0.0680 | -0.0153 | -0.1619 |
| 4 | 1.5 | -3.4284 | -0.1389 | -0.0249 | -0.3002 | -3.5362 | -0.1394 | -0.0251 | -0.3042 |
| 5 | 2.0 | -4.8274 | -0.2303 | -0.0356 | -0.4707 | -4.9013 | -0.2306 | -0.0354 | -0.4735 |
| 6 | 2.5 | -6.1912 | -0.3393 | -0.0465 | -0.6620 | -6.2853 | -0.3395 | -0.0462 | -0.6646 |
| 7 | 3.0 | -7.5942 | -0.4649 | -0.0576 | -0.8712 | -7.6698 | -0.4652 | -0.0571 | -0.8730 |
| 8 | 3.5 | -8.9679 | -0.6057 | -0.0690 | -1.0949 | -9.0504 | -0.6062 | -0.0682 | -1.0959 |
| 9 | 4.0 | -10.3494 | -0.7608 | -0.0806 | -1.3309 | -10.4230 | -0.7617 | -0.0796 | -1.3314 |
| 10 | 4.5 | -11.7061 | -0.9294 | -0.0925 | -1.5775 | -11.7820 | -0.9319 | -0.0911 | -1.5771 |
| 11 | 5.0 | -13.0559 | -1.1104 | -0.1046 | -1.8333 | -13.1260 | -1.1168 | -0.1032 | -1.8314 |
| 12 | 5.5 | -14.3834 | -1.3031 | -0.1170 | -2.0968 | -14.4540 | -1.3140 | -0.1158 | -2.0937 |
| 13 | 6.0 | -15.6980 | -1.5065 | -0.1297 | -2.3675 | -15.7660 | -1.5220 | -0.1289 | -2.3628 |
| 14 | 6.5 | -16.9922 | -1.7191 | -0.1427 | -2.6443 | -17.0590 | -1.7393 | -0.1423 | -2.6382 |
| 15 | 7.0 | -18.2703 | -1.9407 | -0.1561 | -2.9266 | -18.3340 | -1.9646 | -0.1559 | -2.9193 |
| 16 | 7.5 | -19.5289 | -2.1697 | -0.1698 | -3.2137 | -19.5900 | -2.1968 | -0.1698 | -3.2054 |
| 17 | 8.0 | -20.7702 | -2.4052 | -0.1838 | -3.5052 | -20.8270 | -2.4350 | -0.1840 | -3.4958 |
| 18 | 8.5 | -21.9928 | -2.6459 | -0.1982 | -3.8008 | -22.0470 | -2.6791 | -0.1987 | -3.7903 |
| 19 | 9.0 | -23.1985 | -2.8915 | -0.2129 | -4.0998 | -23.2490 | -2.9280 | -0.2137 | -4.0884 |
| 20 | 9.5 | -24.3861 | -3.1409 | -0.2278 | -4.4020 | -24.4350 | -3.1803 | -0.2290 | -4.3899 |
| 21 | 10.0 | -25.5565 | -3.3930 | -0.2431 | -4.7072 | -25.6040 | -3.4346 | -0.2446 | -4.6944 |
| 22 | 11.0 | -26.8586 | -3.8700 | -0.2677 | -5.2515 | -26.8280 | -3.9168 | -0.2695 | -5.2340 |
| 23 | 12.0 | -27.6441 | -4.2998 | -0.2890 | -5.7180 | -27.7100 | -4.3550 | -0.2926 | -5.7048 |
| 24 | 13.0 | -28.4720 | -4.6922 | -0.3118 | -6.1534 | -28.4900 | -4.7535 | -0.3159 | -6.1391 |
| 25 | 14.0 | -29.1607 | -5.0475 | -0.3344 | -6.5629 | -29.2200 | -5.1137 | -0.3397 | -6.5504 |
| 26 | 15.0 | -29.8847 | -5.3663 | -0.3577 | -6.9580 | -29.9210 | -5.4345 | -0.3637 | -6.9463 |
| 27 | 16.0 | -30.5390 | -5.6496 | -0.3810 | -7.3405 | -30.6000 | -5.7195 | -0.3875 | -7.3306 |
| 28 | 17.0 | -31.2178 | -5.8992 | -0.4045 | -7.7149 | -31.2630 | -5.9740 | -0.4116 | -7.7055 |
| 29 | 18.0 | -31.8542 | -6.1172 | -0.4279 | -8.0821 | -31.9160 | -6.1987 | -0.4358 | -8.0734 |
| 30 | 19.0 | -32.5069 | -6.3071 | -0.4512 | -8.4441 | -32.5570 | -6.3933 | -0.4595 | -8.4356 |
| 31 | 20.0 | -33.1307 | -6.4710 | -0.4745 | -8.8014 | -33.1880 | -6.5611 | -0.4830 | -8.7935 |
| 32 | 21.0 | -33.7645 | -6.6120 | -0.4977 | -9.1549 | -33.8140 | -6.7050 | -0.5064 | -9.1475 |
| 33 | 22.0 | -34.3775 | -6.7323 | -0.5208 | -9.5048 | -34.4320 | -6.8282 | -0.5298 | -9.4979 |
| 34 | 23.0 | -34.9962 | -6.8340 | -0.5438 | -9.8519 | -35.0430 | -6.9342 | -0.5532 | -9.8451 |
| 35 | 24.0 | -35.5990 | -6.9196 | -0.5668 | -10.1961 | -35.6460 | -7.0247 | -0.5766 | -10.1890 |
| 36 | 25.0 | -36.2046 | -6.9905 | -0.5898 | -10.5377 | -36.2420 | -7.1012 | -0.6000 | -10.5300 |
| 37 | 26.0 | -36.7976 | -7.0482 | -0.6127 | -10.8769 | -36.8310 | -7.1642 | -0.6234 | -10.8690 |
| 38 | 27.0 | -37.3908 | -7.0943 | -0.6356 | -11.2138 | -37.4140 | -7.2146 | -0.6466 | -11.2050 |
| 39 | 28.0 | -37.9734 | -7.1305 | -0.6585 | -11.5484 | -37.9910 | -7.2544 | -0.6697 | -11.5390 |
| 40 | 29.0 | -38.5551 | -7.1569 | -0.6813 | -11.8808 | -38.5640 | -7.2859 | -0.6928 | -11.8710 |
| 41 | 30.0 | -39.1279 | -7.1746 | -0.7042 | -12.2111 | -39.1300 | -7.3102 | -0.7161 | -12.2010 |
| 42 | 32.0 | -39.1319 | -7.1333 | -0.7416 | -12.7572 | -39.0390 | -7.2800 | -0.7534 | -12.7380 |
| 43 | 34.0 | -38.7607 | -6.9863 | -0.7751 | -13.1816 | -38.7560 | -7.1470 | -0.7883 | -13.1700 |
| 44 | 36.0 | -38.5636 | -6.7670 | -0.8091 | -13.5618 | -38.5000 | -6.9367 | -0.8224 | -13.5500 |
| 45 | 38.0 | -38.3242 | -6.4896 | -0.8412 | -13.9052 | -38.2990 | -6.6685 | -0.8555 | -13.8980 |
| 46 | 40.0 | -38.2081 | -6.1727 | -0.8725 | -14.2275 | -38.1520 | -6.3609 | -0.8877 | -14.2220 |
| 47 | 42.0 | -38.0830 | -5.8322 | -0.9022 | -14.5294 | -38.0500 | -6.0318 | -0.9189 | -14.5260 |
| 48 | 44.0 | -38.0470 | -5.4811 | -0.9312 | -14.8173 | -37.9910 | -5.6927 | -0.9491 | -14.8150 |
| 49 | 46.0 | -38.0083 | -5.1284 | -0.9592 | -15.0913 | -37.9650 | -5.3492 | -0.9783 | -15.0900 |
| 50 | 48.0 | -38.0350 | -4.7805 | -0.9867 | -15.3547 | -37.9730 | -5.0099 | -1.0064 | -15.3530 |
| 51 | 50.0 | -38.0589 | -4.4413 | -1.0133 | -15.6073 | -38.0100 | -4.6790 | -1.0340 | -15.6060 |
| 52 | 52.0 | -38.1320 | -4.1133 | -1.0396 | -15.8513 | -38.0710 | -4.3579 | -1.0610 | -15.8510 |
| 53 | 54.0 | -38.2016 | -3.7980 | -1.0652 | -16.0867 | -38.1510 | -4.0475 | -1.0874 | -16.0860 |
| 54 | 56.0 | -38.3088 | -3.4955 | -1.0905 | -16.3149 | -38.2480 | -3.7480 | -1.1132 | -16.3140 |

| | | | | | | | | | |
|-----|-------|----------|---------|---------|----------|----------|---------|---------|----------|
| 55 | 58.0 | -38.4111 | -3.2060 | -1.1153 | -16.5359 | -38.3560 | -3.4609 | -1.1383 | -16.5340 |
| 56 | 60.0 | -38.5423 | -2.9296 | -1.1397 | -16.7507 | -38.4720 | -3.1856 | -1.1628 | -16.7480 |
| 57 | 62.0 | -38.6682 | -2.6657 | -1.1637 | -16.9594 | -38.5970 | -2.9224 | -1.1868 | -16.9560 |
| 58 | 64.0 | -38.8160 | -2.4142 | -1.1873 | -17.1627 | -38.7300 | -2.6714 | -1.2105 | -17.1580 |
| 59 | 66.0 | -38.9581 | -2.1738 | -1.2105 | -17.3608 | -38.8680 | -2.4312 | -1.2336 | -17.3550 |
| 60 | 68.0 | -39.1173 | -1.9440 | -1.2334 | -17.5542 | -39.0110 | -2.2021 | -1.2563 | -17.5480 |
| 61 | 70.0 | -39.2709 | -1.7241 | -1.2558 | -17.7431 | -39.1570 | -1.9835 | -1.2787 | -17.7360 |
| 62 | 72.0 | -38.3079 | -1.4594 | -1.2697 | -17.8195 | -38.0180 | -1.7136 | -1.2913 | -17.7940 |
| 63 | 74.0 | -36.9876 | -1.1237 | -1.2791 | -17.7784 | -36.7860 | -1.3790 | -1.3018 | -17.7580 |
| 64 | 76.0 | -35.8696 | -0.7459 | -1.2886 | -17.6975 | -35.6040 | -0.9942 | -1.3104 | -17.6760 |
| 65 | 78.0 | -34.7270 | -0.3361 | -1.2958 | -17.5842 | -34.4930 | -0.5795 | -1.3173 | -17.5650 |
| 66 | 80.0 | -33.7334 | 0.0898 | -1.3019 | -17.4545 | -33.4520 | -0.1497 | -1.3223 | -17.4340 |
| 67 | 82.0 | -31.6175 | 0.5727 | -1.2978 | -17.2008 | -31.1920 | 0.3423 | -1.3163 | -17.1630 |
| 68 | 84.0 | -29.2631 | 1.1273 | -1.2886 | -16.8246 | -28.8980 | 0.8967 | -1.3074 | -16.7910 |
| 69 | 86.0 | -27.1135 | 1.7169 | -1.2785 | -16.4030 | -26.7100 | 1.4921 | -1.2963 | -16.3680 |
| 70 | 88.0 | -25.0320 | 2.3264 | -1.2656 | -15.9473 | -24.6480 | 2.1075 | -1.2826 | -15.9140 |
| 71 | 90.0 | -23.1042 | 2.9365 | -1.2508 | -15.4727 | -22.7050 | 2.7207 | -1.2667 | -15.4390 |
| 72 | 92.0 | -21.2591 | 3.5323 | -1.2337 | -14.9823 | -20.8700 | 3.3183 | -1.2488 | -14.9490 |
| 73 | 94.0 | -19.5313 | 4.1021 | -1.2151 | -14.4822 | -19.1310 | 3.8887 | -1.2289 | -14.4480 |
| 74 | 96.0 | -17.8769 | 4.6389 | -1.1948 | -13.9738 | -17.4800 | 4.4256 | -1.2077 | -13.9400 |
| 75 | 98.0 | -16.3144 | 5.1387 | -1.1733 | -13.4607 | -15.9080 | 4.9298 | -1.1852 | -13.4260 |
| 76 | 100.0 | -14.8143 | 5.5993 | -1.1506 | -12.9435 | -14.4090 | 5.3956 | -1.1621 | -12.9070 |
| 77 | 102.0 | -14.5180 | 5.9654 | -1.1351 | -12.5329 | -14.2620 | 5.7620 | -1.1475 | -12.5120 |
| 78 | 104.0 | -14.6258 | 6.2134 | -1.1226 | -12.2344 | -14.2700 | 6.0170 | -1.1336 | -12.2070 |
| 79 | 106.0 | -14.6016 | 6.3732 | -1.1089 | -11.9723 | -14.2860 | 6.1771 | -1.1198 | -11.9430 |
| 80 | 108.0 | -14.6410 | 6.4575 | -1.0963 | -11.7396 | -14.2800 | 6.2636 | -1.1064 | -11.7050 |
| 81 | 110.0 | -14.5892 | 6.4848 | -1.0838 | -11.5218 | -14.2500 | 6.2934 | -1.0935 | -11.4850 |
| 82 | 115.0 | -15.6927 | 6.3071 | -1.0653 | -11.1960 | -15.4610 | 6.0994 | -1.0745 | -11.1870 |
| 83 | 120.0 | -16.7471 | 5.8983 | -1.0524 | -11.0564 | -16.4110 | 5.6885 | -1.0605 | -11.0260 |
| 84 | 125.0 | -17.4470 | 5.4356 | -1.0418 | -10.9641 | -17.1250 | 5.2287 | -1.0504 | -10.9300 |
| 85 | 130.0 | -18.0254 | 5.0021 | -1.0341 | -10.9170 | -17.6580 | 4.7985 | -1.0428 | -10.8750 |
| 86 | 135.0 | -18.4451 | 4.6358 | -1.0271 | -10.8938 | -18.0700 | 4.4238 | -1.0360 | -10.8490 |
| 87 | 140.0 | -18.7962 | 4.3343 | -1.0213 | -10.8924 | -18.4050 | 4.1065 | -1.0307 | -10.8440 |
| 88 | 145.0 | -19.0689 | 4.0920 | -1.0159 | -10.9035 | -18.6810 | 3.8438 | -1.0265 | -10.8510 |
| 89 | 150.0 | -19.3024 | 3.8992 | -1.0113 | -10.9258 | -18.9180 | 3.6282 | -1.0241 | -10.8700 |
| 90 | 155.0 | -19.4940 | 3.7468 | -1.0072 | -10.9542 | -19.1200 | 3.4556 | -1.0229 | -10.8940 |
| 91 | 160.0 | -19.6613 | 3.6270 | -1.0037 | -10.9880 | -19.2880 | 3.3188 | -1.0222 | -10.9230 |
| 92 | 170.0 | -17.4564 | 3.7481 | -0.9748 | -10.6344 | -16.9250 | 3.4711 | -0.9979 | -10.4990 |
| 93 | 180.0 | -15.4556 | 4.1590 | -0.9363 | -10.0200 | -15.0990 | 3.8213 | -0.9621 | -9.9243 |
| 94 | 190.0 | -14.1405 | 4.4474 | -0.8944 | -9.4507 | -13.6560 | 4.0518 | -0.9197 | -9.3329 |
| 95 | 200.0 | -12.8614 | 4.5617 | -0.8504 | -8.8626 | -12.4590 | 4.1501 | -0.8751 | -8.7545 |
| 96 | 210.0 | -11.8875 | 4.5642 | -0.8076 | -8.3131 | -11.4230 | 4.1539 | -0.8310 | -8.2001 |
| 97 | 220.0 | -10.9136 | 4.5017 | -0.7638 | -7.7809 | -10.4990 | 4.0907 | -0.7885 | -7.6689 |
| 98 | 230.0 | -10.1294 | 4.3891 | -0.7217 | -7.2864 | -9.6652 | 3.9761 | -0.7473 | -7.1677 |
| 99 | 240.0 | -9.3403 | 4.2522 | -0.6798 | -6.8167 | -8.9056 | 3.8266 | -0.7067 | -6.6970 |
| 100 | 250.0 | -8.6890 | 4.0958 | -0.6398 | -6.3807 | -8.2083 | 3.6600 | -0.6664 | -6.2555 |
| 101 | 260.0 | -8.0320 | 3.9312 | -0.6007 | -5.9694 | -7.5636 | 3.4845 | -0.6275 | -5.8408 |
| 102 | 270.0 | -7.4835 | 3.7607 | -0.5638 | -5.5874 | -6.9732 | 3.3002 | -0.5911 | -5.4515 |
| 103 | 280.0 | -6.9283 | 3.5898 | -0.5282 | -5.2276 | -6.4307 | 3.1118 | -0.5564 | -5.0853 |
| 104 | 290.0 | -6.4627 | 3.4194 | -0.4948 | -4.8932 | -5.9232 | 2.9302 | -0.5221 | -4.7412 |
| 105 | 300.0 | -5.9892 | 3.2518 | -0.4628 | -4.5785 | -5.4481 | 2.7615 | -0.4882 | -4.4205 |

表7. 6(3) 評価断面6の応力テンソル成分3

F I N A S解と簡易計算値との比較 (ホットショック)

断面6の応力成分3

| ステップ | 時間(S) | F I N A S解 | | | | 簡易計算値 | | | |
|------|-------|------------|---------|--------|----------|----------|---------|--------|----------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.8532 | 0.0448 | 0.0068 | -0.0921 | -1.0130 | 0.0483 | 0.0063 | -0.1022 |
| 3 | 1.0 | -2.2540 | 0.1613 | 0.0282 | -0.3173 | -2.3211 | 0.1638 | 0.0282 | -0.3238 |
| 4 | 1.5 | -3.6481 | 0.3311 | 0.0631 | -0.6293 | -3.7599 | 0.3330 | 0.0629 | -0.6358 |
| 5 | 2.0 | -5.2009 | 0.5489 | 0.1088 | -1.0197 | -5.2780 | 0.5497 | 0.1089 | -1.0239 |
| 6 | 2.5 | -6.7541 | 0.8093 | 0.1644 | -1.4760 | -6.8511 | 0.8093 | 0.1645 | -1.4791 |
| 7 | 3.0 | -8.3815 | 1.1093 | 0.2288 | -1.9928 | -8.4602 | 1.1079 | 0.2288 | -1.9943 |
| 8 | 3.5 | -10.0116 | 1.4459 | 0.3011 | -2.5635 | -10.0980 | 1.4429 | 0.3010 | -2.5635 |
| 9 | 4.0 | -11.6805 | 1.8168 | 0.3804 | -3.1842 | -11.7590 | 1.8123 | 0.3806 | -3.1829 |
| 10 | 4.5 | -13.3539 | 2.2197 | 0.4660 | -3.8508 | -13.4360 | 2.2138 | 0.4667 | -3.8488 |
| 11 | 5.0 | -15.0482 | 2.6534 | 0.5572 | -4.5606 | -15.1250 | 2.6452 | 0.5584 | -4.5579 |
| 12 | 5.5 | -16.7464 | 3.1156 | 0.6533 | -5.3100 | -16.8240 | 3.1050 | 0.6547 | -5.3069 |
| 13 | 6.0 | -18.4568 | 3.6050 | 0.7536 | -6.0968 | -18.5310 | 3.5917 | 0.7550 | -6.0930 |
| 14 | 6.5 | -20.1705 | 4.1206 | 0.8573 | -6.9182 | -20.2450 | 4.1041 | 0.8586 | -6.9139 |
| 15 | 7.0 | -21.8907 | 4.6602 | 0.9640 | -7.7722 | -21.9630 | 4.6414 | 0.9648 | -7.7678 |
| 16 | 7.5 | -23.6131 | 5.2231 | 1.0723 | -8.6564 | -23.6850 | 5.2021 | 1.0732 | -8.6520 |
| 17 | 8.0 | -25.3387 | 5.8080 | 1.1833 | -9.5690 | -25.4080 | 5.7846 | 1.1831 | -9.5647 |
| 18 | 8.5 | -27.0654 | 6.4139 | 1.2951 | -10.5081 | -27.1340 | 6.3880 | 1.2941 | -10.5040 |
| 19 | 9.0 | -28.7936 | 7.0393 | 1.4077 | -11.4718 | -28.8610 | 7.0118 | 1.4059 | -11.4690 |
| 20 | 9.5 | -30.5219 | 7.6832 | 1.5206 | -12.4587 | -30.5900 | 7.6544 | 1.5181 | -12.4570 |
| 21 | 10.0 | -32.2499 | 8.3449 | 1.6336 | -13.4671 | -32.3180 | 8.3149 | 1.6302 | -13.4660 |
| 22 | 11.0 | -34.6624 | 9.6399 | 1.8442 | -15.3918 | -34.6540 | 9.6045 | 1.8391 | -15.3880 |
| 23 | 12.0 | -36.5353 | 11.8764 | 2.0251 | -17.1799 | -36.6270 | 10.8410 | 2.0183 | -17.1370 |
| 24 | 13.0 | -38.4328 | 12.0829 | 2.1804 | -18.9011 | -38.4790 | 12.0450 | 2.1728 | -18.9110 |
| 25 | 14.0 | -40.1727 | 13.2631 | 2.3137 | -20.5622 | -40.2640 | 13.2260 | 2.3049 | -20.5780 |
| 26 | 15.0 | -41.9352 | 14.4224 | 2.4261 | -22.1787 | -42.0050 | 14.3860 | 2.4163 | -22.1980 |
| 27 | 16.0 | -43.6145 | 15.5621 | 2.5203 | -23.7528 | -43.7130 | 15.5280 | 2.5098 | -23.7780 |
| 28 | 17.0 | -45.3082 | 16.6843 | 2.5980 | -25.2915 | -45.3950 | 16.6500 | 2.5872 | -25.3200 |
| 29 | 18.0 | -46.9489 | 17.7898 | 2.6613 | -26.7968 | -47.0550 | 17.7540 | 2.6506 | -26.8300 |
| 30 | 19.0 | -48.5973 | 18.8799 | 2.7122 | -28.2736 | -48.6940 | 18.8420 | 2.7017 | -28.3090 |
| 31 | 20.0 | -50.2077 | 19.9556 | 2.7520 | -29.7233 | -50.3160 | 19.9170 | 2.7420 | -29.7630 |
| 32 | 21.0 | -51.8208 | 21.0173 | 2.7822 | -31.1492 | -51.9220 | 20.9770 | 2.7728 | -31.1910 |
| 33 | 22.0 | -53.4050 | 22.0660 | 2.8039 | -32.5526 | -53.5140 | 22.0240 | 2.7951 | -32.5960 |
| 34 | 23.0 | -54.9884 | 23.1024 | 2.8179 | -33.9358 | -55.0920 | 23.0570 | 2.8098 | -33.9820 |
| 35 | 24.0 | -56.5490 | 24.1265 | 2.8250 | -35.2999 | -56.6560 | 24.0770 | 2.8176 | -35.3480 |
| 36 | 25.0 | -58.1061 | 25.1390 | 2.8260 | -36.6465 | -58.2080 | 25.0850 | 2.8190 | -36.6960 |
| 37 | 26.0 | -59.6441 | 26.1400 | 2.8215 | -37.9763 | -59.7480 | 26.0810 | 2.8147 | -37.9270 |
| 38 | 27.0 | -61.1768 | 27.1299 | 2.8117 | -39.2906 | -61.2760 | 27.0660 | 2.8053 | -39.3430 |
| 39 | 28.0 | -62.6931 | 28.1086 | 2.7972 | -40.5901 | -62.7930 | 28.0400 | 2.7912 | -40.6440 |
| 40 | 29.0 | -64.2029 | 29.0769 | 2.7783 | -41.8755 | -64.3000 | 29.0040 | 2.7726 | -41.9310 |
| 41 | 30.0 | -65.6981 | 30.0348 | 2.7552 | -43.1473 | -65.7950 | 29.9570 | 2.7499 | -43.2040 |
| 42 | 32.0 | -67.4402 | 31.7912 | 2.6726 | -45.4138 | -67.4530 | 31.6990 | 2.6667 | -45.4630 |
| 43 | 34.0 | -68.6394 | 33.3183 | 2.5340 | -47.3205 | -68.7530 | 33.2240 | 2.5276 | -47.3870 |
| 44 | 36.0 | -69.8741 | 34.6829 | 2.3581 | -49.0077 | -69.9410 | 34.5840 | 2.3503 | -49.0780 |
| 45 | 38.0 | -70.9505 | 35.9062 | 2.1568 | -50.5063 | -71.0630 | 35.8070 | 2.1482 | -50.5860 |
| 46 | 40.0 | -72.0529 | 37.0123 | 1.9396 | -51.8603 | -72.1380 | 36.9130 | 1.9319 | -51.9440 |
| 47 | 42.0 | -73.0613 | 38.0169 | 1.7146 | -53.0909 | -73.1740 | 37.9170 | 1.7083 | -53.1800 |
| 48 | 44.0 | -74.0870 | 38.9360 | 1.4863 | -54.2241 | -74.1790 | 38.8320 | 1.4816 | -54.3150 |
| 49 | 46.0 | -75.0461 | 39.7802 | 1.2584 | -55.2734 | -75.1570 | 39.6730 | 1.2540 | -55.3670 |
| 50 | 48.0 | -76.0160 | 40.5603 | 1.0325 | -56.2544 | -76.1100 | 40.4480 | 1.0294 | -56.3480 |
| 51 | 50.0 | -76.9342 | 41.2841 | 0.8104 | -57.1757 | -77.0440 | 41.1660 | 0.8079 | -57.2700 |
| 52 | 52.0 | -77.8591 | 41.9595 | 0.5924 | -58.0476 | -77.9590 | 41.8360 | 0.5902 | -58.1420 |
| 53 | 54.0 | -78.7421 | 42.5922 | 0.3794 | -58.8755 | -78.8530 | 42.4670 | 0.3774 | -58.9710 |
| 54 | 56.0 | -79.6290 | 43.1881 | 0.1713 | -59.6662 | -79.7280 | 43.0620 | 0.1697 | -59.7610 |

| | | | | | | | | | |
|-----|-------|----------|---------|---------|----------|----------|---------|---------|----------|
| 55 | 58.0 | -80.4805 | 43.7516 | -0.0316 | -60.4237 | -80.5860 | 43.6250 | -0.0331 | -60.5190 |
| 56 | 60.0 | -81.3335 | 44.2868 | -0.2293 | -61.1525 | -81.4270 | 44.1600 | -0.2312 | -61.2470 |
| 57 | 62.0 | -82.1567 | 44.7968 | -0.4220 | -61.8554 | -82.2540 | 44.6690 | -0.4245 | -61.9500 |
| 58 | 64.0 | -82.9796 | 45.2845 | -0.6096 | -62.5356 | -83.0670 | 45.1560 | -0.6127 | -62.6310 |
| 59 | 66.0 | -83.7760 | 45.7525 | -0.7924 | -63.1949 | -83.8670 | 45.6220 | -0.7964 | -63.2900 |
| 60 | 68.0 | -84.5709 | 46.2032 | -0.9705 | -63.8359 | -84.6530 | 46.0700 | -0.9755 | -63.9320 |
| 61 | 70.0 | -85.3428 | 46.6381 | -1.1442 | -64.4598 | -85.4260 | 46.5020 | -1.1505 | -64.5560 |
| 62 | 72.0 | -84.8911 | 46.9290 | -1.3388 | -64.8295 | -84.8020 | 46.7760 | -1.3503 | -64.8970 |
| 63 | 74.0 | -83.9204 | 47.0169 | -1.5716 | -64.8734 | -83.9240 | 46.8620 | -1.5861 | -64.9500 |
| 64 | 76.0 | -83.0198 | 46.9682 | -1.8254 | -64.7303 | -82.9630 | 46.8070 | -1.8439 | -64.8030 |
| 65 | 78.0 | -81.9854 | 46.8033 | -2.0898 | -64.4294 | -81.9660 | 46.6380 | -2.1112 | -64.5030 |
| 66 | 80.0 | -81.0099 | 46.5465 | -2.3562 | -64.0140 | -80.9490 | 46.3740 | -2.3796 | -64.0850 |
| 67 | 82.0 | -78.7438 | 46.0826 | -2.6433 | -63.2651 | -78.5410 | 45.8910 | -2.6714 | -63.3060 |
| 68 | 84.0 | -76.0281 | 45.3669 | -2.9641 | -62.1357 | -75.8900 | 45.1720 | -2.9941 | -62.1820 |
| 69 | 86.0 | -73.3437 | 44.4749 | -3.2986 | -60.7757 | -73.1700 | 44.2710 | -3.3314 | -60.8160 |
| 70 | 88.0 | -70.5849 | 43.4369 | -3.6351 | -59.2292 | -70.4320 | 43.2290 | -3.6690 | -59.2680 |
| 71 | 90.0 | -67.8620 | 42.2830 | -3.9643 | -57.5459 | -67.6940 | 42.0710 | -3.9980 | -57.5800 |
| 72 | 92.0 | -65.1225 | 41.0351 | -4.2790 | -55.7555 | -64.9670 | 40.8220 | -4.3122 | -55.7880 |
| 73 | 94.0 | -62.4187 | 39.7134 | -4.5753 | -53.8875 | -62.2550 | 39.4990 | -4.6082 | -53.9180 |
| 74 | 96.0 | -59.7192 | 38.3331 | -4.8508 | -51.9604 | -59.5620 | 38.1160 | -4.8838 | -51.9890 |
| 75 | 98.0 | -57.0551 | 36.9080 | -5.1046 | -49.9924 | -56.8920 | 36.6910 | -5.1373 | -50.0190 |
| 76 | 100.0 | -54.4060 | 35.4488 | -5.3363 | -47.9952 | -54.2450 | 35.2340 | -5.3687 | -48.0190 |
| 77 | 102.0 | -53.0129 | 34.0948 | -5.5208 | -46.2196 | -53.0090 | 33.8970 | -5.5497 | -46.2700 |
| 78 | 104.0 | -52.1391 | 32.9150 | -5.6418 | -44.7455 | -52.0430 | 32.7190 | -5.6696 | -44.7860 |
| 79 | 106.0 | -51.2257 | 31.8504 | -5.7172 | -43.4431 | -51.1750 | 31.6600 | -5.7430 | -43.4870 |
| 80 | 108.0 | -50.4524 | 30.8872 | -5.7585 | -42.2889 | -50.3610 | 30.6980 | -5.7838 | -42.3300 |
| 81 | 110.0 | -49.6500 | 30.0073 | -5.7753 | -41.2457 | -49.5860 | 29.8190 | -5.8019 | -41.2880 |
| 82 | 115.0 | -49.2752 | 28.3421 | -5.7084 | -39.4199 | -49.3540 | 28.1880 | -5.7247 | -39.5310 |
| 83 | 120.0 | -49.3649 | 27.3253 | -5.5339 | -38.4508 | -49.3580 | 27.1690 | -5.5516 | -38.5540 |
| 84 | 125.0 | -49.4301 | 26.7020 | -5.3377 | -37.9123 | -49.4450 | 26.5380 | -5.3598 | -38.0170 |
| 85 | 130.0 | -49.5938 | 26.3506 | -5.1526 | -37.6554 | -49.5800 | 26.1740 | -5.1803 | -37.7560 |
| 86 | 135.0 | -49.7508 | 26.1732 | -4.9901 | -37.5569 | -49.7420 | 25.9830 | -5.0203 | -37.6590 |
| 87 | 140.0 | -49.9433 | 26.1141 | -4.8494 | -37.5654 | -49.9260 | 25.9090 | -4.8805 | -37.6660 |
| 88 | 145.0 | -50.1308 | 26.1299 | -4.7299 | -37.6363 | -50.1190 | 25.9110 | -4.7594 | -37.7370 |
| 89 | 150.0 | -50.3305 | 26.1948 | -4.6292 | -37.7490 | -50.3250 | 25.9620 | -4.6565 | -37.8470 |
| 90 | 155.0 | -50.5253 | 26.2893 | -4.5449 | -37.8847 | -50.5300 | 26.0430 | -4.5691 | -37.9800 |
| 91 | 160.0 | -50.7215 | 26.4019 | -4.4749 | -38.0349 | -50.7260 | 26.1430 | -4.4961 | -38.1250 |
| 92 | 170.0 | -48.0131 | 25.8900 | -4.5051 | -37.1304 | -47.7760 | 25.5090 | -4.5561 | -37.0430 |
| 93 | 180.0 | -44.7664 | 24.5315 | -4.6545 | -35.0619 | -44.6940 | 24.1470 | -4.6797 | -35.0370 |
| 94 | 190.0 | -41.9639 | 22.9627 | -4.7176 | -32.8562 | -41.7480 | 22.5590 | -4.7378 | -32.8270 |
| 95 | 200.0 | -39.1278 | 21.3562 | -4.7008 | -30.6491 | -38.9810 | 20.9590 | -4.7219 | -30.6410 |
| 96 | 210.0 | -36.6102 | 19.8252 | -4.6299 | -28.5712 | -36.4020 | 19.4350 | -4.6496 | -28.5650 |
| 97 | 220.0 | -34.1420 | 18.3848 | -4.5192 | -26.6047 | -33.9850 | 17.9900 | -4.5412 | -26.6060 |
| 98 | 230.0 | -31.9288 | 17.0551 | -4.3799 | -24.7848 | -31.7190 | 16.6450 | -4.4053 | -24.7780 |
| 99 | 240.0 | -29.7831 | 15.8240 | -4.2230 | -23.0836 | -29.6010 | 15.4070 | -4.2490 | -23.0800 |
| 100 | 250.0 | -27.8493 | 14.6925 | -4.0536 | -21.5112 | -27.6230 | 14.2710 | -4.0806 | -21.5040 |
| 101 | 260.0 | -25.9830 | 13.6471 | -3.8782 | -20.0456 | -25.7750 | 13.2210 | -3.9062 | -20.0400 |
| 102 | 270.0 | -24.2964 | 12.6846 | -3.6997 | -18.6888 | -24.0480 | 12.2420 | -3.7290 | -18.6740 |
| 103 | 280.0 | -22.6713 | 11.7945 | -3.5214 | -17.4241 | -22.4330 | 11.3280 | -3.5518 | -17.3960 |
| 104 | 290.0 | -21.2010 | 10.9729 | -3.3451 | -16.2515 | -20.9200 | 10.4790 | -3.3780 | -16.2050 |
| 105 | 300.0 | -19.7846 | 10.2119 | -3.1725 | -15.1580 | -19.5070 | 9.6970 | -3.2086 | -15.1010 |

表7. 6(4) 評価断面6の応力テンソル成分4

FINAS解と簡易計算値との比較 (ホットショック)

断面6の応力成分4

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|---------|---------|---------|---------|---------|---------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.0588 | -0.0018 | 0.0000 | -0.0096 | -0.0705 | -0.0019 | 0.0000 | -0.0104 |
| 3 | 1.0 | -0.1683 | -0.0066 | -0.0004 | -0.0348 | -0.1743 | -0.0066 | -0.0005 | -0.0356 |
| 4 | 1.5 | -0.2820 | -0.0135 | -0.0011 | -0.0712 | -0.2898 | -0.0136 | -0.0010 | -0.0718 |
| 5 | 2.0 | -0.4053 | -0.0225 | -0.0016 | -0.1169 | -0.4114 | -0.0225 | -0.0016 | -0.1172 |
| 6 | 2.5 | -0.5296 | -0.0331 | -0.0021 | -0.1708 | -0.5363 | -0.0331 | -0.0020 | -0.1706 |
| 7 | 3.0 | -0.6567 | -0.0454 | -0.0024 | -0.2320 | -0.6625 | -0.0454 | -0.0023 | -0.2312 |
| 8 | 3.5 | -0.7835 | -0.0592 | -0.0026 | -0.2997 | -0.7890 | -0.0592 | -0.0025 | -0.2983 |
| 9 | 4.0 | -0.9105 | -0.0743 | -0.0027 | -0.3735 | -0.9151 | -0.0745 | -0.0025 | -0.3715 |
| 10 | 4.5 | -1.0366 | -0.0909 | -0.0027 | -0.4530 | -1.0404 | -0.0912 | -0.0025 | -0.4505 |
| 11 | 5.0 | -1.1620 | -0.1087 | -0.0026 | -0.5378 | -1.1650 | -0.1096 | -0.0023 | -0.5343 |
| 12 | 5.5 | -1.2863 | -0.1275 | -0.0024 | -0.6274 | -1.2887 | -0.1292 | -0.0021 | -0.6231 |
| 13 | 6.0 | -1.4094 | -0.1475 | -0.0021 | -0.7217 | -1.4111 | -0.1498 | -0.0017 | -0.7166 |
| 14 | 6.5 | -1.5311 | -0.1683 | -0.0018 | -0.8203 | -1.5321 | -0.1713 | -0.0013 | -0.8145 |
| 15 | 7.0 | -1.6513 | -0.1899 | -0.0013 | -0.9230 | -1.6518 | -0.1936 | -0.0008 | -0.9165 |
| 16 | 7.5 | -1.7702 | -0.2122 | -0.0008 | -1.0294 | -1.7703 | -0.2166 | -0.0002 | -1.0223 |
| 17 | 8.0 | -1.8876 | -0.2350 | -0.0001 | -1.1393 | -1.8873 | -0.2401 | 0.0004 | -1.1317 |
| 18 | 8.5 | -2.0035 | -0.2583 | 0.0005 | -1.2525 | -2.0027 | -0.2640 | 0.0012 | -1.2445 |
| 19 | 9.0 | -2.1180 | -0.2819 | 0.0013 | -1.3687 | -2.1167 | -0.2881 | 0.0020 | -1.3602 |
| 20 | 9.5 | -2.2309 | -0.3058 | 0.0021 | -1.4877 | -2.2290 | -0.3124 | 0.0028 | -1.4787 |
| 21 | 10.0 | -2.3424 | -0.3298 | 0.0030 | -1.6092 | -2.3396 | -0.3369 | 0.0037 | -1.5997 |
| 22 | 11.0 | -2.4846 | -0.3751 | 0.0050 | -1.8425 | -2.4746 | -0.3829 | 0.0058 | -1.8315 |
| 23 | 12.0 | -2.5705 | -0.4153 | 0.0076 | -2.0589 | -2.5681 | -0.4240 | 0.0085 | -2.0475 |
| 24 | 13.0 | -2.6555 | -0.4515 | 0.0103 | -2.2659 | -2.6491 | -0.4611 | 0.0111 | -2.2538 |
| 25 | 14.0 | -2.7286 | -0.4838 | 0.0128 | -2.4648 | -2.7244 | -0.4940 | 0.0137 | -2.4524 |
| 26 | 15.0 | -2.8017 | -0.5122 | 0.0152 | -2.6570 | -2.7965 | -0.5228 | 0.0161 | -2.6441 |
| 27 | 16.0 | -2.8696 | -0.5370 | 0.0175 | -2.8428 | -2.8658 | -0.5479 | 0.0184 | -2.8296 |
| 28 | 17.0 | -2.9376 | -0.5584 | 0.0198 | -3.0227 | -2.9331 | -0.5700 | 0.0206 | -3.0092 |
| 29 | 18.0 | -3.0027 | -0.5766 | 0.0219 | -3.1972 | -2.9988 | -0.5892 | 0.0228 | -3.1833 |
| 30 | 19.0 | -3.0676 | -0.5922 | 0.0240 | -3.3666 | -3.0626 | -0.6056 | 0.0249 | -3.3525 |
| 31 | 20.0 | -3.1307 | -0.6054 | 0.0261 | -3.5315 | -3.1252 | -0.6195 | 0.0270 | -3.5172 |
| 32 | 21.0 | -3.1936 | -0.6166 | 0.0280 | -3.6924 | -3.1875 | -0.6314 | 0.0290 | -3.6778 |
| 33 | 22.0 | -3.2552 | -0.6259 | 0.0300 | -3.8495 | -3.2490 | -0.6417 | 0.0309 | -3.8347 |
| 34 | 23.0 | -3.3164 | -0.6336 | 0.0319 | -4.0033 | -3.3097 | -0.6505 | 0.0329 | -3.9881 |
| 35 | 24.0 | -3.3766 | -0.6400 | 0.0337 | -4.1541 | -3.3697 | -0.6578 | 0.0348 | -4.1385 |
| 36 | 25.0 | -3.4365 | -0.6451 | 0.0355 | -4.3021 | -3.4290 | -0.6640 | 0.0366 | -4.2860 |
| 37 | 26.0 | -3.4955 | -0.6491 | 0.0373 | -4.4477 | -3.4877 | -0.6690 | 0.0385 | -4.4311 |
| 38 | 27.0 | -3.5540 | -0.6521 | 0.0391 | -4.5911 | -3.5461 | -0.6730 | 0.0403 | -4.5740 |
| 39 | 28.0 | -3.6118 | -0.6544 | 0.0409 | -4.7323 | -3.6043 | -0.6762 | 0.0420 | -4.7148 |
| 40 | 29.0 | -3.6691 | -0.6558 | 0.0426 | -4.8717 | -3.6625 | -0.6787 | 0.0438 | -4.8538 |
| 41 | 30.0 | -3.7258 | -0.6565 | 0.0443 | -5.0093 | -3.7206 | -0.6808 | 0.0455 | -4.9910 |
| 42 | 32.0 | -3.7445 | -0.6509 | 0.0480 | -5.2523 | -3.7352 | -0.6770 | 0.0491 | -5.2320 |
| 43 | 34.0 | -3.7173 | -0.6353 | 0.0518 | -5.4516 | -3.7228 | -0.6635 | 0.0526 | -5.4323 |
| 44 | 36.0 | -3.7044 | -0.6131 | 0.0550 | -5.6240 | -3.7094 | -0.6425 | 0.0556 | -5.6045 |
| 45 | 38.0 | -3.6868 | -0.5856 | 0.0578 | -5.7739 | -3.6984 | -0.6153 | 0.0582 | -5.7547 |
| 46 | 40.0 | -3.6787 | -0.5549 | 0.0603 | -5.9062 | -3.6917 | -0.5848 | 0.0604 | -5.8874 |
| 47 | 42.0 | -3.6704 | -0.5225 | 0.0625 | -6.0243 | -3.6887 | -0.5536 | 0.0624 | -6.0064 |
| 48 | 44.0 | -3.6687 | -0.4897 | 0.0645 | -6.1317 | -3.6893 | -0.5223 | 0.0643 | -6.1146 |
| 49 | 46.0 | -3.6677 | -0.4571 | 0.0664 | -6.2305 | -3.6933 | -0.4913 | 0.0661 | -6.2142 |
| 50 | 48.0 | -3.6714 | -0.4254 | 0.0682 | -6.3227 | -3.7003 | -0.4610 | 0.0678 | -6.3067 |
| 51 | 50.0 | -3.6757 | -0.3948 | 0.0699 | -6.4096 | -3.7094 | -0.4316 | 0.0694 | -6.3935 |
| 52 | 52.0 | -3.6834 | -0.3654 | 0.0716 | -6.4921 | -3.7202 | -0.4028 | 0.0709 | -6.4756 |
| 53 | 54.0 | -3.6918 | -0.3373 | 0.0731 | -6.5710 | -3.7324 | -0.3747 | 0.0723 | -6.5541 |
| 54 | 56.0 | -3.7027 | -0.3106 | 0.0746 | -6.6469 | -3.7457 | -0.3475 | 0.0736 | -6.6294 |

| | | | | | | | | | |
|-----|-------|---------|---------|--------|---------|---------|---------|--------|---------|
| 55 | 58.0 | -3.7139 | -0.2851 | 0.0761 | -6.7202 | -3.7600 | -0.3218 | 0.0749 | -6.7020 |
| 56 | 60.0 | -3.7269 | -0.2609 | 0.0775 | -6.7912 | -3.7750 | -0.2977 | 0.0762 | -6.7720 |
| 57 | 62.0 | -3.7403 | -0.2379 | 0.0788 | -6.8602 | -3.7905 | -0.2749 | 0.0775 | -6.8401 |
| 58 | 64.0 | -3.7549 | -0.2160 | 0.0802 | -6.9273 | -3.8068 | -0.2533 | 0.0788 | -6.9068 |
| 59 | 66.0 | -3.7696 | -0.1951 | 0.0815 | -6.9928 | -3.8238 | -0.2325 | 0.0801 | -6.9720 |
| 60 | 68.0 | -3.7853 | -0.1753 | 0.0827 | -7.0569 | -3.8410 | -0.2128 | 0.0813 | -7.0356 |
| 61 | 70.0 | -3.8011 | -0.1563 | 0.0840 | -7.1195 | -3.8581 | -0.1940 | 0.0826 | -7.0979 |
| 62 | 72.0 | -3.7243 | -0.1329 | 0.0855 | -7.1535 | -3.7646 | -0.1700 | 0.0843 | -7.1278 |
| 63 | 74.0 | -3.6042 | -0.1024 | 0.0871 | -7.1484 | -3.6560 | -0.1396 | 0.0857 | -7.1233 |
| 64 | 76.0 | -3.5007 | -0.0678 | 0.0881 | -7.1207 | -3.5502 | -0.1039 | 0.0865 | -7.0952 |
| 65 | 78.0 | -3.3945 | -0.0300 | 0.0887 | -7.0742 | -3.4495 | -0.0653 | 0.0871 | -7.0483 |
| 66 | 80.0 | -3.3001 | 0.0091 | 0.0891 | -7.0137 | -3.3544 | -0.0259 | 0.0873 | -6.9870 |
| 67 | 82.0 | -3.1143 | 0.0534 | 0.0895 | -6.9151 | -3.1546 | 0.0191 | 0.0878 | -6.8843 |
| 68 | 84.0 | -2.8935 | 0.1045 | 0.0899 | -6.7711 | -2.9445 | 0.0698 | 0.0878 | -6.7413 |
| 69 | 86.0 | -2.6916 | 0.1588 | 0.0895 | -6.6002 | -2.7414 | 0.1245 | 0.0873 | -6.5706 |
| 70 | 88.0 | -2.4936 | 0.2148 | 0.0887 | -6.4080 | -2.5483 | 0.1812 | 0.0864 | -6.3787 |
| 71 | 90.0 | -2.3096 | 0.2705 | 0.0875 | -6.2004 | -2.3664 | 0.2370 | 0.0850 | -6.1711 |
| 72 | 92.0 | -2.1325 | 0.3245 | 0.0860 | -5.9817 | -2.1940 | 0.2910 | 0.0834 | -5.9529 |
| 73 | 94.0 | -1.9660 | 0.3757 | 0.0843 | -5.7556 | -2.0295 | 0.3422 | 0.0816 | -5.7276 |
| 74 | 96.0 | -1.8062 | 0.4235 | 0.0825 | -5.5248 | -1.8720 | 0.3898 | 0.0797 | -5.4977 |
| 75 | 98.0 | -1.6549 | 0.4676 | 0.0805 | -5.2914 | -1.7216 | 0.4342 | 0.0776 | -5.2650 |
| 76 | 100.0 | -1.5094 | 0.5081 | 0.0784 | -5.0569 | -1.5783 | 0.4744 | 0.0754 | -5.0312 |
| 77 | 102.0 | -1.4638 | 0.5394 | 0.0760 | -4.8497 | -1.5516 | 0.5051 | 0.0726 | -4.8285 |
| 78 | 104.0 | -1.4669 | 0.5594 | 0.0733 | -4.6812 | -1.5460 | 0.5252 | 0.0700 | -4.6598 |
| 79 | 106.0 | -1.4593 | 0.5710 | 0.0713 | -4.5357 | -1.5433 | 0.5359 | 0.0678 | -4.5150 |
| 80 | 108.0 | -1.4585 | 0.5755 | 0.0694 | -4.4098 | -1.5399 | 0.5398 | 0.0660 | -4.3893 |
| 81 | 110.0 | -1.4510 | 0.5750 | 0.0679 | -4.2990 | -1.5345 | 0.5392 | 0.0644 | -4.2787 |
| 82 | 115.0 | -1.5403 | 0.5526 | 0.0645 | -4.1172 | -1.6366 | 0.5143 | 0.0609 | -4.1058 |
| 83 | 120.0 | -1.6387 | 0.5109 | 0.0622 | -4.0378 | -1.7222 | 0.4698 | 0.0590 | -4.0248 |
| 84 | 125.0 | -1.7021 | 0.4664 | 0.0612 | -4.0042 | -1.7860 | 0.4231 | 0.0580 | -3.9905 |
| 85 | 130.0 | -1.7574 | 0.4264 | 0.0604 | -3.9970 | -1.8343 | 0.3811 | 0.0573 | -3.9806 |
| 86 | 135.0 | -1.7964 | 0.3935 | 0.0599 | -4.0009 | -1.8728 | 0.3450 | 0.0569 | -3.9827 |
| 87 | 140.0 | -1.8304 | 0.3668 | 0.0595 | -4.0114 | -1.9059 | 0.3152 | 0.0565 | -3.9922 |
| 88 | 145.0 | -1.8560 | 0.3457 | 0.0593 | -4.0254 | -1.9356 | 0.2908 | 0.0562 | -4.0055 |
| 89 | 150.0 | -1.8789 | 0.3291 | 0.0591 | -4.0414 | -1.9615 | 0.2715 | 0.0559 | -4.0212 |
| 90 | 155.0 | -1.8970 | 0.3160 | 0.0590 | -4.0585 | -1.9853 | 0.2570 | 0.0556 | -4.0380 |
| 91 | 160.0 | -1.9134 | 0.3059 | 0.0589 | -4.0762 | -2.0073 | 0.2456 | 0.0553 | -4.0553 |
| 92 | 170.0 | -1.7160 | 0.3197 | 0.0586 | -3.9671 | -1.7977 | 0.2636 | 0.0546 | -3.9221 |
| 93 | 180.0 | -1.5197 | 0.3595 | 0.0563 | -3.7186 | -1.6268 | 0.2995 | 0.0518 | -3.6771 |
| 94 | 190.0 | -1.3931 | 0.3852 | 0.0531 | -3.4629 | -1.4941 | 0.3263 | 0.0484 | -3.4208 |
| 95 | 200.0 | -1.2668 | 0.3945 | 0.0502 | -3.2177 | -1.3832 | 0.3401 | 0.0452 | -3.1755 |
| 96 | 210.0 | -1.1719 | 0.3944 | 0.0471 | -2.9918 | -1.2859 | 0.3447 | 0.0422 | -2.9466 |
| 97 | 220.0 | -1.0759 | 0.3887 | 0.0442 | -2.7792 | -1.1974 | 0.3424 | 0.0392 | -2.7338 |
| 98 | 230.0 | -0.9988 | 0.3786 | 0.0414 | -2.5839 | -1.1160 | 0.3330 | 0.0363 | -2.5363 |
| 99 | 240.0 | -0.9212 | 0.3667 | 0.0388 | -2.4020 | -1.0436 | 0.3180 | 0.0336 | -2.3544 |
| 100 | 250.0 | -0.8569 | 0.3530 | 0.0362 | -2.2344 | -0.9781 | 0.3029 | 0.0311 | -2.1870 |
| 101 | 260.0 | -0.7924 | 0.3388 | 0.0338 | -2.0787 | -0.9162 | 0.2892 | 0.0290 | -2.0319 |
| 102 | 270.0 | -0.7381 | 0.3240 | 0.0316 | -1.9350 | -0.8586 | 0.2741 | 0.0269 | -1.8866 |
| 103 | 280.0 | -0.6836 | 0.3092 | 0.0295 | -1.8015 | -0.8070 | 0.2574 | 0.0247 | -1.7506 |
| 104 | 290.0 | -0.6374 | 0.2945 | 0.0275 | -1.6779 | -0.7600 | 0.2405 | 0.0225 | -1.6245 |
| 105 | 300.0 | -0.5911 | 0.2801 | 0.0256 | -1.5631 | -0.7149 | 0.2240 | 0.0206 | -1.5084 |

表7. 7(1) 評価断面7の応力テンソル成分1

FINAS解と簡易計算値との比較 (ホットショック)

断面7の応力成分1

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|---------|---------|---------|---------|---------|---------|---------|---------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.2439 | 0.0000 | -0.0095 | -0.0237 | -0.3072 | 0.0000 | -0.0109 | -0.0282 |
| 3 | 1.0 | -0.4663 | -0.0001 | -0.0219 | -0.0498 | -0.4816 | -0.0001 | -0.0220 | -0.0505 |
| 4 | 1.5 | -0.5477 | -0.0003 | -0.0342 | -0.0694 | -0.6026 | -0.0003 | -0.0356 | -0.0736 |
| 5 | 2.0 | -0.6561 | -0.0005 | -0.0505 | -0.0953 | -0.6942 | -0.0004 | -0.0506 | -0.0971 |
| 6 | 2.5 | -0.7125 | -0.0007 | -0.0663 | -0.1177 | -0.7671 | -0.0006 | -0.0667 | -0.1205 |
| 7 | 3.0 | -0.7769 | -0.0009 | -0.0837 | -0.1417 | -0.8267 | -0.0009 | -0.0835 | -0.1434 |
| 8 | 3.5 | -0.8198 | -0.0012 | -0.1012 | -0.1639 | -0.8781 | -0.0011 | -0.1009 | -0.1658 |
| 9 | 4.0 | -0.8638 | -0.0015 | -0.1194 | -0.1862 | -0.9218 | -0.0014 | -0.1187 | -0.1876 |
| 10 | 4.5 | -0.8986 | -0.0018 | -0.1378 | -0.2075 | -0.9614 | -0.0017 | -0.1368 | -0.2087 |
| 11 | 5.0 | -0.9323 | -0.0021 | -0.1566 | -0.2285 | -0.9972 | -0.0020 | -0.1552 | -0.2293 |
| 12 | 5.5 | -0.9614 | -0.0025 | -0.1757 | -0.2487 | -1.0299 | -0.0023 | -0.1737 | -0.2492 |
| 13 | 6.0 | -0.9890 | -0.0028 | -0.1950 | -0.2684 | -1.0595 | -0.0026 | -0.1924 | -0.2683 |
| 14 | 6.5 | -1.0137 | -0.0032 | -0.2145 | -0.2875 | -1.0873 | -0.0029 | -0.2112 | -0.2869 |
| 15 | 7.0 | -1.0370 | -0.0036 | -0.2342 | -0.3061 | -1.1134 | -0.0032 | -0.2303 | -0.3050 |
| 16 | 7.5 | -1.0589 | -0.0040 | -0.2541 | -0.3241 | -1.1385 | -0.0036 | -0.2494 | -0.3226 |
| 17 | 8.0 | -1.0796 | -0.0044 | -0.2741 | -0.3417 | -1.1621 | -0.0039 | -0.2687 | -0.3398 |
| 18 | 8.5 | -1.0989 | -0.0048 | -0.2943 | -0.3588 | -1.1843 | -0.0043 | -0.2882 | -0.3566 |
| 19 | 9.0 | -1.1178 | -0.0053 | -0.3146 | -0.3755 | -1.2056 | -0.0046 | -0.3078 | -0.3730 |
| 20 | 9.5 | -1.1357 | -0.0059 | -0.3351 | -0.3918 | -1.2255 | -0.0050 | -0.3276 | -0.3889 |
| 21 | 10.0 | -1.1526 | -0.0066 | -0.3557 | -0.4076 | -1.2444 | -0.0054 | -0.3474 | -0.4044 |
| 22 | 11.0 | -0.9634 | -0.0074 | -0.3866 | -0.4142 | -1.0228 | -0.0062 | -0.3753 | -0.4066 |
| 23 | 12.0 | -0.8735 | -0.0085 | -0.4141 | -0.4196 | -0.9485 | -0.0069 | -0.4014 | -0.4118 |
| 24 | 13.0 | -0.8665 | -0.0096 | -0.4398 | -0.4253 | -0.9145 | -0.0076 | -0.4255 | -0.4158 |
| 25 | 14.0 | -0.8264 | -0.0108 | -0.4637 | -0.4275 | -0.8989 | -0.0080 | -0.4487 | -0.4196 |
| 26 | 15.0 | -0.8368 | -0.0121 | -0.4884 | -0.4334 | -0.8937 | -0.0091 | -0.4716 | -0.4232 |
| 27 | 16.0 | -0.8181 | -0.0135 | -0.5115 | -0.4362 | -0.8954 | -0.0112 | -0.4943 | -0.4271 |
| 28 | 17.0 | -0.8293 | -0.0154 | -0.5353 | -0.4418 | -0.9013 | -0.0132 | -0.5170 | -0.4316 |
| 29 | 18.0 | -0.8213 | -0.0173 | -0.5581 | -0.4454 | -0.9092 | -0.0153 | -0.5394 | -0.4363 |
| 30 | 19.0 | -0.8313 | -0.0193 | -0.5812 | -0.4507 | -0.9183 | -0.0173 | -0.5617 | -0.4408 |
| 31 | 20.0 | -0.8291 | -0.0222 | -0.6037 | -0.4547 | -0.9293 | -0.0203 | -0.5839 | -0.4452 |
| 32 | 21.0 | -0.8376 | -0.0250 | -0.6264 | -0.4598 | -0.9425 | -0.0246 | -0.6061 | -0.4497 |
| 33 | 22.0 | -0.8389 | -0.0282 | -0.6486 | -0.4641 | -0.9556 | -0.0299 | -0.6281 | -0.4541 |
| 34 | 23.0 | -0.8466 | -0.0316 | -0.6708 | -0.4691 | -0.9687 | -0.0356 | -0.6499 | -0.4584 |
| 35 | 24.0 | -0.8499 | -0.0350 | -0.6927 | -0.4735 | -0.9819 | -0.0413 | -0.6716 | -0.4627 |
| 36 | 25.0 | -0.8568 | -0.0389 | -0.7145 | -0.4783 | -0.9944 | -0.0466 | -0.6931 | -0.4670 |
| 37 | 26.0 | -0.8611 | -0.0427 | -0.7361 | -0.4828 | -1.0055 | -0.0515 | -0.7143 | -0.4712 |
| 38 | 27.0 | -0.8678 | -0.0473 | -0.7576 | -0.4874 | -1.0157 | -0.0568 | -0.7354 | -0.4751 |
| 39 | 28.0 | -0.8726 | -0.0516 | -0.7790 | -0.4918 | -1.0254 | -0.0630 | -0.7562 | -0.4788 |
| 40 | 29.0 | -0.8789 | -0.0560 | -0.8001 | -0.4963 | -1.0351 | -0.0696 | -0.7770 | -0.4825 |
| 41 | 30.0 | -0.8843 | -0.0603 | -0.8211 | -0.5008 | -1.0448 | -0.0756 | -0.7976 | -0.4864 |
| 42 | 32.0 | -0.7174 | -0.0696 | -0.8506 | -0.4858 | -0.8767 | -0.0856 | -0.8263 | -0.4701 |
| 43 | 34.0 | -0.6868 | -0.0789 | -0.8743 | -0.4719 | -0.8359 | -0.0955 | -0.8492 | -0.4549 |
| 44 | 36.0 | -0.6763 | -0.0885 | -0.8956 | -0.4595 | -0.8202 | -0.1064 | -0.8700 | -0.4423 |
| 45 | 38.0 | -0.6542 | -0.0978 | -0.9158 | -0.4491 | -0.8119 | -0.1160 | -0.8893 | -0.4322 |
| 46 | 40.0 | -0.6604 | -0.1070 | -0.9350 | -0.4415 | -0.8104 | -0.1257 | -0.9071 | -0.4238 |
| 47 | 42.0 | -0.6435 | -0.1163 | -0.9527 | -0.4338 | -0.8109 | -0.1372 | -0.9239 | -0.4165 |
| 48 | 44.0 | -0.6529 | -0.1252 | -0.9702 | -0.4290 | -0.8114 | -0.1493 | -0.9400 | -0.4103 |
| 49 | 46.0 | -0.6404 | -0.1337 | -0.9863 | -0.4235 | -0.8106 | -0.1612 | -0.9555 | -0.4048 |
| 50 | 48.0 | -0.6499 | -0.1423 | -1.0024 | -0.4205 | -0.8094 | -0.1714 | -0.9701 | -0.3997 |
| 51 | 50.0 | -0.6406 | -0.1505 | -1.0173 | -0.4166 | -0.8072 | -0.1789 | -0.9840 | -0.3953 |
| 52 | 52.0 | -0.6492 | -0.1583 | -1.0322 | -0.4149 | -0.8044 | -0.1842 | -0.9971 | -0.3916 |
| 53 | 54.0 | -0.6431 | -0.1658 | -1.0461 | -0.4123 | -0.8014 | -0.1897 | -1.0098 | -0.3886 |
| 54 | 56.0 | -0.6505 | -0.1728 | -1.0601 | -0.4115 | -0.7982 | -0.1957 | -1.0221 | -0.3863 |

| | | | | | | | | | |
|-----|-------|---------|---------|---------|---------|---------|---------|---------|---------|
| 55 | 58.0 | -0.6461 | -0.1793 | -1.0733 | -0.4100 | -0.7966 | -0.2022 | -1.0341 | -0.3846 |
| 56 | 60.0 | -0.6529 | -0.1855 | -1.0834 | -0.4098 | -0.7962 | -0.2091 | -1.0459 | -0.3831 |
| 57 | 62.0 | -0.6503 | -0.1912 | -1.0989 | -0.4090 | -0.7978 | -0.2162 | -1.0575 | -0.3820 |
| 58 | 64.0 | -0.6562 | -0.1966 | -1.1114 | -0.4094 | -0.8019 | -0.2225 | -1.0690 | -0.3814 |
| 59 | 66.0 | -0.6549 | -0.2018 | -1.1233 | -0.4092 | -0.8081 | -0.2280 | -1.0805 | -0.3810 |
| 60 | 68.0 | -0.6602 | -0.2066 | -1.1352 | -0.4099 | -0.8137 | -0.2324 | -1.0916 | -0.3807 |
| 61 | 70.0 | -0.6596 | -0.2114 | -1.1466 | -0.4101 | -0.8179 | -0.2355 | -1.1025 | -0.3805 |
| 62 | 72.0 | -0.4852 | -0.2160 | -1.1457 | -0.3872 | -0.6776 | -0.2375 | -1.1005 | -0.3579 |
| 63 | 74.0 | -0.4434 | -0.2200 | -1.1393 | -0.3653 | -0.6237 | -0.2390 | -1.0935 | -0.3353 |
| 64 | 76.0 | -0.4251 | -0.2237 | -1.1311 | -0.3455 | -0.5883 | -0.2406 | -1.0848 | -0.3153 |
| 65 | 78.0 | -0.3924 | -0.2271 | -1.1218 | -0.3277 | -0.5627 | -0.2428 | -1.0753 | -0.2979 |
| 66 | 80.0 | -0.3909 | -0.2301 | -1.1120 | -0.3132 | -0.5428 | -0.2460 | -1.0650 | -0.2822 |
| 67 | 82.0 | -0.1850 | -0.2333 | -1.0889 | -0.2747 | -0.3849 | -0.2494 | -1.0418 | -0.2456 |
| 68 | 84.0 | -0.1446 | -0.2356 | -1.0607 | -0.2409 | -0.3175 | -0.2523 | -1.0134 | -0.2100 |
| 69 | 86.0 | -0.1002 | -0.2377 | -1.0297 | -0.2079 | -0.2706 | -0.2539 | -0.9832 | -0.1780 |
| 70 | 88.0 | -0.0686 | -0.2392 | -0.9985 | -0.1801 | -0.2332 | -0.2540 | -0.9522 | -0.1492 |
| 71 | 90.0 | -0.0455 | -0.2405 | -0.9658 | -0.1542 | -0.2016 | -0.2524 | -0.9205 | -0.1232 |
| 72 | 92.0 | -0.0187 | -0.2414 | -0.9328 | -0.1309 | -0.1725 | -0.2484 | -0.8883 | -0.0997 |
| 73 | 94.0 | -0.0020 | -0.2413 | -0.8993 | -0.1098 | -0.1433 | -0.2441 | -0.8554 | -0.0780 |
| 74 | 96.0 | 0.0212 | -0.2409 | -0.8654 | -0.0901 | -0.1128 | -0.2393 | -0.8221 | -0.0580 |
| 75 | 98.0 | 0.0350 | -0.2399 | -0.8315 | -0.0725 | -0.0849 | -0.2347 | -0.7883 | -0.0395 |
| 76 | 100.0 | 0.0548 | -0.2382 | -0.7973 | -0.0556 | -0.0604 | -0.2306 | -0.7542 | -0.0225 |
| 77 | 102.0 | -0.1118 | -0.2359 | -0.7755 | -0.0642 | -0.1799 | -0.2257 | -0.7323 | -0.0294 |
| 78 | 104.0 | -0.1362 | -0.2333 | -0.7587 | -0.0721 | -0.2121 | -0.2202 | -0.7153 | -0.0376 |
| 79 | 106.0 | -0.1474 | -0.2300 | -0.7439 | -0.0798 | -0.2251 | -0.2145 | -0.6999 | -0.0445 |
| 80 | 108.0 | -0.1650 | -0.2265 | -0.7297 | -0.0856 | -0.2292 | -0.2086 | -0.6854 | -0.0498 |
| 81 | 110.0 | -0.1596 | -0.2223 | -0.7165 | -0.0898 | -0.2275 | -0.2022 | -0.6717 | -0.0540 |
| 82 | 115.0 | -0.2925 | -0.2114 | -0.7009 | -0.1210 | -0.2786 | -0.1820 | -0.6560 | -0.0841 |
| 83 | 120.0 | -0.2726 | -0.2004 | -0.6941 | -0.1431 | -0.2981 | -0.1617 | -0.6464 | -0.1053 |
| 84 | 125.0 | -0.3068 | -0.1904 | -0.6897 | -0.1596 | -0.3104 | -0.1434 | -0.6405 | -0.1203 |
| 85 | 130.0 | -0.2994 | -0.1819 | -0.6874 | -0.1701 | -0.3171 | -0.1298 | -0.6375 | -0.1308 |
| 86 | 135.0 | -0.3158 | -0.1751 | -0.6872 | -0.1795 | -0.3244 | -0.1210 | -0.6365 | -0.1382 |
| 87 | 140.0 | -0.3114 | -0.1701 | -0.6873 | -0.1849 | -0.3407 | -0.1137 | -0.6360 | -0.1443 |
| 88 | 145.0 | -0.3213 | -0.1666 | -0.6888 | -0.1904 | -0.3576 | -0.1108 | -0.6359 | -0.1486 |
| 89 | 150.0 | -0.3181 | -0.1643 | -0.6902 | -0.1932 | -0.3632 | -0.1107 | -0.6351 | -0.1506 |
| 90 | 155.0 | -0.3246 | -0.1628 | -0.6925 | -0.1967 | -0.3637 | -0.1135 | -0.6342 | -0.1517 |
| 91 | 160.0 | -0.3225 | -0.1616 | -0.6944 | -0.1983 | -0.3613 | -0.1187 | -0.6331 | -0.1524 |
| 92 | 170.0 | -0.1725 | -0.1599 | -0.6655 | -0.1607 | -0.2684 | -0.1312 | -0.5949 | -0.1116 |
| 93 | 180.0 | -0.2084 | -0.1582 | -0.6252 | -0.1363 | -0.2337 | -0.1422 | -0.5519 | -0.0845 |
| 94 | 190.0 | -0.1581 | -0.1542 | -0.5880 | -0.1221 | -0.2029 | -0.1353 | -0.5100 | -0.0682 |
| 95 | 200.0 | -0.1663 | -0.1481 | -0.5496 | -0.1098 | -0.1733 | -0.1211 | -0.4702 | -0.0564 |
| 96 | 210.0 | -0.1414 | -0.1403 | -0.5144 | -0.1012 | -0.1480 | -0.1071 | -0.4317 | -0.0459 |
| 97 | 220.0 | -0.1393 | -0.1322 | -0.4804 | -0.0931 | -0.1271 | -0.0868 | -0.3943 | -0.0377 |
| 98 | 230.0 | -0.1251 | -0.1244 | -0.4490 | -0.0865 | -0.1041 | -0.0585 | -0.3593 | -0.0304 |
| 99 | 240.0 | -0.1184 | -0.1169 | -0.4192 | -0.0802 | -0.0853 | -0.0229 | -0.3279 | -0.0250 |
| 100 | 250.0 | -0.1106 | -0.1095 | -0.3917 | -0.0748 | -0.0666 | 0.0097 | -0.2990 | -0.0204 |
| 101 | 260.0 | -0.1019 | -0.1026 | -0.3658 | -0.0695 | -0.0423 | 0.0304 | -0.2706 | -0.0150 |
| 102 | 270.0 | -0.0974 | -0.0959 | -0.3418 | -0.0649 | -0.0231 | 0.0408 | -0.2435 | -0.0083 |
| 103 | 280.0 | -0.0877 | -0.0897 | -0.3192 | -0.0604 | -0.0158 | 0.0445 | -0.2187 | -0.0012 |
| 104 | 290.0 | -0.0857 | -0.0840 | -0.2983 | -0.0564 | -0.0077 | 0.0497 | -0.1969 | 0.0037 |
| 105 | 300.0 | -0.0756 | -0.0786 | -0.2786 | -0.0524 | 0.0094 | 0.0581 | -0.1776 | 0.0060 |

表 7. 7 (2) 評価断面 7 の応力テンソル成分 2

FINAS解と簡易計算値との比較 (ホットショック)

断面 7 の応力成分 2

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|----------|---------|---------|----------|----------|---------|---------|----------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.8301 | 0.0166 | -0.0156 | -0.0990 | -1.0101 | 0.0179 | -0.0180 | -0.1118 |
| 3 | 1.0 | -2.2069 | 0.0597 | -0.0415 | -0.3100 | -2.2894 | 0.0609 | -0.0425 | -0.3171 |
| 4 | 1.5 | -3.5418 | 0.1224 | -0.0693 | -0.5802 | -3.6742 | 0.1236 | -0.0713 | -0.5907 |
| 5 | 2.0 | -5.0177 | 0.2025 | -0.1011 | -0.9108 | -5.1186 | 0.2037 | -0.1018 | -0.9178 |
| 6 | 2.5 | -6.4839 | 0.2981 | -0.1320 | -1.2813 | -6.6028 | 0.2992 | -0.1329 | -1.2887 |
| 7 | 3.0 | -8.0055 | 0.4078 | -0.1635 | -1.6912 | -8.1122 | 0.4083 | -0.1636 | -1.6964 |
| 8 | 3.5 | -9.5265 | 0.5303 | -0.1940 | -2.1317 | -9.6391 | 0.5299 | -0.1938 | -2.1359 |
| 9 | 4.0 | -11.0699 | 0.6651 | -0.2240 | -2.6017 | -11.1760 | 0.6639 | -0.2232 | -2.6040 |
| 10 | 4.5 | -12.6148 | 0.8112 | -0.2531 | -3.0966 | -12.7210 | 0.8091 | -0.2516 | -3.0977 |
| 11 | 5.0 | -14.1679 | 0.9683 | -0.2814 | -3.6150 | -14.2700 | 0.9645 | -0.2792 | -3.6140 |
| 12 | 5.5 | -15.7212 | 1.1358 | -0.3087 | -4.1545 | -15.8200 | 1.1304 | -0.3056 | -4.1514 |
| 13 | 6.0 | -17.2764 | 1.3133 | -0.3351 | -4.7136 | -17.3710 | 1.3061 | -0.3310 | -4.7081 |
| 14 | 6.5 | -18.8300 | 1.5004 | -0.3607 | -5.2907 | -18.9210 | 1.4911 | -0.3555 | -5.2828 |
| 15 | 7.0 | -20.3820 | 1.6968 | -0.3855 | -5.8845 | -20.4700 | 1.6855 | -0.3792 | -5.8745 |
| 16 | 7.5 | -21.9315 | 1.9023 | -0.4095 | -6.4940 | -22.0160 | 1.8890 | -0.4020 | -6.4818 |
| 17 | 8.0 | -23.4777 | 2.1167 | -0.4327 | -7.1182 | -23.5590 | 2.1014 | -0.4240 | -7.1039 |
| 18 | 8.5 | -25.0200 | 2.3396 | -0.4551 | -7.7562 | -25.0990 | 2.3223 | -0.4454 | -7.7400 |
| 19 | 9.0 | -26.5583 | 2.5711 | -0.4768 | -8.4070 | -26.6350 | 2.5515 | -0.4662 | -8.3894 |
| 20 | 9.5 | -28.0920 | 2.8107 | -0.4979 | -9.0700 | -28.1670 | 2.7885 | -0.4862 | -9.0511 |
| 21 | 10.0 | -29.6206 | 3.0583 | -0.5184 | -9.7444 | -29.6940 | 3.0334 | -0.5056 | -9.7243 |
| 22 | 11.0 | -31.6498 | 3.5480 | -0.5382 | -10.9788 | -31.6290 | 3.5171 | -0.5213 | -10.9480 |
| 23 | 12.0 | -33.1524 | 4.0243 | -0.5443 | -12.0909 | -33.2340 | 3.9895 | -0.5266 | -12.0670 |
| 24 | 13.0 | -34.7099 | 4.4991 | -0.5480 | -13.1562 | -34.7330 | 4.4606 | -0.5283 | -13.1300 |
| 25 | 14.0 | -36.1081 | 4.9750 | -0.5497 | -14.1818 | -36.1730 | 4.9353 | -0.5291 | -14.1600 |
| 26 | 15.0 | -37.5388 | 5.4551 | -0.5528 | -15.1887 | -37.5750 | 5.4152 | -0.5299 | -15.1670 |
| 27 | 16.0 | -38.8884 | 5.9395 | -0.5547 | -16.1737 | -38.9520 | 5.8996 | -0.5313 | -16.1560 |
| 28 | 17.0 | -40.2563 | 6.4292 | -0.5578 | -17.1479 | -40.3060 | 6.3878 | -0.5331 | -17.1300 |
| 29 | 18.0 | -41.5744 | 6.9235 | -0.5603 | -18.1077 | -41.6400 | 6.8800 | -0.5351 | -18.0920 |
| 30 | 19.0 | -42.9006 | 7.4227 | -0.5635 | -19.0594 | -42.9580 | 7.3766 | -0.5372 | -19.0440 |
| 31 | 20.0 | -44.1934 | 7.9253 | -0.5663 | -20.0005 | -44.2610 | 7.8772 | -0.5395 | -19.9860 |
| 32 | 21.0 | -45.4877 | 8.4322 | -0.5696 | -20.9348 | -45.5520 | 8.3813 | -0.5420 | -20.9190 |
| 33 | 22.0 | -46.7582 | 8.9418 | -0.5726 | -21.8605 | -46.8310 | 8.8891 | -0.5444 | -21.8450 |
| 34 | 23.0 | -48.0261 | 9.4540 | -0.5758 | -22.7800 | -48.0980 | 9.3988 | -0.5469 | -22.7630 |
| 35 | 24.0 | -49.2758 | 9.9681 | -0.5788 | -23.6920 | -49.3530 | 9.9089 | -0.5494 | -23.6740 |
| 36 | 25.0 | -50.5204 | 10.4833 | -0.5819 | -24.5980 | -50.5970 | 10.4190 | -0.5518 | -24.5790 |
| 37 | 26.0 | -51.7504 | 10.9992 | -0.5849 | -25.4974 | -51.8300 | 10.9290 | -0.5541 | -25.4770 |
| 38 | 27.0 | -52.9740 | 11.5149 | -0.5880 | -26.3909 | -53.0520 | 11.4400 | -0.5562 | -26.3690 |
| 39 | 28.0 | -54.1849 | 12.0302 | -0.5910 | -27.2780 | -54.2650 | 11.9510 | -0.5584 | -27.2560 |
| 40 | 29.0 | -55.3883 | 12.5451 | -0.5939 | -28.1594 | -55.4670 | 12.4610 | -0.5605 | -28.1370 |
| 41 | 30.0 | -56.5809 | 13.0588 | -0.5968 | -29.0347 | -56.6600 | 12.9700 | -0.5627 | -29.0110 |
| 42 | 32.0 | -57.7634 | 14.0338 | -0.5794 | -30.5562 | -57.7530 | 13.9300 | -0.5430 | -30.5210 |
| 43 | 34.0 | -58.4709 | 14.9322 | -0.5519 | -31.8329 | -58.5650 | 14.8150 | -0.5168 | -31.8090 |
| 44 | 36.0 | -59.2632 | 15.7768 | -0.5296 | -32.9944 | -59.3080 | 15.6450 | -0.4936 | -32.9700 |
| 45 | 38.0 | -59.9222 | 16.5713 | -0.5102 | -34.0554 | -60.0170 | 16.4270 | -0.4738 | -34.0360 |
| 46 | 40.0 | -60.6419 | 17.3208 | -0.4943 | -35.0429 | -60.7040 | 17.1650 | -0.4562 | -35.0230 |
| 47 | 42.0 | -61.2873 | 18.0271 | -0.4800 | -35.9615 | -61.3780 | 17.8610 | -0.4407 | -35.9430 |
| 48 | 44.0 | -61.9746 | 18.6924 | -0.4683 | -36.8266 | -62.0400 | 18.5170 | -0.4273 | -36.8040 |
| 49 | 46.0 | -62.6115 | 19.3189 | -0.4577 | -37.6393 | -62.6900 | 19.1370 | -0.4157 | -37.6180 |
| 50 | 48.0 | -63.2780 | 19.9083 | -0.4492 | -38.4109 | -63.3350 | 19.7210 | -0.4052 | -38.3860 |
| 51 | 50.0 | -63.9064 | 20.4630 | -0.4414 | -39.1412 | -63.9720 | 20.2730 | -0.3958 | -39.1150 |
| 52 | 52.0 | -64.5557 | 20.9855 | -0.4352 | -39.8337 | -64.6030 | 20.7950 | -0.3873 | -39.8110 |
| 53 | 54.0 | -65.1755 | 21.4784 | -0.4295 | -40.5032 | -65.2270 | 21.2880 | -0.3798 | -40.4750 |
| 54 | 56.0 | -65.8092 | 21.9440 | -0.4252 | -41.1410 | -65.8440 | 21.7540 | -0.3731 | -41.1120 |

| | | | | | | | | | |
|-----|-------|----------|---------|---------|----------|----------|---------|---------|----------|
| 55 | 58.0 | -66.4187 | 22.3840 | -0.4211 | -41.7519 | -66.4560 | 22.1940 | -0.3673 | -41.7240 |
| 56 | 60.0 | -67.0373 | 22.8016 | -0.4181 | -42.3408 | -67.0630 | 22.6100 | -0.3622 | -42.3120 |
| 57 | 62.0 | -67.6357 | 23.1984 | -0.4153 | -42.9075 | -67.6650 | 23.0040 | -0.3578 | -42.8790 |
| 58 | 64.0 | -68.2399 | 23.5761 | -0.4134 | -43.4559 | -68.2620 | 23.3790 | -0.3543 | -43.4270 |
| 59 | 66.0 | -68.8266 | 23.9362 | -0.4116 | -43.9856 | -68.8540 | 23.7340 | -0.3515 | -43.9570 |
| 60 | 68.0 | -69.4160 | 24.2808 | -0.4105 | -44.4999 | -69.4370 | 24.0740 | -0.3491 | -44.4710 |
| 61 | 70.0 | -69.9901 | 24.6105 | -0.4095 | -44.9985 | -70.0120 | 24.4000 | -0.3470 | -44.9690 |
| 62 | 72.0 | -69.3871 | 24.8795 | -0.3859 | -45.2718 | -69.2360 | 24.6610 | -0.3180 | -45.2130 |
| 63 | 74.0 | -68.3329 | 25.0669 | -0.3526 | -45.3100 | -68.2730 | 24.8510 | -0.2856 | -45.2620 |
| 64 | 76.0 | -67.3953 | 25.1988 | -0.3249 | -45.2442 | -67.2690 | 24.9850 | -0.2569 | -45.1960 |
| 65 | 78.0 | -66.3479 | 25.2814 | -0.3003 | -45.0890 | -66.2620 | 25.0700 | -0.2321 | -45.0460 |
| 66 | 80.0 | -65.3905 | 25.3210 | -0.2794 | -44.8728 | -65.2630 | 25.1110 | -0.2103 | -44.8300 |
| 67 | 82.0 | -63.2043 | 25.2724 | -0.2374 | -44.3877 | -62.9390 | 25.0580 | -0.1643 | -44.3180 |
| 68 | 84.0 | -60.6496 | 25.1182 | -0.1885 | -43.6403 | -60.4520 | 24.9050 | -0.1169 | -43.5790 |
| 69 | 86.0 | -58.1849 | 24.8852 | -0.1461 | -42.7612 | -57.9500 | 24.6700 | -0.0750 | -42.7000 |
| 70 | 88.0 | -55.6775 | 24.5817 | -0.1091 | -41.7766 | -55.4690 | 24.3650 | -0.0388 | -41.7190 |
| 71 | 90.0 | -53.2471 | 24.2160 | -0.0763 | -40.7134 | -53.0190 | 23.9970 | -0.0071 | -40.6560 |
| 72 | 92.0 | -50.8211 | 23.7937 | -0.0473 | -39.5847 | -50.6060 | 23.5710 | 0.0208 | -39.5280 |
| 73 | 94.0 | -48.4594 | 23.3205 | -0.0216 | -38.4056 | -48.2310 | 23.0950 | 0.0455 | -38.3490 |
| 74 | 96.0 | -46.1171 | 22.8011 | 0.0016 | -37.1835 | -45.8950 | 22.5720 | 0.0678 | -37.1290 |
| 75 | 98.0 | -43.8312 | 22.2398 | 0.0221 | -35.9290 | -43.6000 | 22.0130 | 0.0880 | -35.8750 |
| 76 | 100.0 | -41.5698 | 21.6422 | 0.0407 | -34.6472 | -41.3460 | 21.4190 | 0.1064 | -34.5950 |
| 77 | 102.0 | -40.5355 | 21.0604 | 0.0341 | -33.5578 | -40.4710 | 20.8490 | 0.0962 | -33.5370 |
| 78 | 104.0 | -39.9668 | 20.5203 | 0.0163 | -32.6743 | -39.8120 | 20.3150 | 0.0806 | -32.6460 |
| 79 | 106.0 | -39.3248 | 20.0015 | 0.0022 | -31.8729 | -39.2200 | 19.8020 | 0.0669 | -31.8470 |
| 80 | 108.0 | -38.8087 | 19.5022 | -0.0100 | -31.1416 | -38.6590 | 19.3080 | 0.0555 | -31.1140 |
| 81 | 110.0 | -38.2408 | 19.0209 | -0.0201 | -30.4581 | -38.1180 | 18.8310 | 0.0457 | -30.4320 |
| 82 | 115.0 | -38.3210 | 17.9895 | -0.0661 | -29.2551 | -38.3120 | 17.8220 | -0.0032 | -29.2900 |
| 83 | 120.0 | -38.6972 | 17.1967 | -0.1070 | -28.5421 | -38.6110 | 17.0380 | -0.0376 | -28.5630 |
| 84 | 125.0 | -38.9614 | 16.5876 | -0.1325 | -28.0515 | -38.9090 | 16.4380 | -0.0624 | -28.0820 |
| 85 | 130.0 | -39.2544 | 16.1405 | -0.1528 | -27.7419 | -39.1880 | 15.9970 | -0.0811 | -27.7730 |
| 86 | 135.0 | -39.4917 | 15.8225 | -0.1674 | -27.5478 | -39.4470 | 15.6800 | -0.0955 | -27.5820 |
| 87 | 140.0 | -39.7308 | 15.6057 | -0.1783 | -27.4417 | -39.6890 | 15.4610 | -0.1054 | -27.4760 |
| 88 | 145.0 | -39.9376 | 15.4641 | -0.1866 | -27.3959 | -39.9120 | 15.3170 | -0.1122 | -27.4290 |
| 89 | 150.0 | -40.1406 | 15.3783 | -0.1926 | -27.3940 | -40.1150 | 15.2350 | -0.1155 | -27.4250 |
| 90 | 155.0 | -40.3237 | 15.3325 | -0.1975 | -27.4225 | -40.3040 | 15.1950 | -0.1168 | -27.4510 |
| 91 | 160.0 | -40.5020 | 15.3158 | -0.2010 | -27.4721 | -40.4810 | 15.1860 | -0.1162 | -27.4980 |
| 92 | 170.0 | -37.9770 | 15.0505 | -0.1560 | -26.7156 | -37.7560 | 14.9080 | -0.0585 | -26.6230 |
| 93 | 180.0 | -35.1525 | 14.4679 | -0.1225 | -25.2946 | -35.0910 | 14.3460 | -0.0236 | -25.2620 |
| 94 | 190.0 | -32.8212 | 13.7276 | -0.1111 | -23.8261 | -32.6330 | 13.6080 | -0.0023 | -23.7680 |
| 95 | 200.0 | -30.4919 | 12.8871 | -0.0977 | -22.2937 | -30.3740 | 12.7900 | 0.0122 | -22.2600 |
| 96 | 210.0 | -28.4716 | 12.0343 | -0.0930 | -20.8340 | -28.2890 | 11.9600 | 0.0240 | -20.8000 |
| 97 | 220.0 | -26.4883 | 11.2023 | -0.0862 | -19.4254 | -26.3420 | 11.1380 | 0.0344 | -19.4020 |
| 98 | 230.0 | -24.7369 | 10.4123 | -0.0831 | -18.1120 | -24.5370 | 10.3450 | 0.0428 | -18.0850 |
| 99 | 240.0 | -23.0292 | 9.6685 | -0.0784 | -16.8721 | -22.8760 | 9.5915 | 0.0477 | -16.8530 |
| 100 | 250.0 | -21.5102 | 8.9758 | -0.0757 | -15.7222 | -21.3350 | 8.8911 | 0.0517 | -15.7020 |
| 101 | 260.0 | -20.0329 | 8.3308 | -0.0719 | -14.6446 | -19.8900 | 8.2483 | 0.0571 | -14.6290 |
| 102 | 270.0 | -18.7143 | 7.7326 | -0.0692 | -13.6460 | -18.5300 | 7.6530 | 0.0635 | -13.6230 |
| 103 | 280.0 | -17.4333 | 7.1769 | -0.0659 | -12.7122 | -17.2520 | 7.1032 | 0.0697 | -12.6810 |
| 104 | 290.0 | -16.2883 | 6.6620 | -0.0634 | -11.8465 | -16.0650 | 6.5928 | 0.0733 | -11.8030 |
| 105 | 300.0 | -15.1757 | 6.1845 | -0.0603 | -11.0377 | -14.9720 | 6.1190 | 0.0742 | -10.9910 |

表7. 7(3) 評価断面7の応力テンソル成分3

FINAS解と簡易計算値との比較 (ホットショック)

断面7の応力成分3

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|----------|---------|---------|----------|----------|---------|---------|----------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | -0.8359 | 0.0186 | -0.0178 | -0.1034 | -1.0162 | 0.0200 | -0.0203 | -0.1165 |
| 3 | 1.0 | -2.2277 | 0.0668 | -0.0494 | -0.3257 | -2.3101 | 0.0681 | -0.0504 | -0.3329 |
| 4 | 1.5 | -3.5843 | 0.1371 | -0.0854 | -0.6125 | -3.7166 | 0.1382 | -0.0874 | -0.6229 |
| 5 | 2.0 | -5.0882 | 0.2269 | -0.1279 | -0.9643 | -5.1889 | 0.2278 | -0.1285 | -0.9709 |
| 6 | 2.5 | -6.5879 | 0.3339 | -0.1715 | -1.3600 | -6.7065 | 0.3346 | -0.1721 | -1.3669 |
| 7 | 3.0 | -8.1483 | 0.4569 | -0.2178 | -1.7990 | -8.2549 | 0.4569 | -0.2177 | -1.8037 |
| 8 | 3.5 | -9.7127 | 0.5943 | -0.2646 | -2.2723 | -9.8254 | 0.5935 | -0.2643 | -2.2759 |
| 9 | 4.0 | -11.3042 | 0.7455 | -0.3128 | -2.7782 | -11.4110 | 0.7438 | -0.3119 | -2.7801 |
| 10 | 4.5 | -12.9012 | 0.9097 | -0.3614 | -3.3122 | -13.0080 | 0.9070 | -0.3603 | -3.3132 |
| 11 | 5.0 | -14.5106 | 1.0861 | -0.4107 | -3.8727 | -14.6140 | 1.0819 | -0.4092 | -3.8719 |
| 12 | 5.5 | -16.1239 | 1.2744 | -0.4604 | -4.4570 | -16.2260 | 1.2685 | -0.4585 | -4.4546 |
| 13 | 6.0 | -17.7429 | 1.4740 | -0.5105 | -5.0636 | -17.8420 | 1.4663 | -0.5081 | -5.0594 |
| 14 | 6.5 | -19.3636 | 1.6845 | -0.5609 | -5.6908 | -19.4600 | 1.6747 | -0.5580 | -5.6850 |
| 15 | 7.0 | -20.9863 | 1.9056 | -0.6116 | -6.3372 | -21.0810 | 1.8937 | -0.6082 | -6.3298 |
| 16 | 7.5 | -22.6094 | 2.1370 | -0.6626 | -7.0016 | -22.7020 | 2.1231 | -0.6585 | -6.9924 |
| 17 | 8.0 | -24.2324 | 2.3783 | -0.7138 | -7.6829 | -24.3220 | 2.3624 | -0.7089 | -7.6719 |
| 18 | 8.5 | -25.8544 | 2.6294 | -0.7652 | -8.3802 | -25.9420 | 2.6114 | -0.7596 | -8.3676 |
| 19 | 9.0 | -27.4751 | 2.8901 | -0.8168 | -9.0923 | -27.5620 | 2.8697 | -0.8105 | -9.0785 |
| 20 | 9.5 | -29.0939 | 3.1600 | -0.8686 | -9.8185 | -29.1790 | 3.1371 | -0.8615 | -9.8039 |
| 21 | 10.0 | -30.7102 | 3.4389 | -0.9205 | -10.5582 | -30.7950 | 3.4136 | -0.9128 | -10.5430 |
| 22 | 11.0 | -32.9118 | 3.9909 | -1.0017 | -11.9208 | -32.9050 | 3.9604 | -0.9905 | -11.8960 |
| 23 | 12.0 | -34.5810 | 4.5281 | -1.0662 | -13.1564 | -34.6790 | 4.4950 | -1.0549 | -13.1400 |
| 24 | 13.0 | -36.3023 | 5.0636 | -1.1266 | -14.3434 | -36.3440 | 5.0283 | -1.1136 | -14.3270 |
| 25 | 14.0 | -37.8624 | 5.6005 | -1.1837 | -15.4893 | -37.9480 | 5.5651 | -1.1700 | -15.4790 |
| 26 | 15.0 | -39.4536 | 6.1417 | -1.2409 | -16.6157 | -39.5120 | 6.1075 | -1.2250 | -16.6060 |
| 27 | 16.0 | -40.9624 | 6.6875 | -1.2962 | -17.7197 | -41.0480 | 6.6551 | -1.2791 | -17.7150 |
| 28 | 17.0 | -42.4886 | 7.2390 | -1.3518 | -18.8122 | -42.5610 | 7.2068 | -1.3326 | -18.8090 |
| 29 | 18.0 | -43.9645 | 7.7954 | -1.4061 | -19.8901 | -44.0520 | 7.7627 | -1.3859 | -19.8890 |
| 30 | 19.0 | -45.4477 | 8.3571 | -1.4605 | -20.9597 | -45.5270 | 8.3231 | -1.4388 | -20.9590 |
| 31 | 20.0 | -46.8968 | 8.9228 | -1.5138 | -22.0184 | -46.9870 | 8.8882 | -1.4913 | -22.0200 |
| 32 | 21.0 | -48.3469 | 9.4931 | -1.5670 | -23.0701 | -48.4340 | 9.4570 | -1.5434 | -23.0710 |
| 33 | 22.0 | -49.7728 | 10.0664 | -1.6195 | -24.1133 | -49.8690 | 10.0290 | -1.5952 | -24.1150 |
| 34 | 23.0 | -51.1955 | 10.6426 | -1.6717 | -25.1499 | -51.2910 | 10.6040 | -1.6467 | -25.1510 |
| 35 | 24.0 | -52.5996 | 11.2213 | -1.7232 | -26.1791 | -52.7010 | 11.1790 | -1.6976 | -26.1800 |
| 36 | 25.0 | -53.9983 | 11.8016 | -1.7743 | -27.2023 | -54.0990 | 11.7550 | -1.7482 | -27.2020 |
| 37 | 26.0 | -55.3820 | 12.3829 | -1.8248 | -28.2187 | -55.4870 | 12.3300 | -1.7985 | -28.2180 |
| 38 | 27.0 | -56.7588 | 12.9645 | -1.8749 | -29.2292 | -56.8640 | 12.9070 | -1.8484 | -29.2280 |
| 39 | 28.0 | -58.1227 | 13.5461 | -1.9245 | -30.2335 | -58.2300 | 13.4840 | -1.8976 | -30.2320 |
| 40 | 29.0 | -59.4786 | 14.1276 | -1.9737 | -31.2318 | -59.5860 | 14.0620 | -1.9463 | -31.2310 |
| 41 | 30.0 | -60.8232 | 14.7083 | -2.0223 | -32.2241 | -60.9320 | 14.6380 | -1.9946 | -32.2230 |
| 42 | 32.0 | -62.2918 | 15.8126 | -2.0888 | -33.9664 | -62.3140 | 15.7290 | -2.0593 | -33.9560 |
| 43 | 34.0 | -63.2592 | 16.8331 | -2.1343 | -35.4451 | -63.3880 | 16.7380 | -2.1069 | -35.4490 |
| 44 | 36.0 | -64.2928 | 17.7951 | -2.1772 | -36.7960 | -64.3740 | 17.6880 | -2.1491 | -36.8010 |
| 45 | 38.0 | -65.1772 | 18.7032 | -2.2166 | -38.0355 | -65.3080 | 18.5850 | -2.1878 | -38.0460 |
| 46 | 40.0 | -66.1089 | 19.5629 | -2.2540 | -39.1925 | -66.2080 | 19.4360 | -2.2233 | -39.2040 |
| 47 | 42.0 | -66.9542 | 20.3761 | -2.2883 | -40.2724 | -67.0820 | 20.2420 | -2.2555 | -40.2870 |
| 48 | 44.0 | -67.8312 | 21.1459 | -2.3213 | -41.2920 | -67.9330 | 21.0050 | -2.2860 | -41.3040 |
| 49 | 46.0 | -68.6486 | 21.8742 | -2.3518 | -42.2530 | -68.7650 | 21.7300 | -2.3149 | -42.2680 |
| 50 | 48.0 | -69.4875 | 22.5632 | -2.3813 | -43.1672 | -69.5840 | 22.4160 | -2.3423 | -43.1810 |
| 51 | 50.0 | -70.2811 | 23.2157 | -2.4086 | -44.0354 | -70.3890 | 23.0680 | -2.3685 | -44.0510 |
| 52 | 52.0 | -71.0890 | 23.8340 | -2.4352 | -44.8663 | -71.1800 | 23.6880 | -2.3934 | -44.8820 |
| 53 | 54.0 | -71.8613 | 24.4210 | -2.4600 | -45.6600 | -71.9590 | 24.2760 | -2.4170 | -45.6780 |
| 54 | 56.0 | -72.6421 | 24.9790 | -2.4842 | -46.4236 | -72.7260 | 24.8370 | -2.4393 | -46.4420 |

| | | | | | | | | | |
|-----|-------|----------|---------|---------|----------|----------|---------|---------|----------|
| 55 | 58.0 | -73.3940 | 25.5101 | -2.5069 | -47.1566 | -73.4820 | 25.3690 | -2.4606 | -47.1770 |
| 56 | 60.0 | -74.1505 | 26.0174 | -2.5290 | -47.8648 | -74.2270 | 25.8760 | -2.4812 | -47.8860 |
| 57 | 62.0 | -74.8826 | 26.5025 | -2.5499 | -48.5478 | -74.9630 | 26.3590 | -2.5009 | -48.5700 |
| 58 | 64.0 | -75.6167 | 26.9671 | -2.5703 | -49.2098 | -75.6900 | 26.8210 | -2.5198 | -49.2320 |
| 59 | 66.0 | -76.3298 | 27.4131 | -2.5898 | -49.8507 | -76.4080 | 27.2640 | -2.5380 | -49.8740 |
| 60 | 68.0 | -77.0425 | 27.8424 | -2.6088 | -50.4739 | -77.1160 | 27.6910 | -2.5553 | -50.4980 |
| 61 | 70.0 | -77.7369 | 28.2558 | -2.6268 | -51.0794 | -77.8110 | 28.1040 | -2.5717 | -51.1050 |
| 62 | 72.0 | -77.2348 | 28.6016 | -2.6150 | -51.4449 | -77.1360 | 28.4450 | -2.5537 | -51.4420 |
| 63 | 74.0 | -76.2542 | 28.8565 | -2.5834 | -51.5549 | -76.2490 | 28.7040 | -2.5231 | -51.5650 |
| 64 | 76.0 | -75.3714 | 29.0491 | -2.5508 | -51.5471 | -75.3000 | 28.9010 | -2.4893 | -51.5590 |
| 65 | 78.0 | -74.3620 | 29.1862 | -2.5155 | -51.4377 | -74.3320 | 29.0430 | -2.4539 | -51.4560 |
| 66 | 80.0 | -73.4292 | 29.2748 | -2.4796 | -51.2571 | -73.3570 | 29.1330 | -2.4175 | -51.2750 |
| 67 | 82.0 | -71.2387 | 29.2646 | -2.4125 | -50.7860 | -71.0270 | 29.1180 | -2.3461 | -50.7760 |
| 68 | 84.0 | -68.6450 | 29.1360 | -2.3263 | -50.0266 | -68.5010 | 28.9910 | -2.2619 | -50.0260 |
| 69 | 86.0 | -66.1157 | 28.9186 | -2.2380 | -49.1165 | -65.9330 | 28.7720 | -2.1739 | -49.1160 |
| 70 | 88.0 | -63.5217 | 28.6218 | -2.1481 | -48.0844 | -63.3650 | 28.4760 | -2.0844 | -48.0880 |
| 71 | 90.0 | -60.9863 | 28.2549 | -2.0570 | -46.9599 | -60.8100 | 28.1090 | -1.9938 | -46.9650 |
| 72 | 92.0 | -58.4396 | 27.8241 | -1.9653 | -45.7577 | -58.2760 | 27.6770 | -1.9025 | -45.7650 |
| 73 | 94.0 | -55.9434 | 27.3358 | -1.8731 | -44.4945 | -55.7660 | 27.1870 | -1.8110 | -44.5030 |
| 74 | 96.0 | -53.4550 | 26.7952 | -1.7807 | -43.1793 | -53.2840 | 26.6450 | -1.7195 | -43.1900 |
| 75 | 98.0 | -51.0127 | 26.2073 | -1.6886 | -41.8235 | -50.8330 | 26.0600 | -1.6279 | -41.8360 |
| 76 | 100.0 | -48.5865 | 25.5779 | -1.5967 | -40.4333 | -48.4140 | 25.4350 | -1.5363 | -40.4480 |
| 77 | 102.0 | -47.3965 | 24.9654 | -1.5350 | -39.2419 | -47.3840 | 24.8350 | -1.4789 | -39.2890 |
| 78 | 104.0 | -46.6901 | 24.3987 | -1.4927 | -38.2692 | -46.5860 | 24.2740 | -1.4342 | -38.3090 |
| 79 | 106.0 | -45.9215 | 23.8552 | -1.4521 | -37.3860 | -45.8680 | 23.7370 | -1.3934 | -37.4290 |
| 80 | 108.0 | -45.2885 | 23.3325 | -1.4141 | -36.5791 | -45.1920 | 23.2210 | -1.3548 | -36.6210 |
| 81 | 110.0 | -44.6112 | 22.8288 | -1.3776 | -35.8246 | -44.5420 | 22.7220 | -1.3180 | -35.8690 |
| 82 | 115.0 | -44.4760 | 21.7556 | -1.3315 | -34.4845 | -44.5280 | 21.6750 | -1.2771 | -34.5960 |
| 83 | 120.0 | -44.7093 | 20.9390 | -1.3101 | -33.6838 | -44.6860 | 20.8680 | -1.2499 | -33.7820 |
| 84 | 125.0 | -44.8756 | 20.3166 | -1.2914 | -33.1351 | -44.8870 | 20.2550 | -1.2312 | -33.2430 |
| 85 | 130.0 | -45.1037 | 19.8644 | -1.2806 | -32.7892 | -45.1000 | 19.8100 | -1.2182 | -32.8980 |
| 86 | 135.0 | -45.2990 | 19.5470 | -1.2729 | -32.5738 | -45.3160 | 19.4950 | -1.2096 | -32.6850 |
| 87 | 140.0 | -45.5132 | 19.3352 | -1.2681 | -32.4578 | -45.5310 | 19.2800 | -1.2038 | -32.5690 |
| 88 | 145.0 | -45.7074 | 19.2018 | -1.2654 | -32.4100 | -45.7390 | 19.1440 | -1.1991 | -32.5190 |
| 89 | 150.0 | -45.9069 | 19.1267 | -1.2638 | -32.4123 | -45.9340 | 19.0680 | -1.1951 | -32.5150 |
| 90 | 155.0 | -46.0932 | 19.0937 | -1.2635 | -32.4495 | -46.1200 | 19.0360 | -1.1914 | -32.5440 |
| 91 | 160.0 | -46.2793 | 19.0912 | -1.2634 | -32.5110 | -46.2990 | 19.0360 | -1.1879 | -32.5980 |
| 92 | 170.0 | -43.6793 | 18.8219 | -1.1782 | -31.7097 | -43.4800 | 18.7420 | -1.0864 | -31.6620 |
| 93 | 180.0 | -40.6679 | 18.1919 | -1.0670 | -30.1599 | -40.6260 | 18.1290 | -0.9770 | -30.1700 |
| 94 | 190.0 | -38.1105 | 17.3819 | -0.9701 | -28.5315 | -37.9370 | 17.3100 | -0.8728 | -28.5090 |
| 95 | 200.0 | -35.5356 | 16.4553 | -0.8701 | -26.8207 | -35.4330 | 16.3950 | -0.7766 | -26.8180 |
| 96 | 210.0 | -33.2667 | 15.5063 | -0.7829 | -25.1767 | -33.1050 | 15.4620 | -0.6880 | -25.1710 |
| 97 | 220.0 | -31.0363 | 14.5705 | -0.6988 | -23.5809 | -30.9180 | 14.5310 | -0.6057 | -23.5880 |
| 98 | 230.0 | -29.0450 | 13.6724 | -0.6248 | -22.0823 | -28.8810 | 13.6310 | -0.5305 | -22.0900 |
| 99 | 240.0 | -27.1050 | 12.8173 | -0.5552 | -20.6600 | -26.9950 | 12.7660 | -0.4635 | -20.6790 |
| 100 | 250.0 | -25.3634 | 12.0119 | -0.4936 | -19.3323 | -25.2330 | 11.9510 | -0.4022 | -19.3520 |
| 101 | 260.0 | -23.6730 | 11.2535 | -0.4365 | -18.0819 | -23.5720 | 11.1930 | -0.3438 | -18.1020 |
| 102 | 270.0 | -22.1514 | 10.5424 | -0.3858 | -16.9162 | -22.0060 | 10.4850 | -0.2893 | -16.9280 |
| 103 | 280.0 | -20.6768 | 9.8749 | -0.3391 | -15.8212 | -20.5360 | 9.8254 | -0.2403 | -15.8260 |
| 104 | 290.0 | -19.3482 | 9.2499 | -0.2976 | -14.8005 | -19.1650 | 9.2039 | -0.1974 | -14.7920 |
| 105 | 300.0 | -18.0609 | 8.6640 | -0.2595 | -13.8425 | -17.8920 | 8.6170 | -0.1605 | -13.8260 |

表7. 7(4) 評価断面7の応力テンソル成分4

FINAS解と簡易計算値との比較 (ホットショック)

断面7の応力成分4

| ステップ | 時間(S) | FINAS解 | | | | 簡易計算値 | | | |
|------|-------|--------|---------|---------|--------|--------|---------|---------|--------|
| | | 内面值 | 外面値 | 平均値 | 曲げ成分 | 内面值 | 外面値 | 平均値 | 曲げ成分 |
| 1 | 0.0 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 0.5 | 0.0126 | -0.0003 | 0.0001 | 0.0015 | 0.0153 | -0.0003 | 0.0001 | 0.0017 |
| 3 | 1.0 | 0.0367 | -0.0009 | 0.0002 | 0.0052 | 0.0383 | -0.0009 | 0.0002 | 0.0053 |
| 4 | 1.5 | 0.0616 | -0.0019 | 0.0002 | 0.0101 | 0.0637 | -0.0018 | 0.0002 | 0.0101 |
| 5 | 2.0 | 0.0880 | -0.0031 | 0.0001 | 0.0159 | 0.0898 | -0.0030 | 0.0002 | 0.0158 |
| 6 | 2.5 | 0.1142 | -0.0045 | 0.0000 | 0.0224 | 0.1163 | -0.0044 | 0.0001 | 0.0222 |
| 7 | 3.0 | 0.1406 | -0.0061 | -0.0002 | 0.0294 | 0.1424 | -0.0059 | -0.0002 | 0.0290 |
| 8 | 3.5 | 0.1666 | -0.0079 | -0.0006 | 0.0369 | 0.1677 | -0.0076 | -0.0005 | 0.0362 |
| 9 | 4.0 | 0.1923 | -0.0099 | -0.0010 | 0.0448 | 0.1926 | -0.0095 | -0.0009 | 0.0439 |
| 10 | 4.5 | 0.2176 | -0.0120 | -0.0015 | 0.0532 | 0.2171 | -0.0115 | -0.0014 | 0.0519 |
| 11 | 5.0 | 0.2425 | -0.0143 | -0.0021 | 0.0618 | 0.2414 | -0.0136 | -0.0020 | 0.0602 |
| 12 | 5.5 | 0.2669 | -0.0167 | -0.0027 | 0.0707 | 0.2648 | -0.0157 | -0.0027 | 0.0686 |
| 13 | 6.0 | 0.2909 | -0.0192 | -0.0034 | 0.0797 | 0.2873 | -0.0180 | -0.0034 | 0.0770 |
| 14 | 6.5 | 0.3144 | -0.0218 | -0.0042 | 0.0890 | 0.3092 | -0.0203 | -0.0042 | 0.0856 |
| 15 | 7.0 | 0.3374 | -0.0245 | -0.0051 | 0.0985 | 0.3308 | -0.0227 | -0.0051 | 0.0944 |
| 16 | 7.5 | 0.3600 | -0.0273 | -0.0060 | 0.1081 | 0.3518 | -0.0251 | -0.0060 | 0.1032 |
| 17 | 8.0 | 0.3822 | -0.0302 | -0.0070 | 0.1179 | 0.3724 | -0.0277 | -0.0070 | 0.1122 |
| 18 | 8.5 | 0.4040 | -0.0332 | -0.0080 | 0.1278 | 0.3927 | -0.0303 | -0.0080 | 0.1214 |
| 19 | 9.0 | 0.4254 | -0.0361 | -0.0091 | 0.1378 | 0.4127 | -0.0331 | -0.0091 | 0.1307 |
| 20 | 9.5 | 0.4464 | -0.0393 | -0.0102 | 0.1479 | 0.4324 | -0.0359 | -0.0102 | 0.1401 |
| 21 | 10.0 | 0.4670 | -0.0424 | -0.0113 | 0.1582 | 0.4517 | -0.0388 | -0.0113 | 0.1496 |
| 22 | 11.0 | 0.4905 | -0.0486 | -0.0138 | 0.1765 | 0.4711 | -0.0443 | -0.0138 | 0.1663 |
| 23 | 12.0 | 0.5017 | -0.0543 | -0.0164 | 0.1920 | 0.4820 | -0.0494 | -0.0163 | 0.1807 |
| 24 | 13.0 | 0.5136 | -0.0599 | -0.0189 | 0.2064 | 0.4909 | -0.0544 | -0.0188 | 0.1939 |
| 25 | 14.0 | 0.5236 | -0.0652 | -0.0213 | 0.2200 | 0.4995 | -0.0591 | -0.0212 | 0.2063 |
| 26 | 15.0 | 0.5339 | -0.0705 | -0.0237 | 0.2330 | 0.5078 | -0.0639 | -0.0236 | 0.2181 |
| 27 | 16.0 | 0.5437 | -0.0756 | -0.0261 | 0.2456 | 0.5160 | -0.0686 | -0.0259 | 0.2297 |
| 28 | 17.0 | 0.5538 | -0.0807 | -0.0283 | 0.2579 | 0.5245 | -0.0732 | -0.0282 | 0.2411 |
| 29 | 18.0 | 0.5636 | -0.0856 | -0.0306 | 0.2699 | 0.5332 | -0.0778 | -0.0304 | 0.2524 |
| 30 | 19.0 | 0.5736 | -0.0905 | -0.0328 | 0.2816 | 0.5417 | -0.0823 | -0.0326 | 0.2634 |
| 31 | 20.0 | 0.5834 | -0.0954 | -0.0350 | 0.2932 | 0.5500 | -0.0867 | -0.0347 | 0.2743 |
| 32 | 21.0 | 0.5932 | -0.1001 | -0.0371 | 0.3046 | 0.5585 | -0.0911 | -0.0368 | 0.2851 |
| 33 | 22.0 | 0.6030 | -0.1048 | -0.0392 | 0.3159 | 0.5668 | -0.0955 | -0.0389 | 0.2957 |
| 34 | 23.0 | 0.6129 | -0.1095 | -0.0413 | 0.3270 | 0.5751 | -0.0998 | -0.0410 | 0.3062 |
| 35 | 24.0 | 0.6226 | -0.1141 | -0.0434 | 0.3379 | 0.5835 | -0.1041 | -0.0431 | 0.3167 |
| 36 | 25.0 | 0.6322 | -0.1187 | -0.0454 | 0.3487 | 0.5918 | -0.1085 | -0.0452 | 0.3271 |
| 37 | 26.0 | 0.6419 | -0.1232 | -0.0475 | 0.3594 | 0.6000 | -0.1128 | -0.0472 | 0.3374 |
| 38 | 27.0 | 0.6515 | -0.1276 | -0.0495 | 0.3701 | 0.6080 | -0.1171 | -0.0493 | 0.3475 |
| 39 | 28.0 | 0.6611 | -0.1321 | -0.0514 | 0.3806 | 0.6158 | -0.1213 | -0.0513 | 0.3574 |
| 40 | 29.0 | 0.6705 | -0.1364 | -0.0534 | 0.3911 | 0.6234 | -0.1255 | -0.0533 | 0.3672 |
| 41 | 30.0 | 0.6799 | -0.1407 | -0.0554 | 0.4014 | 0.6311 | -0.1299 | -0.0553 | 0.3770 |
| 42 | 32.0 | 0.6784 | -0.1485 | -0.0593 | 0.4182 | 0.6243 | -0.1380 | -0.0593 | 0.3926 |
| 43 | 34.0 | 0.6680 | -0.1550 | -0.0628 | 0.4307 | 0.6125 | -0.1448 | -0.0630 | 0.4042 |
| 44 | 36.0 | 0.6624 | -0.1608 | -0.0659 | 0.4417 | 0.6028 | -0.1502 | -0.0662 | 0.4139 |
| 45 | 38.0 | 0.6565 | -0.1660 | -0.0688 | 0.4516 | 0.5950 | -0.1548 | -0.0691 | 0.4225 |
| 46 | 40.0 | 0.6532 | -0.1707 | -0.0713 | 0.4607 | 0.5883 | -0.1579 | -0.0717 | 0.4299 |
| 47 | 42.0 | 0.6502 | -0.1748 | -0.0737 | 0.4690 | 0.5825 | -0.1600 | -0.0740 | 0.4362 |
| 48 | 44.0 | 0.6489 | -0.1787 | -0.0758 | 0.4769 | 0.5777 | -0.1620 | -0.0762 | 0.4422 |
| 49 | 46.0 | 0.6479 | -0.1823 | -0.0778 | 0.4843 | 0.5738 | -0.1640 | -0.0782 | 0.4481 |
| 50 | 48.0 | 0.6480 | -0.1855 | -0.0797 | 0.4914 | 0.5707 | -0.1658 | -0.0800 | 0.4536 |
| 51 | 50.0 | 0.6483 | -0.1886 | -0.0814 | 0.4983 | 0.5680 | -0.1677 | -0.0818 | 0.4587 |
| 52 | 52.0 | 0.6495 | -0.1914 | -0.0831 | 0.5048 | 0.5656 | -0.1693 | -0.0835 | 0.4635 |
| 53 | 54.0 | 0.6509 | -0.1941 | -0.0846 | 0.5112 | 0.5635 | -0.1706 | -0.0851 | 0.4680 |
| 54 | 56.0 | 0.6529 | -0.1966 | -0.0861 | 0.5173 | 0.5618 | -0.1713 | -0.0866 | 0.4721 |

| | | | | | | | | | |
|-----|-------|--------|---------|---------|--------|---------|---------|---------|--------|
| 55 | 58.0 | 0.6549 | -0.1991 | -0.0876 | 0.5233 | 0.5604 | -0.1721 | -0.0880 | 0.4762 |
| 56 | 60.0 | 0.6573 | -0.2014 | -0.0889 | 0.5290 | 0.5591 | -0.1728 | -0.0894 | 0.4802 |
| 57 | 62.0 | 0.6599 | -0.2037 | -0.0902 | 0.5347 | 0.5582 | -0.1735 | -0.0908 | 0.4840 |
| 58 | 64.0 | 0.6627 | -0.2058 | -0.0915 | 0.5402 | 0.5579 | -0.1743 | -0.0921 | 0.4881 |
| 59 | 66.0 | 0.6655 | -0.2079 | -0.0927 | 0.5455 | 0.5581 | -0.1752 | -0.0933 | 0.4922 |
| 60 | 68.0 | 0.6686 | -0.2100 | -0.0939 | 0.5508 | 0.5587 | -0.1759 | -0.0945 | 0.4963 |
| 61 | 70.0 | 0.6718 | -0.2120 | -0.0950 | 0.5559 | 0.5596 | -0.1764 | -0.0956 | 0.5002 |
| 62 | 72.0 | 0.6549 | -0.2133 | -0.0962 | 0.5573 | 0.5361 | -0.1761 | -0.0967 | 0.4999 |
| 63 | 74.0 | 0.6295 | -0.2135 | -0.0970 | 0.5547 | 0.5113 | -0.1749 | -0.0974 | 0.4965 |
| 64 | 76.0 | 0.6094 | -0.2132 | -0.0975 | 0.5510 | 0.4884 | -0.1733 | -0.0978 | 0.4918 |
| 65 | 78.0 | 0.5891 | -0.2122 | -0.0976 | 0.5461 | 0.4679 | -0.1714 | -0.0979 | 0.4865 |
| 66 | 80.0 | 0.5717 | -0.2110 | -0.0975 | 0.5407 | 0.4486 | -0.1692 | -0.0979 | 0.4804 |
| 67 | 82.0 | 0.5350 | -0.2087 | -0.0973 | 0.5312 | 0.4060 | -0.1661 | -0.0977 | 0.4697 |
| 68 | 84.0 | 0.4915 | -0.2052 | -0.0966 | 0.5176 | 0.3634 | -0.1618 | -0.0971 | 0.4557 |
| 69 | 86.0 | 0.4538 | -0.2009 | -0.0955 | 0.5025 | 0.3238 | -0.1567 | -0.0960 | 0.4403 |
| 70 | 88.0 | 0.4174 | -0.1962 | -0.0940 | 0.4865 | 0.2879 | -0.1515 | -0.0944 | 0.4244 |
| 71 | 90.0 | 0.3845 | -0.1909 | -0.0922 | 0.4699 | 0.2544 | -0.1461 | -0.0926 | 0.4082 |
| 72 | 92.0 | 0.3531 | -0.1852 | -0.0901 | 0.4528 | 0.2230 | -0.1406 | -0.0906 | 0.3916 |
| 73 | 94.0 | 0.3241 | -0.1792 | -0.0879 | 0.4355 | 0.1935 | -0.1348 | -0.0884 | 0.3748 |
| 74 | 96.0 | 0.2965 | -0.1730 | -0.0855 | 0.4180 | 0.1658 | -0.1287 | -0.0860 | 0.3577 |
| 75 | 98.0 | 0.2707 | -0.1667 | -0.0830 | 0.4006 | 0.1394 | -0.1225 | -0.0836 | 0.3405 |
| 76 | 100.0 | 0.2460 | -0.1603 | -0.0804 | 0.3831 | 0.1142 | -0.1158 | -0.0810 | 0.3228 |
| 77 | 102.0 | 0.2427 | -0.1545 | -0.0777 | 0.3693 | 0.1146 | -0.1096 | -0.0783 | 0.3094 |
| 78 | 104.0 | 0.2489 | -0.1496 | -0.0752 | 0.3595 | 0.1177 | -0.1043 | -0.0759 | 0.2989 |
| 79 | 106.0 | 0.2511 | -0.1453 | -0.0731 | 0.3509 | 0.1204 | -0.0995 | -0.0737 | 0.2899 |
| 80 | 108.0 | 0.2541 | -0.1415 | -0.0711 | 0.3433 | 0.1219 | -0.0951 | -0.0718 | 0.2818 |
| 81 | 110.0 | 0.2550 | -0.1381 | -0.0694 | 0.3365 | 0.1234 | -0.0912 | -0.0700 | 0.2747 |
| 82 | 115.0 | 0.2786 | -0.1320 | -0.0658 | 0.3268 | 0.1504 | -0.0840 | -0.0662 | 0.2651 |
| 83 | 120.0 | 0.3009 | -0.1289 | -0.0635 | 0.3237 | 0.1672 | -0.0795 | -0.0640 | 0.2595 |
| 84 | 125.0 | 0.3141 | -0.1275 | -0.0622 | 0.3220 | 0.1795 | -0.0772 | -0.0626 | 0.2566 |
| 85 | 130.0 | 0.3255 | -0.1271 | -0.0613 | 0.3217 | 0.1892 | -0.0765 | -0.0617 | 0.2556 |
| 86 | 135.0 | 0.3330 | -0.1274 | -0.0609 | 0.3220 | 0.1969 | -0.0770 | -0.0612 | 0.2558 |
| 87 | 140.0 | 0.3396 | -0.1282 | -0.0606 | 0.3229 | 0.2018 | -0.0774 | -0.0610 | 0.2556 |
| 88 | 145.0 | 0.3442 | -0.1291 | -0.0605 | 0.3239 | 0.2043 | -0.0775 | -0.0610 | 0.2551 |
| 89 | 150.0 | 0.3483 | -0.1301 | -0.0605 | 0.3252 | 0.2044 | -0.0772 | -0.0612 | 0.2537 |
| 90 | 155.0 | 0.3513 | -0.1311 | -0.0606 | 0.3265 | 0.2030 | -0.0761 | -0.0616 | 0.2520 |
| 91 | 160.0 | 0.3542 | -0.1321 | -0.0608 | 0.3278 | 0.2003 | -0.0741 | -0.0620 | 0.2495 |
| 92 | 170.0 | 0.3131 | -0.1300 | -0.0601 | 0.3161 | 0.1471 | -0.0648 | -0.0615 | 0.2287 |
| 93 | 180.0 | 0.2773 | -0.1240 | -0.0576 | 0.2956 | 0.1085 | -0.0527 | -0.0590 | 0.2045 |
| 94 | 190.0 | 0.2560 | -0.1172 | -0.0544 | 0.2769 | 0.0810 | -0.0422 | -0.0562 | 0.1834 |
| 95 | 200.0 | 0.2336 | -0.1102 | -0.0512 | 0.2581 | 0.0604 | -0.0330 | -0.0532 | 0.1647 |
| 96 | 210.0 | 0.2177 | -0.1036 | -0.0479 | 0.2409 | 0.0411 | -0.0241 | -0.0501 | 0.1463 |
| 97 | 220.0 | 0.2008 | -0.0974 | -0.0449 | 0.2245 | 0.0236 | -0.0151 | -0.0469 | 0.1282 |
| 98 | 230.0 | 0.1877 | -0.0916 | -0.0420 | 0.2094 | 0.0085 | -0.0072 | -0.0439 | 0.1120 |
| 99 | 240.0 | 0.1739 | -0.0863 | -0.0392 | 0.1953 | -0.0025 | -0.0019 | -0.0411 | 0.0989 |
| 100 | 250.0 | 0.1628 | -0.0813 | -0.0366 | 0.1823 | -0.0119 | 0.0028 | -0.0386 | 0.0870 |
| 101 | 260.0 | 0.1510 | -0.0766 | -0.0342 | 0.1700 | -0.0234 | 0.0091 | -0.0362 | 0.0736 |
| 102 | 270.0 | 0.1415 | -0.0722 | -0.0320 | 0.1588 | -0.0366 | 0.0159 | -0.0339 | 0.0597 |
| 103 | 280.0 | 0.1315 | -0.0681 | -0.0299 | 0.1482 | -0.0489 | 0.0214 | -0.0316 | 0.0472 |
| 104 | 290.0 | 0.1232 | -0.0644 | -0.0279 | 0.1385 | -0.0566 | 0.0244 | -0.0295 | 0.0381 |
| 105 | 300.0 | 0.1146 | -0.0607 | -0.0260 | 0.1293 | -0.0590 | 0.0248 | -0.0276 | 0.0322 |

表 8 温度曲げ成分が最大となる時点の F I N A S 解と簡易計算値の比較 (ホットショック)

| 評価 断面 | 時点 t (sec) | 評価 項目 | F I N A S 解 | | | | 簡易計算値 | | | |
|----------|---------------|-------------------|-------------|--------|--------|--------|--------|--------|--------|--------|
| | | | 内面值 | 外面値 | 平均値 | 曲げ | 内面值 | 外面値 | 平均値 | 曲げ |
| 1 | 10.0 | 温度 T | 386.73 | 375.10 | 379.19 | 5.90 | 386.69 | 375.11 | 379.21 | 6.04 |
| | | 応力 S ₁ | -0.014 | -0.016 | -0.028 | -0.003 | 0.049 | 0.034 | -0.022 | 0.006 |
| | | S ₂ | -3.591 | 1.753 | -0.125 | -2.713 | -3.540 | 1.776 | -0.124 | -2.774 |
| | | S ₃ | -3.591 | 1.753 | -0.107 | -2.710 | -3.540 | 1.776 | -0.106 | -2.771 |
| | | S ₄ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 2 | 10.0 | 温度 T | 384.97 | 372.87 | 376.91 | 6.06 | 385.11 | 372.66 | 376.94 | 6.15 |
| | | 応力 S ₁ | -0.045 | -0.026 | -0.354 | -0.256 | -0.030 | 0.034 | -0.369 | -0.255 |
| | | S ₂ | -9.573 | 6.316 | -0.151 | -7.786 | -9.696 | 6.504 | -0.152 | -7.877 |
| | | S ₃ | -4.582 | 4.083 | 0.782 | -4.369 | -4.652 | 4.234 | 0.774 | -4.426 |
| | | S ₄ | 0.057 | -0.046 | -0.244 | -0.011 | 0.076 | -0.041 | -0.251 | -0.026 |
| 3 | 10.0 | 温度 T | 384.66 | 367.03 | 372.82 | 8.67 | 384.90 | 366.89 | 372.77 | 8.88 |
| | | 応力 S ₁ | -0.031 | -0.094 | 0.323 | -0.059 | -0.061 | -0.035 | 0.329 | -0.070 |
| | | S ₂ | -8.235 | 7.091 | 0.030 | -7.414 | -8.357 | 7.110 | 0.032 | -7.487 |
| | | S ₃ | -6.123 | 4.141 | 0.319 | -5.029 | -6.245 | 4.207 | 0.338 | -5.119 |
| | | S ₄ | 0.044 | -0.170 | -0.258 | 0.203 | 0.047 | -0.161 | -0.262 | 0.214 |
| 4 | 30.0 | 温度 T | 477.64 | 419.21 | 439.06 | 29.30 | 478.27 | 419.73 | 439.03 | 29.33 |
| | | 応力 S ₁ | -0.48 | -0.46 | 0.89 | -0.32 | -0.65 | -0.47 | 0.89 | -0.36 |
| | | S ₂ | -49.12 | 39.44 | -0.66 | -45.31 | -49.39 | 39.44 | -0.67 | -45.35 |
| | | S ₃ | -18.89 | 25.99 | 8.78 | -22.80 | -19.27 | 25.79 | 8.75 | -22.84 |
| | | S ₄ | 4.19 | 0.67 | -3.67 | 3.24 | 4.23 | 0.67 | -3.67 | 3.30 |
| 5 | 32.0 | 温度 T | 477.76 | 391.22 | 421.68 | 44.12 | 477.67 | 391.58 | 421.73 | 44.15 |
| | | 応力 S ₁ | -18.76 | 0.79 | -2.74 | -12.27 | -18.59 | 0.75 | -2.72 | -12.25 |
| | | S ₂ | -23.08 | 52.43 | 1.20 | -32.73 | -22.65 | 52.59 | 1.24 | -32.72 |
| | | S ₃ | -33.96 | 37.26 | 4.52 | -34.88 | -33.80 | 37.13 | 4.47 | -34.89 |
| | | S ₄ | -20.26 | 3.44 | -2.33 | -14.80 | -20.23 | 3.45 | -2.33 | -14.79 |
| 6 | 70.0 | 温度 T | 578.23 | 398.96 | 450.02 | 86.23 | 578.48 | 398.84 | 449.78 | 86.51 |
| | | 応力 S ₁ | -0.76 | 0.04 | 3.04 | -1.46 | -0.67 | -0.04 | 3.03 | -1.50 |
| | | S ₂ | -39.27 | -1.72 | -1.26 | -17.74 | -39.16 | -1.98 | -1.28 | -17.74 |
| | | S ₃ | -85.34 | 46.64 | -1.14 | -64.46 | -85.43 | 46.50 | -1.15 | -64.56 |
| | | S ₄ | -3.80 | -0.16 | 0.08 | -7.12 | -3.86 | -0.19 | 0.08 | -7.10 |
| 7 | 76.0 | 温度 T | 576.20 | 338.04 | 413.31 | 117.78 | 575.70 | 338.03 | 412.98 | 117.89 |
| | | 応力 S ₁ | -0.43 | -0.22 | -1.13 | -0.35 | -0.59 | -0.24 | -1.08 | -0.32 |
| | | S ₂ | -67.40 | 25.20 | -0.32 | -45.24 | -67.27 | 24.99 | -0.26 | -45.20 |
| | | S ₃ | -75.37 | 29.05 | -2.55 | -51.55 | -75.30 | 28.90 | -2.49 | -51.56 |
| | | S ₄ | 0.61 | -0.21 | -0.10 | 0.55 | 0.49 | -0.17 | -0.10 | 0.49 |