

JAERI-Data/Code
97-018



FINCRUSH:
A COMPUTER PROGRAM FOR IMPACT ANALYSIS OF
RADIOACTIVE MATERIAL TRANSPORT CASK WITH FINS

May 1997

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編集兼発行 日本原子力研究所
印 刷 (株)原子力資料サービス

FINCRUSH : A Computer Program for Impact Analysis
of Radioactive Material Transport Cask with Fins

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(Received April 14, 1997)

In drop impact analyses for radioactive material transport cask with cooling fins, relationship between fin plastic deformation and fin energy absorption is used. This relationship was obtained by ORNL experiments and MONSER Co. in Canada. Based on ORNL experiments, a computer program FINCRUSH has been developed for rapid safety analysis of cask drop impact to obtain the maximum impact acceleration and the maximum fin deformation.

Main features of FINCRUSH are as follows:

- (1) annulus fins on a cylindrical shell and plate fins on a disk can be treated,
- (2) it is capable of graphical representations for calculation results and fin absorption energy data and
- (3) not only main frame computer but also work stations (OS UNIX) and personal computer (OS Windows) are available for use of the FINCRUSH.

In the paper, brief illustration of calculation method of FINCRUSH is presented. The second section presents comparisons between FINCRUSH and experimental results. The third section provides a user's guide for FINCRUSH.

Keywords: Computer Program, Impact Analysis, Cask, Drop Impact, Fin, Transport Cask, Structural Analysis, Static Analysis

FINCRUSH：フィン付き放射性物質輸送容器の衝突計算プログラム

日本原子力研究所東海研究所燃料サイクル安全工学部
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(1997年4月14日受理)

放熱用フィン付き放射性物質輸送容器の落下衝突解析では、米国オークリッジ研究所の研究によっては得られたフィンの塑性変形量とフィンエネルギー吸収データが用いられている。このフィンエネルギー吸収データは、オークリッジ研究所およびカナダのモンセルコ社の実験によって得られている。落下衝突時のフィン付き輸送容器の安全解析に必要な最大加速度とフィンの最大変形量を迅速に計算するために、オークリッジ研究所の研究に基づくフィンの塑性変形エネルギーを用いた静的計算手法による計算プログラムFINCRUSHを開発した。

主要な特徴は次の通りである。

- (1) 円筒上の垂直フィンおよび円盤上の垂直フィンを取り扱うことができる。
- (2) 計算結果およびフィンエネルギー吸収データを図形表示することができる。
- (3) 大型計算機以外にもワークステーション(OS UNIX) およびパーソナルコンピュータ (OS Windows 3.1) によっても使用できるようにした。

本報告書はFINCRUSHの計算手法、FINCRUSHによる計算結果と実験結果との比較およびFINCRUSHの使用のための、入力データ等のユーザーガイドについても記述した。

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1 . Introduction

In the drop impact analyses for radioactive transport cask with cooling fins, it has become possible to perform them in detail by using interaction evaluation, computer programs, such as DYNA2D, DYNA3D, PISCES and HONDO. However, the considerable cost and computer time are necessitated to perform analyses by these programs. To meet the above requirements, a simplified computer program FINCRUSH as shown in Fig.1.1 has been developed. The FINCRUSH is a static calculation computer program capable of evaluating the maximum acceleration of cask bodies and the maximum fin deformation using a relationship between the fin plastic deformation and the fin absorption energy. This relationship, the fin absorption energy vs. the fin deformation data, are obtained by Davis⁽¹⁾ of ORNL and Torr^{(2), (3)} of MONSERCO in Canada from experiments. Using these data, the maximum acceleration of cask bodies and the maximum fin deformation are easily obtained.

Main features of the computer program are as follows;

- (1) annulus fins on a cylindrical shell and plate fins on a disk or a plate can be treated,
- (2) it is capable of graphical representations for calculation results and the fin energy absorption data and
- (3) not only main frame computers but also work stations(OS UNIX) and personal computers(OS Windows) are available for use of FINCRUSH.

In the paper, brief illustration of calculation method using fin energy absorption data is presented. The second section presents comparisons between calculation results using fin energy absorption data and experimental results. The third section provides a user's guide for FINCRUSH.

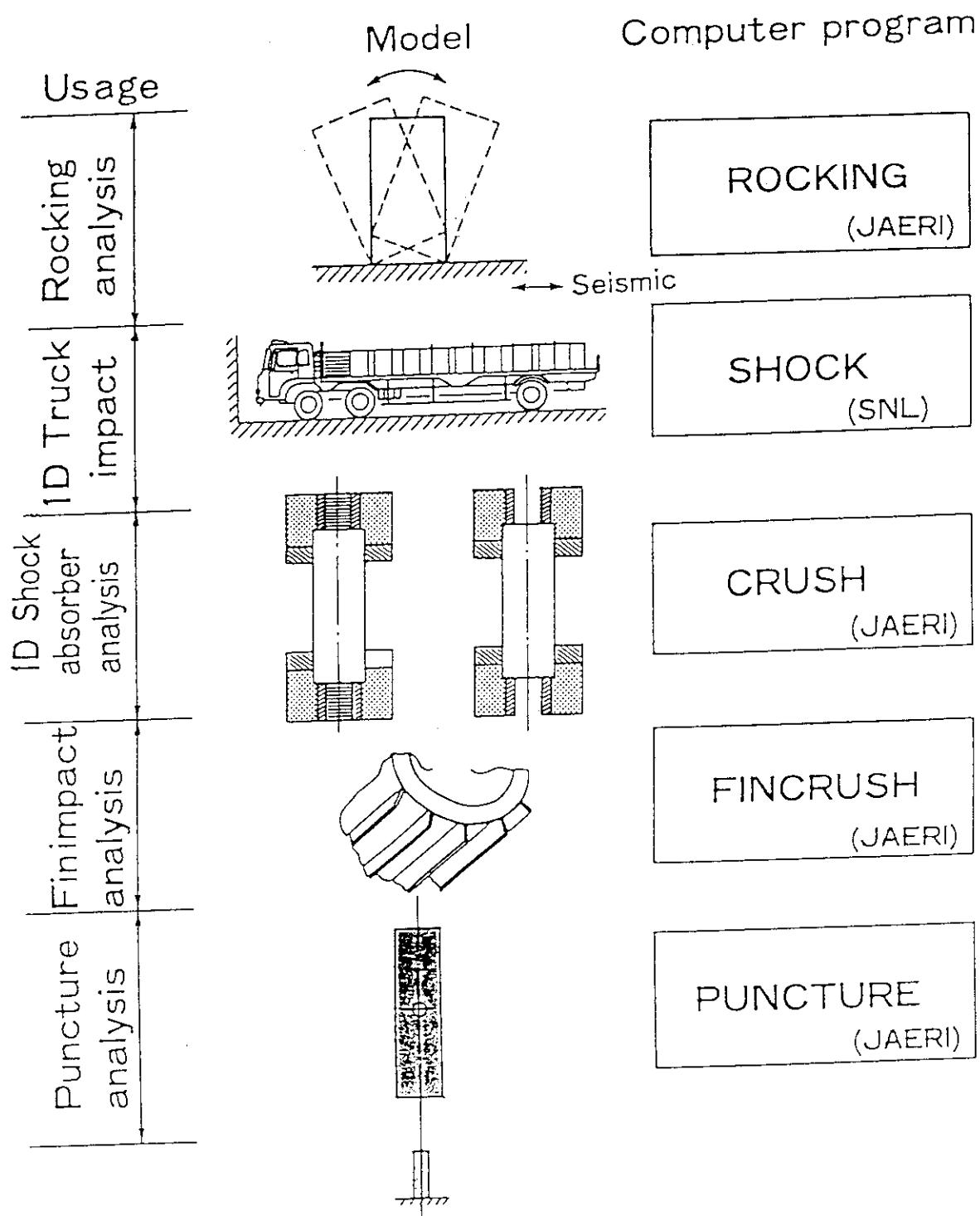


Fig.1.1 Simplified analysis computer programs

2.Calculation equation

In the modeling of a fin impact analysis program FINCRUSH, it is assumed that the static plastic moment of fins is balanced with impact energy. That is

$$E_v = W H_0 , \quad (2.1)$$

where

- E_v : impact energy,
- W : weight of cask,
- H_0 : height of cask drop.

On the other hand, absorption energy of fins is

$$E_\Phi = F \delta , \quad (2.2)$$

where

- E_Φ : impact energy,
- F : impact force,
- δ : fin deformation.

The cask drop energy equal to the fin absorption energy. Therfore

$$E_v = E_\Phi . \quad (2.3)$$

The impact energy is absorbed by bending deformation of fins as shown in Fig. 2.1. The expression of the impact energy is derived from the Davis assumption. The static plastic moment may be expressed by the following equation:

$$M_p' = \sigma_y \left(\frac{b T^2}{4} \right) , \quad (2.4)$$

where

- σ_y : yield stress,
- b : length of fin,

T : thickness of fin,
 M_p' : static plastic moment.

The static plastic moment per unit length of each of these fins is determined from the expression

$$M_p = \sigma_y \left(\frac{T^2}{4} \right), \quad (2.5)$$

where M_p is static plastic moment per unit length. The fin absorption energy is given by

$$E_\Phi = \beta (y) M_p b . \quad (2.6)$$

where β is the absorbed energy divided by the plastic moment and is written as follows:

$$\beta(y) = E_\Phi / (M_p b) . \quad (2.7)$$

In the other words, β is a constant depends on the fin absorption energy vs. the fin plastic moment obtained by Davis and Torr. In the data curve, β is shown on the ordinate and y on the abscissa. The fin deformation ratio is defined by

$$y = \delta_\Phi / H , \quad (2.8)$$

where

r : fin deformation ratio,
 δ_Φ : fin deformation,
 H : fin height.

In the case of the inclined fin, the deformation of the fin is the following equation as shown in Fig. 2.2,

$$\delta_\Phi = R_0 - \frac{R_0 - \delta_0}{\cos\phi} , \quad (2.9)$$

where

- δ_ϕ : fin deformation,
- R_o : outer radius of fin,
- ϕ : attached angle of fin.

The fin deformation of the inclined fin is given by

$$\delta_o = R_o \cos\theta . \quad (2.10)$$

Davis and Torr present the fin absorption energy data as a function of the fin deformation ratio as shown in Figs 2.3 through 2.22. Therfore, the absorption energy in the case of fin impact is given by the following equation:

$$E_\phi = \beta (y) M_p b . \quad (2.11)$$

The force of the cask body is may be expressed by the following equation:

$$F = dE_\phi / d\delta_\phi . \quad (2.12)$$

The acceleration of the cask body is determined by the following formula:

$$a = F / (W / g) , \quad (2.13)$$

where

- a : acceleration of cask body,
- g : gravity constant.

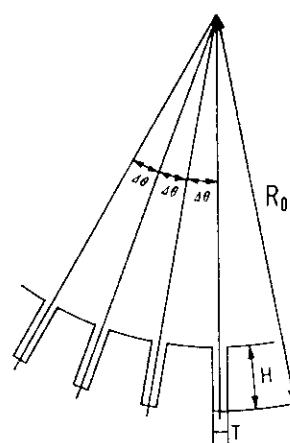
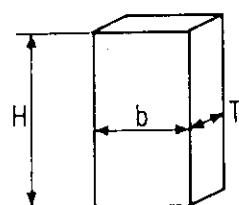


Fig. 2.1 Fin geometry

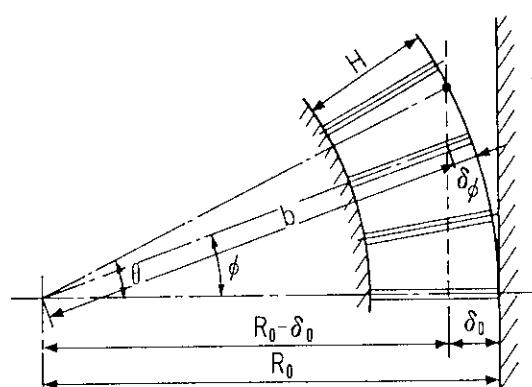


Fig. 2.2 Relationship between fin displacement and angle

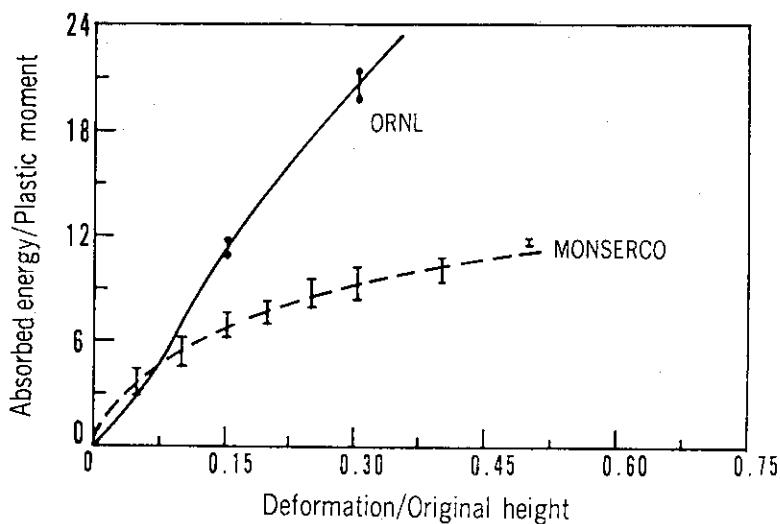


Fig. 2.3 Absorbed energy vs. deformation ratio of fin

[Fin height : 3.5 in. (89mm)
Inclination angle : 0 degree]

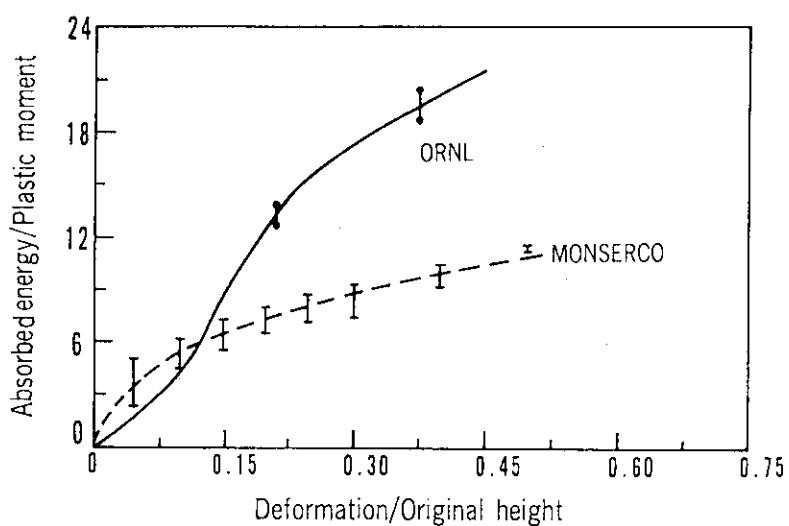


Fig. 2.4 Absorbed energy vs. deformation ratio of fin

[Fin height : 4.0 in. (102mm)
Inclination angle : 0 degree]

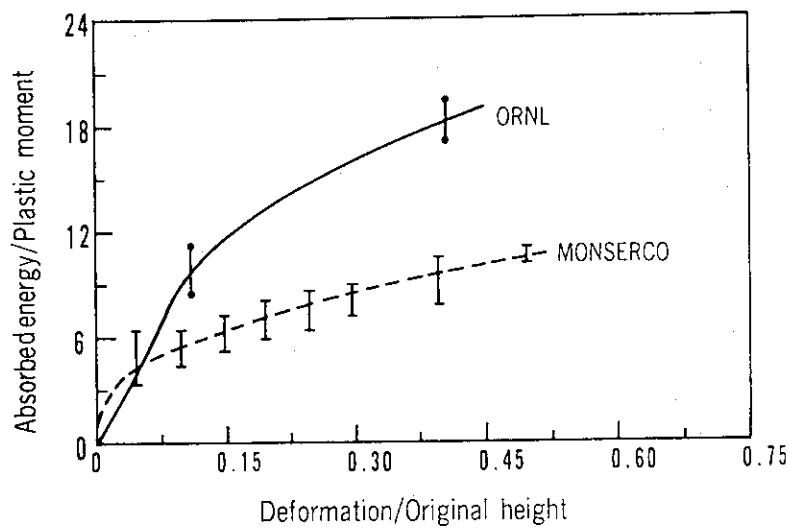


Fig.2.5 Absorbed energy vs. deformation ratio of fin

[Fin height : 6.0 in. (152mm)]
 [Inclination angle : 0 degree]

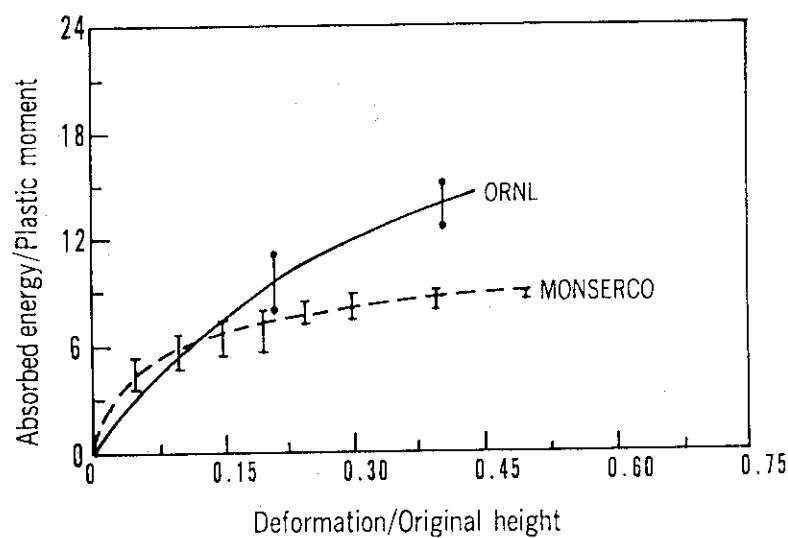


Fig.2.6 Absorbed energy vs. deformation ratio of fin

[Fin height : 8.0 in. (203 mm)]
 [Inclination angle : 0 degree]

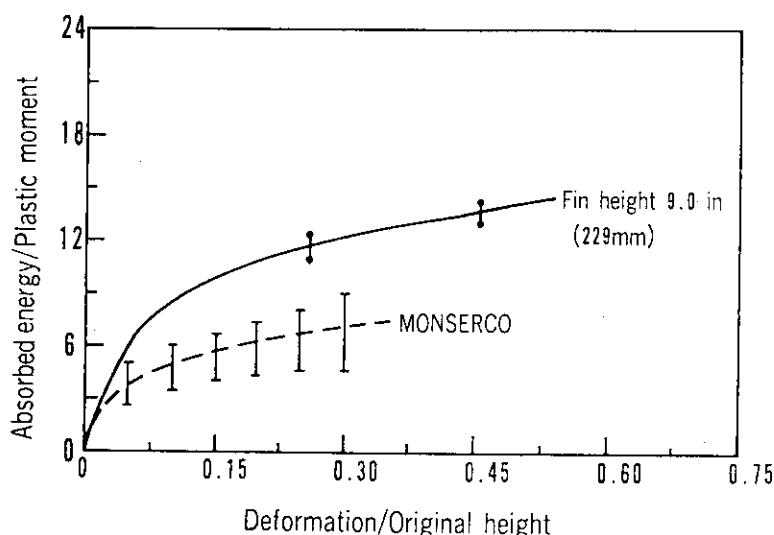


Fig.2.7 Absorbed energy vs. deformation ratio of fin

[Fin height : 10.0 in.(254mm)
Inclination angle : 0 degree]

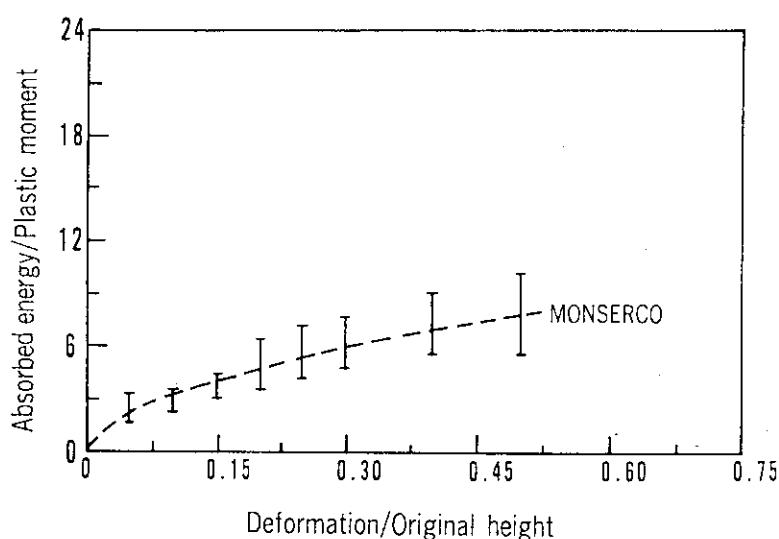


Fig.2.8 Absorbed energy vs. deformation ratio of fin

[Fin height : 3.5 in. (89mm)
Inclination angle : 10 degree]

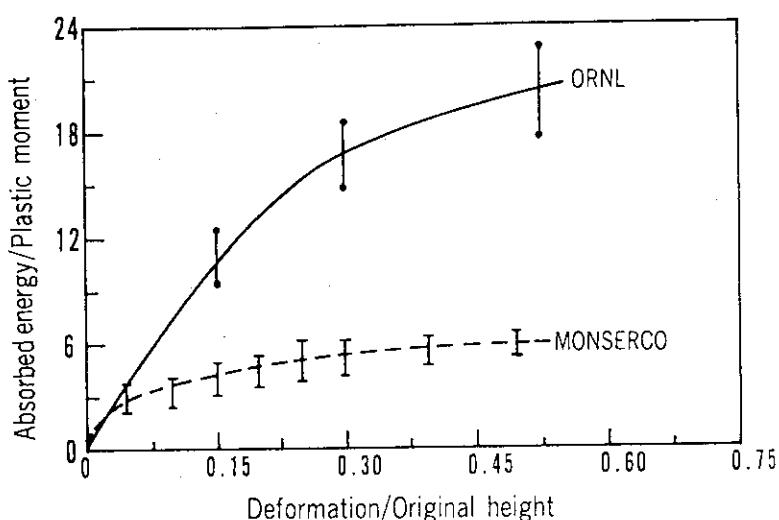


Fig.2.9 Absorbed energy vs. deformation ratio of fin

[Fin height : 4.0 in. (102mm)]
 [Inclination angle : 10 degree]

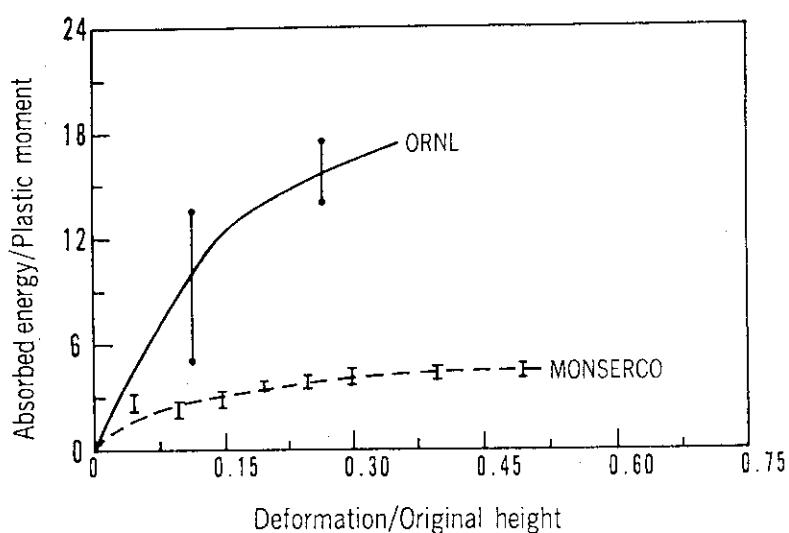


Fig.2.10 Absorbed energy vs. deformation ratio of fin

[Fin height : 6.0 in. (152mm)]
 [Inclination angle : 10 degree]

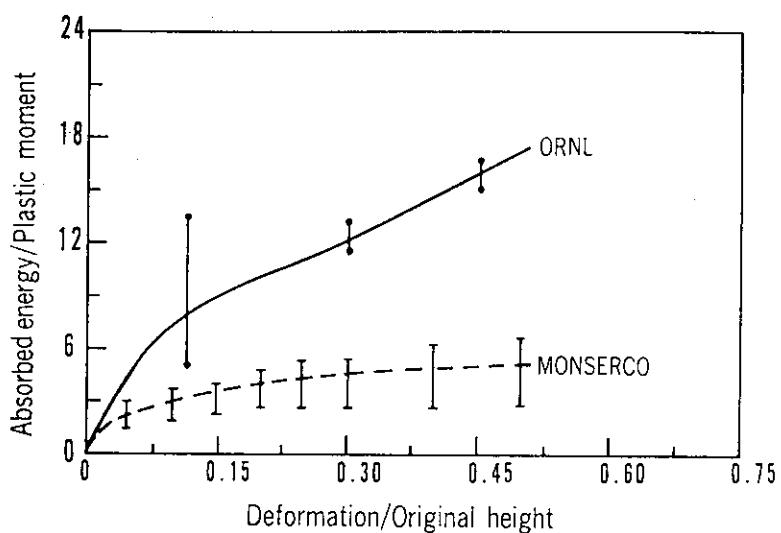


Fig. 2.11 Absorbed energy vs. deformation ratio of fin

[Fin height : 8.0 in. (203mm)
Inclination angle : 10 degree]

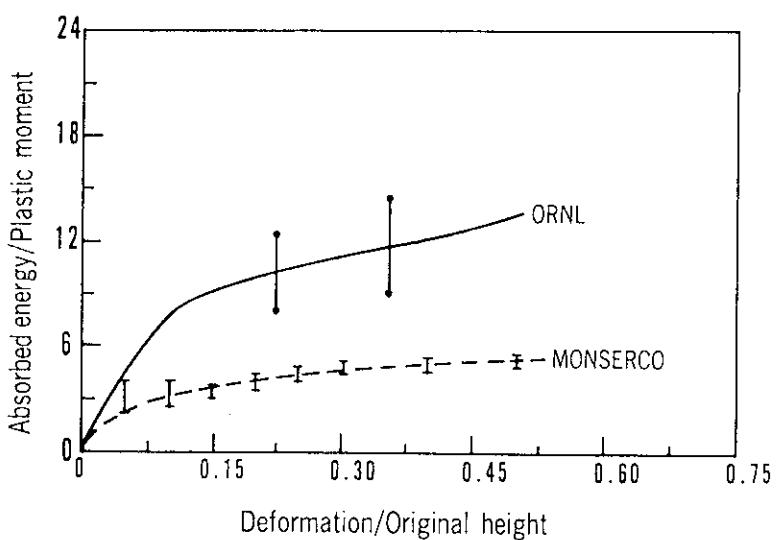


Fig. 2.12 Absorbed energy vs. deformation ratio of fin

[Fin height : 10.0 in. (254mm)
Inclination angle : 10 degree]

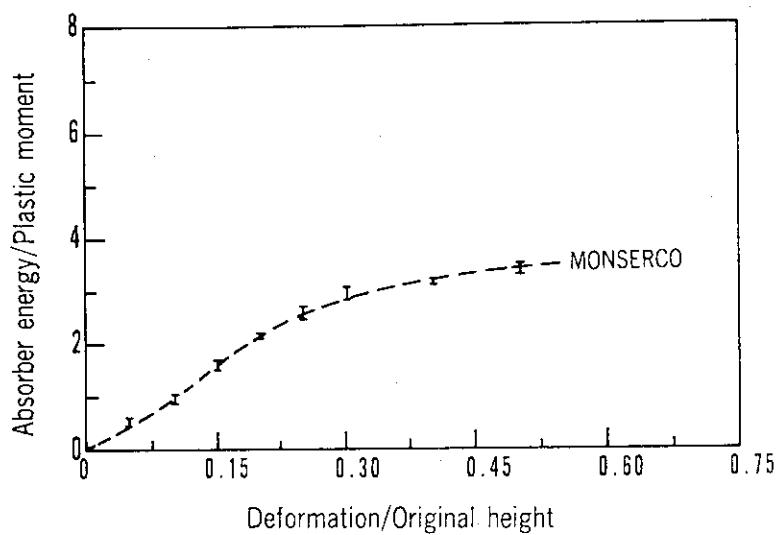


Fig.2.13 Absorbed energy vs. deformation ratio of fin

[Fin height : 3.5 in. (89mm)]
[Inclination angle : 20 degree]

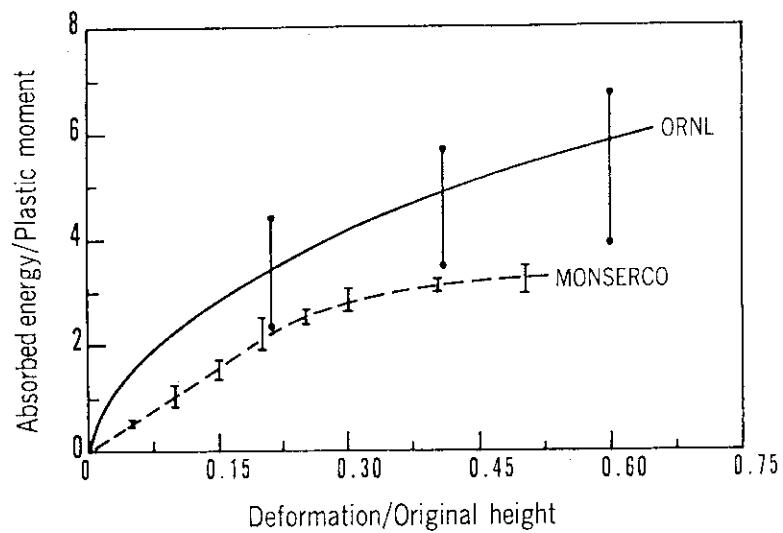


Fig.2.14 Absorbed energy vs. deformation ratio of fin

[Fin height : 4.0 in. (102mm)]
[Inclination angle : 20 degree]

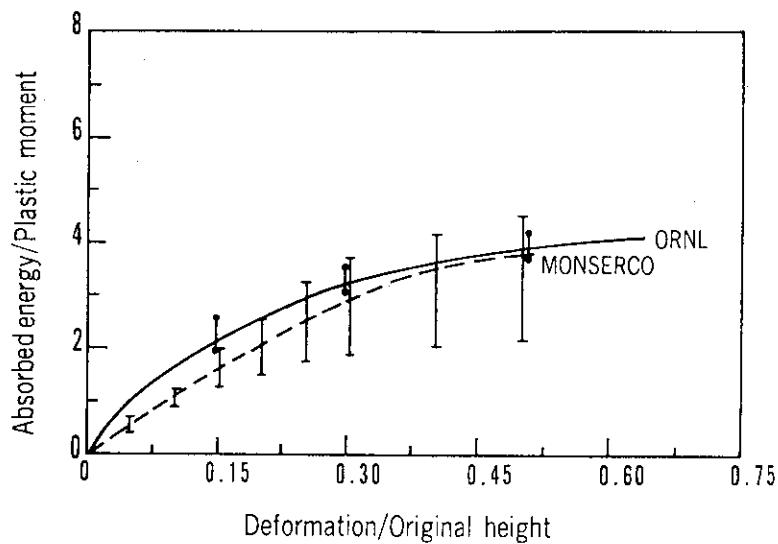


Fig.2.15 Absorbed energy vs. deformation ratio of fin

[Fin height : 6.0 in. (152mm)]
[Inclination angle : 20 degree]

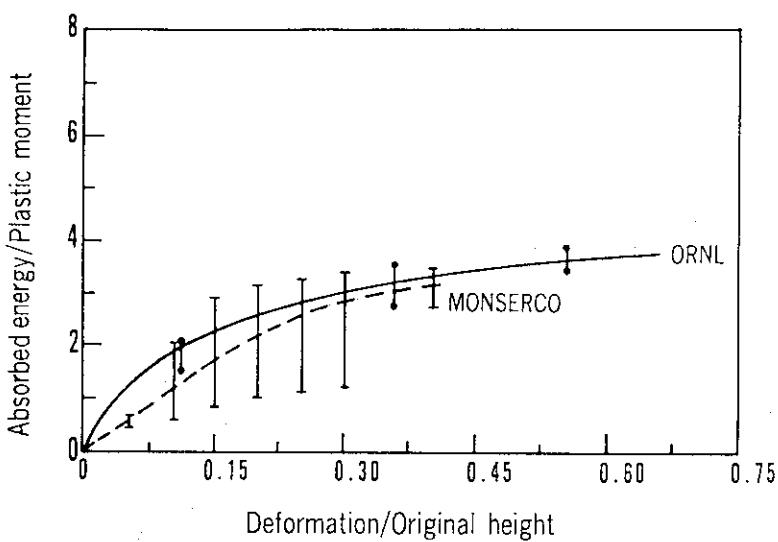


Fig.2.16 Absorbed energy vs. deformation ratio of fin

[Fin height : 8.0 in. (203mm)]
[Inclination angle : 20 degree]

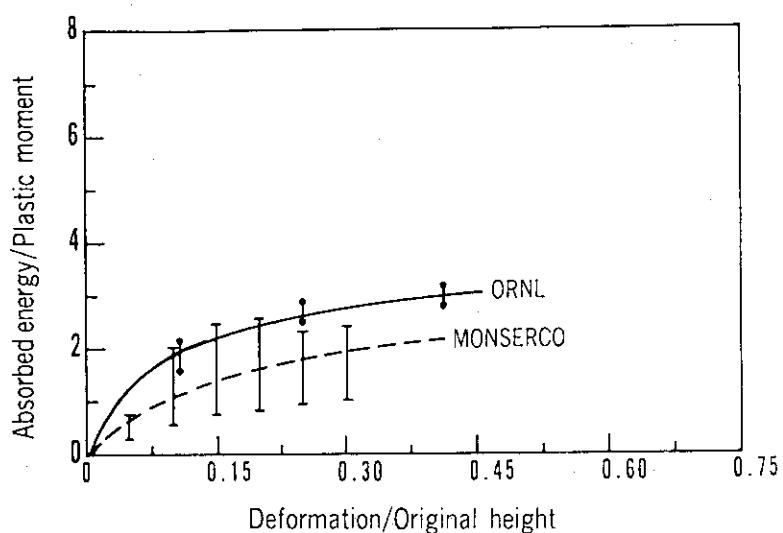


Fig.2.17 Absorbed energy vs. deformation ratio of fin

[Fin height : 10 in. (254mm)]
[Inclination angle : 20 degree]

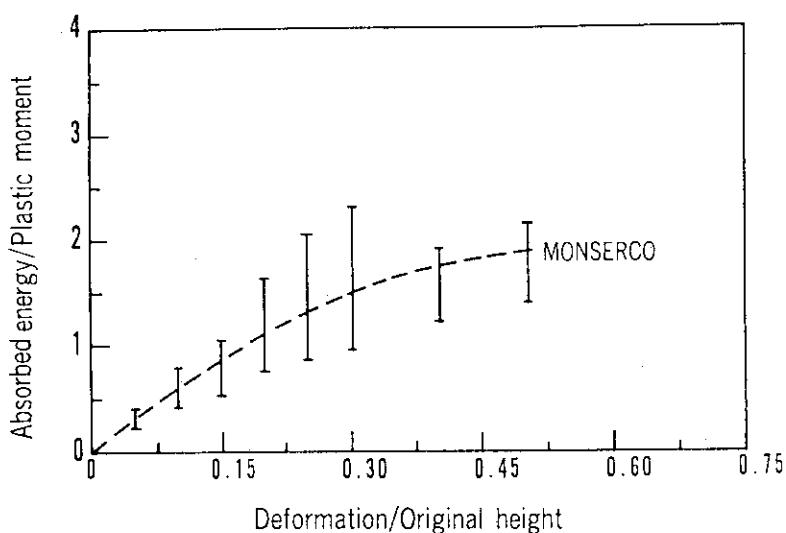


Fig.2.18 Absorbed energy vs. deformation ratio of fin

[Fin height : 3.5 in. (89mm)]
[Inclination angle : 30 degree]

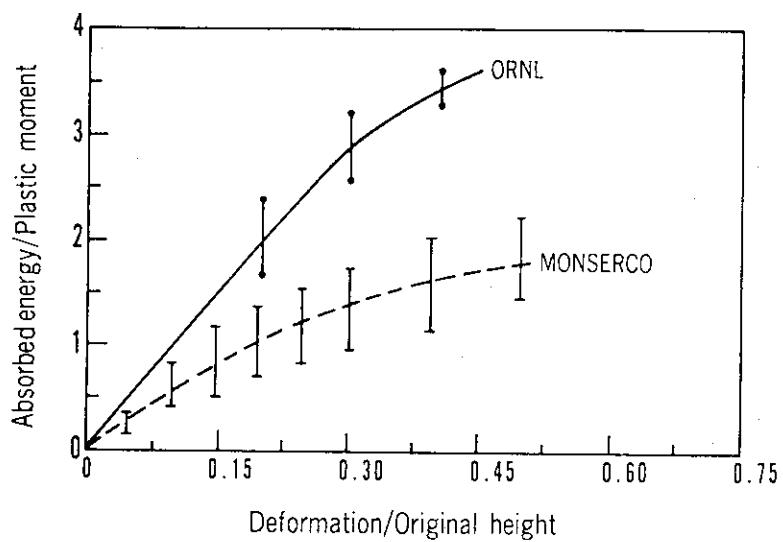


Fig.2.19 Absorbed energy vs. deformation ratio of fin

[Fin height : 4.0 in. (102mm)
Inclination angle : 30 degree]

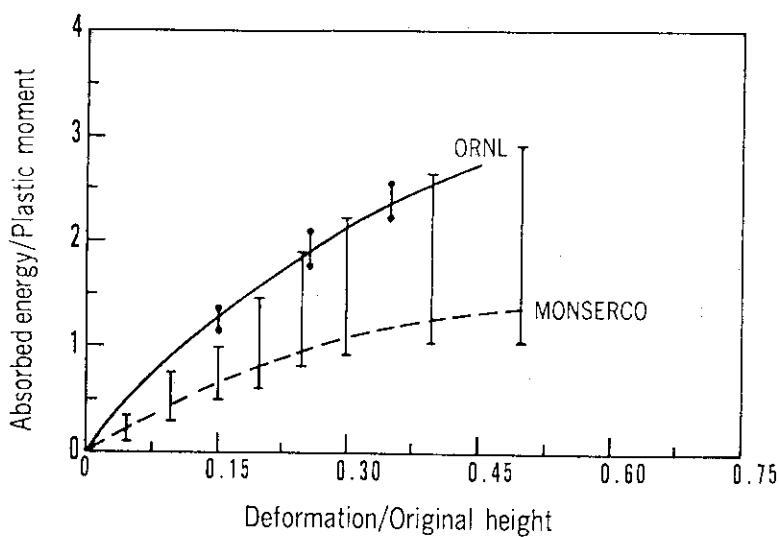


Fig.2.20 Absorbed energy vs. deformation ratio of fin

[Fin height : 6.0 in. (152mm)
Inclination angle : 30 degree]

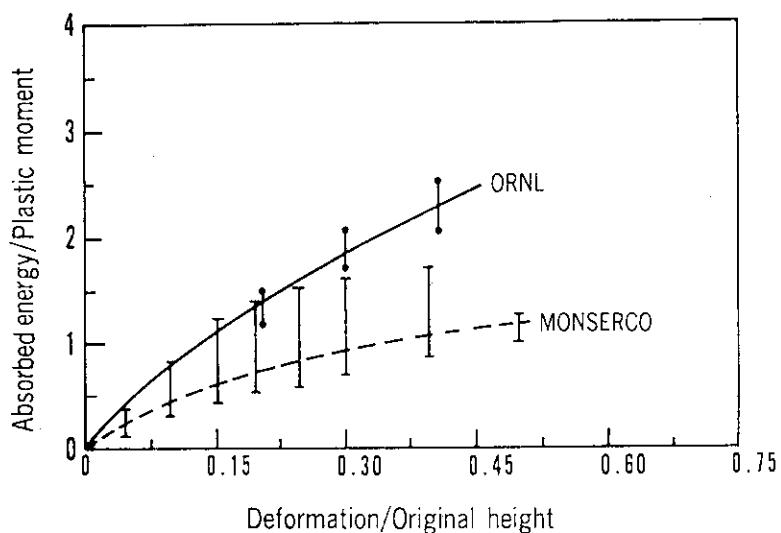


Fig.2.21 Absorbed energy vs. deformation ratio of fin

[Fin height : 8.0 in. (203mm)
Inclination angle : 30 degree]

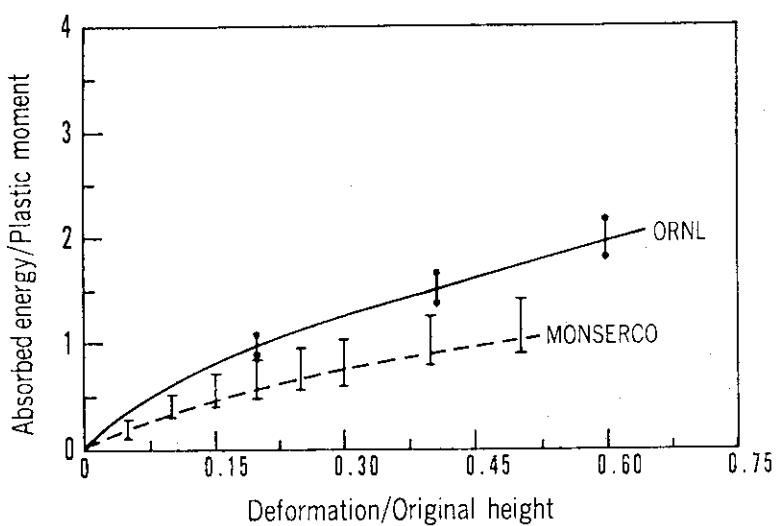


Fig.2.22 Absorbed energy vs. deformation ratio of fin

[Fin height : 10.0 in. (254mm)
Inclination angle : 30 degree]

3. Benchmark Calculation

In order to demonstrate the adequacy of the simplified computer program FINCRUSH, the benchmark calculations using experimental results of the JMS-18T-89Y(Japan Material Testing Reactor Spent Fuel Transport Cask) cask as shown in Fig. 3.1 have been performed.

Figure 3.2 and Table 3.1 show comparison between experiment and analysis. According to Fig. 3.2 Table 3.1, results by the computer program FINCRUSH agree with the experimental results.

Table 3.1 Comparison between experiment and analysis

Item	Experiment	Analysis	
		Fin data library	
		ORNL	MONSERCO
Acceleration (G)	—	50.3	42.2
Displacement (mm)	25	20.0	24.8

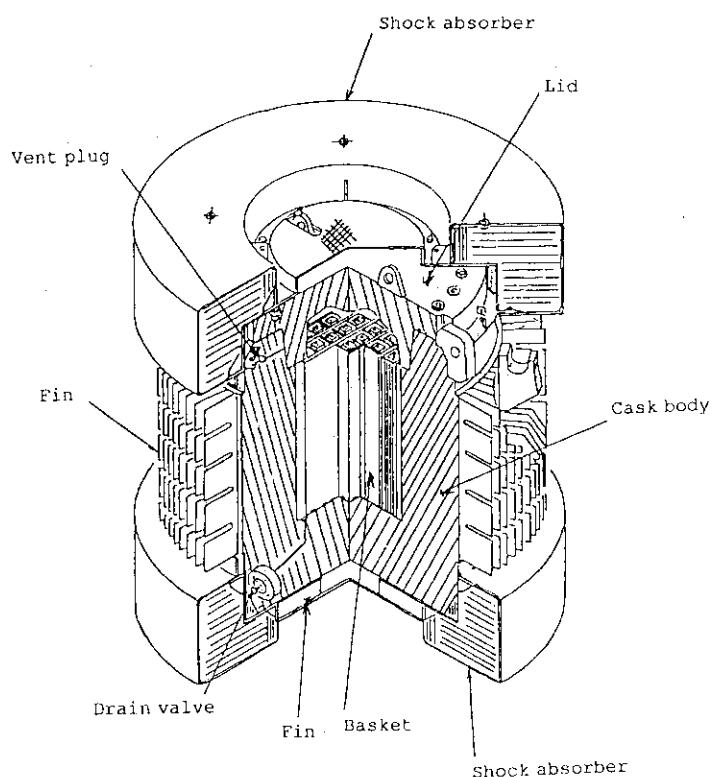


Fig.3.1 JMS-18T-89Y cask
(JMTR spent fuel cask)

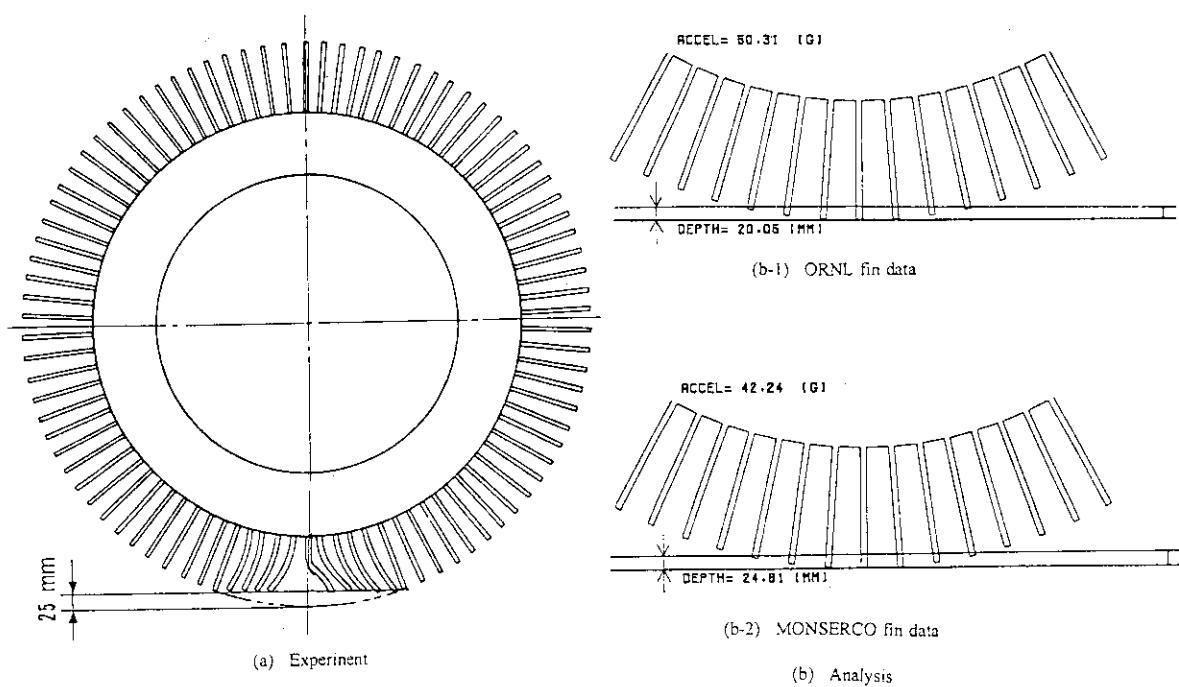


Fig. 3.2 Comparison between experiment and analysis

4. Computer Program

4.1 Program Description

The computer program FINCRUSH is static calculation program capable of evaluating the maximum acceleration of the cask body and the maximum fin deformation using relationship between fin plastic deformation and fin platic energy absoption based on experimental data.

The computer program FINCRUSH consists of a main routine and ten subroutines that are MAIN, CARDIN, SOLV, SOLV2, GETE, TTABLE, LPLOT, MPLOT, DPLOT and UPLOT. The eleven basic subroutines for plotting are GOSCAL, XYSICAL, PLTBGN, PLPEN, PLINEs, PLMARK, PSYM, PNUMB, PNUMBB, PLTOR and PLREND. Overall structure of FINCRUSH is shown in Fig. 4.1.

Functions of subroutines are as follows:

```
MAIN   : initiarizes start of run,  
CARDIN : reads input data,  
SOLV   : computes acceleration and deformation in the case  
          of annulus fin on a cylinrical shell,  
SOLV2  : computes acceleration and deformation in the case  
          of plate fin on a disk,  
GETE   : computes strain of fin,  
TTABLE : computes relation of fin deformation and fin energy  
          absorption data,  
LPLOT  : plot fin energy absoption vs. fin deformation ratio,  
MPLOT  : geometry plot,  
DPLOT  : X-Y curve plot,  
UPLOT  : deformation plot.
```

The plot basic subroutines are as follows:

```
GOSCAL : scaling of geometry plot,  
XYSICAL : scaling of X-Y plot  
PLTBGN : initiatization of plotter,  
PLPEN  : change plotter pen size,  
PLINES : draw line,  
PLMARK : plot round mark,  
PSYM   : write letter,
```

PNUMB : write number,
PNUMBB : write number,
PLTEOR : plot new figure,
PLTEND : plot end.

A macroscopic flow chart of FINCRUSH is shown in Fig. 4.2.

4.2 Description of Input Data

This section describes the input data required by FINCRUSH. The input data consists of the job description, the analysis type such as drop attitude, geometry, the cask weight, the initial condition, the boundary condition constants, the geometry unit selection and options for output plotting. The input instruction is simple and easy follow. The input data forms are presented in Table 4.1.

4.3 Description of Output Data

This section describes the output data forms of FINCRUSH. The contents of these various quantities are describes in the followings.

(1) Input data

The input data are printed in two formats. The first print format is exactly the same as they were read. Second, the computer program lists the input data as interpreted by FINCRUSH.

(2) Calculation data

The calculation data; the deformation, the force, the energy and acceleration are printed at every interval steps.

(3) Graphical output

CRUSH2 provides users with graphical output of the deformation, relationship acceleration and deformation, dissipation energy and deformation, acceleration and dissipation energy and so forth.

Table 4.1 Input data for FINCRUSH

Columns	Format	Variables	Descriptions
Data set No. 1:Job description.			
1 - 5	A5	NAME	Flag for data type. 'TITLE'.
6 - 10	5X	-	Blank,
11 - 80	70A1	NTITLE	Job description.
Data set No. 2:Calculation model data.			
1 - 7	A7	NAME	Flag for fin data. 'FINDATA'.
8 - 10	3X	-	Blank.
11 - 20	F10.0	WEIGHT	Weight of cask(kg).
21 - 30	F10.0	HEIGHT	Height of fin(mm).
31 - 40	F10.0	WIDEL	Width of fin(mm).
41 - 50	F10.0	THICK	Thickness of fin(mm).
51 - 60	F10.0	ROUT	Outer diameter of fin tip(mm).
61 - 70	F10.0	DANGLE	Angle between fins(mm) (see Fig. 4.3).
71 - 75	A5	NAME1	Flag for kind of fin. ' ':fin data generation from upper data. 'INPUT':fin data from next data set 2A (annulus type fin). 'PLATE':fin data from next data set 2A (edge type fin) (see Fig. 4.4).
Data set No. 2A:Geometry data.			
1 - 3	A3	NAME	Flag for fin geometry data. 'FIN':fin geometry data start. 'END':fin geometry data end.
4 - 10	7X	--	Blank.
11 - 20	F10.0	AG	Attachment angle of fin(degree).
21 - 30	F10.0	HH	Height of fin(mm).

Table 4.1 (Continued)

Columns	Format	Variables	Descriptions
31 - 40	F10. 0	AL	Thickness of fin(mm).

Data set No. 3: Options for calculation and plotting.

1 - 4	A4	NAME	Flag for input data calculation and plotting 'DISP'.
5 - 10	6X	-	Blank.
11 - 20	F10. 0	ANGO	Impact angle for fin(degree). $0.0 \leq ANGO \leq DANGLE$.
21 - 30	F10. 0	DISP	Deformation increase of calculation(mm).
31 - 40	F10. 0	SIGY	Yield stress(kg/mm ²).
41 - 50	F10. 0	ENERGY	Maximum absorption energy(kg-mm).
51 - 60	F10. 0	DRATIO	Maximum deformation of fin(%).
61 - 64	A4	NAME1	Flag for plotting of calculation results. 'PLOT': plotting of calculation results. ' ': no plotting.
65	1X	-	Blank.
66 - 69	A4	NAME2	Flag for plotting of deformation-energy absorption data of fin. 'PLOT': plotting of fin energy absorption data. ' ': no plotting.

Data set No. 4: Fin data.

1 - 7	A7	NAME	Flag for fin data. 'FINDATA'.
8 - 10	3X	-	Blank.
11 - 18	2A4	KHEAD	Name of fin data library. 'ORNLDATA': ORNL data. 'MONSDATA': MONSERCO data. 'FILE ': fin data input from file No. 20.
19 - 20	2X	-	

Table 4.1 (Continued)

Columns	Format	Variables	Descriptions
21 ~ 25	I5	NOT	Data file numbers of fin deformation-energy absorption data. If KHEAD is 'FILE', NOT is 3.
Data set No. 5:Fin data(I:fin thickness data).			
1 ~ 9	9A1	NAME	Flag for fin thickness. 'THICKNESS'.
10	1X	—	Blank.
11 ~ 20	F10. 0	TD	Fin thickness.
Data set No. 6:fin data(II:fin angle data).			
1 ~ 5	A5	NAME	Flag for coordinate of axial direction. 'ANGLE'.
6 ~ 10	5X	—	Blank.
11 ~ 20	F10. 0	THETA	Angle of fin.
21 ~ 30	F10. 0	NOF	Number of fin data for fin attached angle.
Data set No. 7:fin data(III:fin energy absorption data).			
1 ~ 4	A4	NAME	Flag for data type. 'FINH'.
5 ~ 10	6X	—	Blank.
11 ~ 20	F10. 0	FINH1	Height of fin.
21 ~ 25	I5	NOR	Number of data for fin height.
Data set No. 8A:Fin deformation ratio.			
1 ~ 10	F10. 0	XD(1)	Fin deformation ratio.
11 ~ 20	F10. 0	XD(2)	.....
21 ~ 30	F10. 0	XD(3)	.....
31 ~ 40	F10. 0	XD(4)	.....
41 ~ 50	F10. 0	XD(5)	.....
51 ~ 60	F10. 0	XD(6)	.....
61 ~ 70	F10. 0	XD(7)	Fin deformation ratio.

Table 4.1 (Continued)

Columns	Format	Variables	Descriptions
71 - 80	F10.0	XD(8)	Fin deformation ratio. Repeat 8A data set for number of necessary data NOR of data set No. 7.
Data set No. 8B:fin energy absorption data.			
1 - 10	F10.0	YD(1)	Fin energy absorption data.
11 - 20	F10.0	YD(2)	.....
21 - 30	F10.0	YD(3)	.....
31 - 40	F10.0	YD(4)	.....
41 - 50	F10.0	YD(5)	.....
51 - 60	F10.0	YD(6)	.....
61 - 70	F10.0	YD(7)	.....
71 - 80	F10.0	YD(8)	Fin energy absorption data. Repeat 8B data set for number of necessary data NOR of data set No. 7.

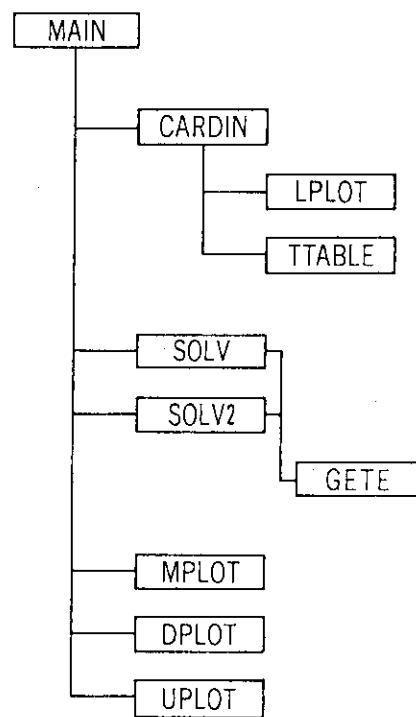


Fig. 4.1 Structure of computer program
FINCRUSH

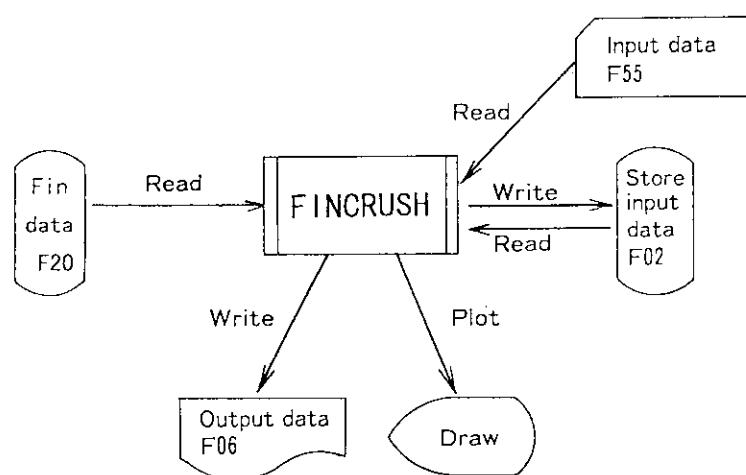


Fig. 4.2 Program flow

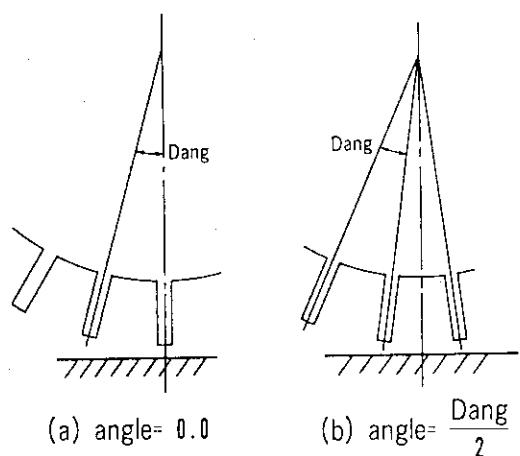


Fig.4.3 Impact direction of fin

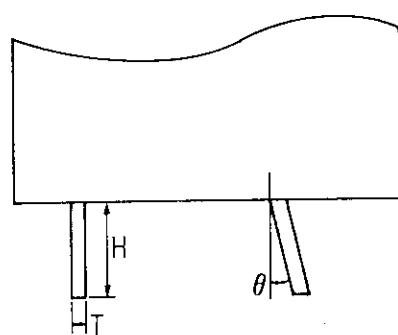


Fig.4.4 Fin on plate

5. Conclusions

In regard to the evaluation of the maximum acceleration of the cask bodies and the maximum deformation of the fin on the drop impact, a simplified computer program FINCRUSH make to analyze economical and by shortening input and computer time as compared with other detailed computer programs to analyze dynamic interactions. The results obtained by the simplified computer program FINCRUSH has an enough adequacy for its practical use. FINCRUSH is further being utilized satisfactory in safety analysis and designing not only spent fuel transport casks but also those for various radioactive transport casks.

Acknowledgements

The author is indebted Dr. Kazuo Asada of Mitsubishi Heavy Industries, Ltd. for providing the sample problems and valuable discussions. He is also indebted Mr. Yutaka Hasegawa, Junji Oshika and Takashi Ishiwata of CRC Research Institute, Inc. for assistance of making the computer program.

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In regard to the evaluation of the maximum acceleration of the cask body and the maximum deformation of the fin on the drop impact, a simplified computer program FINCRUSH make to analyze economical and by shortening input and computer time as compared with other detailed computer programs to analyze dynamic interactions. The results obtained by the simplified computer program FINCRUSH has an enough adequacy for its practical use. FINCRUSH is further being utilized satisfactory in safety analysis and designing not only spent fuel transport casks but also those for various radioactive transport casks.

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References

- (1) Davis, F. C., "Structural Analysis of Shipping Casks, Vol.9: Energy Absorption Capabilities of Plastic Deformed Struts under Specified Loading Conditions", ORNL TM-1312 Vol.9, (1971).
- (2) Torr. K. G., "Verification of the Performance of Impact Limiting Fins for Transportation Containers", INFO-0146, (1984) .
- (3) Torr. K. G., "Verification of the Performance of Impact Limiting Fins for Transportation Containers, Part II", INFO-0146-2, (1986) .
- (4) Asada, K. et al., "Development of Simplified Analysis Codes for Nine Meter Drop and One Meter Puncture Tests for a Radioactive Material Transport Cask", Waste Management '88 (Tuscon) (1988) .
- (5) Ikushima, T. et al., "Simplified Computer Codes for Cask Impact Analysis" , 10th Int. symposium on the Packaging and Transportation of Radioactive Materials, pp.1419-1426, Japan(Yokohama), (1992) .
- (6) Ikushima, T., Ohshika, J. and Ishiwata, T., "Computer Codes System for Structural Analysis of Radioactive Materials Transport" , 11th Int. symposium on the Packaging and Transportation of Radioactive Materials, pp.1174-1181, U.S.A(Las Vegas), (1995) .

Appendix A Sample Problem Input

Appendix B Sample Problem Output

```

      F I N C R U S H   M O D E L   D A T A
      1       2       3       4       5       6       7       8
      .0.....0.....0.....0.....0.....0.....0.....0.....0
TITLE    FINCRUSH BENCHMARK TEST(FIN DATA DRNL)
FINDATA 17900.0  200.0   850.0   10.0     864.0   4.0
DISP     0.0       0.25    17.4    1.0140E+7   PLOT
MATERIAL FILE      3

```

```

----- MODEL WEIGHT      =    17900.00 (KG)
----- FIN HEIGHT       =     200.00 (MM)
----- FIN WIDTH        =     850.00 (MM)
----- FIN THICKNESS   =      10.00 (MM)
----- OUTER RADIUS US =     864.00 (MM)
----- FIN PITCH         =      4.00 (ANGLE)
----- INCREMENT DISP =      0.25 (MM)
----- YIELD STRESS      =     17.40 (KG/MM*MM)
----- TOTAL ENERGY      = 10140000.0

```

NO.	PHI	HEIGHT	WIDTH
1	0.000	200.000	850.000
2	4.000	200.000	850.000
3	8.000	200.000	850.000
4	12.000	200.000	850.000
5	16.000	200.000	850.000
6	20.000	200.000	850.000
7	24.000	200.000	850.000
8	28.000	200.000	850.000
9	-4.000	200.000	850.000
10	-8.000	200.000	850.000
11	-12.000	200.000	850.000
12	-16.000	200.000	850.000
13	-20.000	200.000	850.000
14	-24.000	200.000	850.000
15	-28.000	200.000	850.000

Appendix B (Continued)

FINCRAH BENCHMARK TEST(FIN DATA ORNL)

STEP	DEPTH	ANGLE	FORCE	ENERGY	ACCELERATION
1	0.2500	1.38	113404.50	28351.13	6.34
2	0.5000	1.95	113404.50	56702.25	6.34
3	0.7500	2.39	113404.50	85053.38	6.34
4	1.0000	2.76	113404.50	113404.50	6.34
5	1.2500	3.08	113404.50	141755.63	6.34
6	1.5000	3.38	113404.50	170106.75	6.34
7	1.7500	3.65	113404.50	198457.88	6.34
8	2.0000	3.90	113404.50	226809.00	6.34
9	2.2500	4.14	372942.90	292973.52	20.83
10	2.5000	4.36	372942.90	386367.69	20.83
11	2.7500	4.57	372942.90	479761.86	20.83
12	3.0000	4.78	372942.90	573156.02	20.83
13	3.2500	4.97	372942.90	666550.19	20.83
14	3.5000	5.16	372942.90	759944.36	20.83
15	3.7500	5.34	372942.90	853338.52	20.83
16	4.0000	5.52	372942.90	946732.69	20.83
17	4.2500	5.69	372942.90	1040126.86	20.83
18	4.5000	5.85	372942.90	1133521.02	20.83
19	4.7500	6.01	372942.90	1226915.19	20.83
20	5.0000	6.17	372942.90	1320309.36	20.83
21	5.2500	6.32	372942.90	1413703.52	20.83
22	5.5000	6.47	372942.90	1507097.69	20.83
23	5.7500	6.61	372942.90	1600491.85	20.83
24	6.0000	6.76	372942.90	1693886.02	20.83
25	6.2500	6.90	372942.90	1787280.19	20.83
26	6.5000	7.03	372942.90	1880674.35	20.83
27	6.7500	7.17	372942.90	1974068.52	20.83
28	7.0000	7.30	372942.90	2067462.69	20.83
29	7.2500	7.43	372942.90	2160856.85	20.83
30	7.5000	7.55	372942.90	2254251.02	20.83
31	7.7500	7.68	372942.90	2347645.19	20.83
32	8.0000	7.80	372942.90	2441039.35	20.83
33	8.2500	7.92	372942.90	2534433.52	20.83
34	8.5000	8.04	665210.70	2654866.45	37.16
35	8.7500	8.16	665210.70	2822045.64	37.16
36	9.0000	8.28	665210.70	2989224.82	37.16
37	9.2500	8.39	665210.70	3156404.01	37.16
38	9.5000	8.50	665210.70	3323583.20	37.16
39	9.7500	8.62	665210.70	3490762.38	37.16
40	10.0000	8.73	665210.70	3657941.57	37.16
41	10.2500	8.83	664883.92	3821771.26	37.14
42	10.5000	8.94	664572.70	3985600.95	37.13
43	10.7500	9.05	664275.96	4149430.63	37.11
44	11.0000	9.15	663992.70	4313260.32	37.09
45	11.2500	9.26	663722.03	4477090.01	37.08
46	11.5000	9.36	663463.13	4640919.69	37.06
47	11.7500	9.46	663215.25	4804749.38	37.05
48	12.0000	9.56	662977.70	4968579.07	37.04
49	12.2500	9.66	662072.87	5125523.84	36.99
50	12.5000	9.76	660897.08	5279210.72	36.92

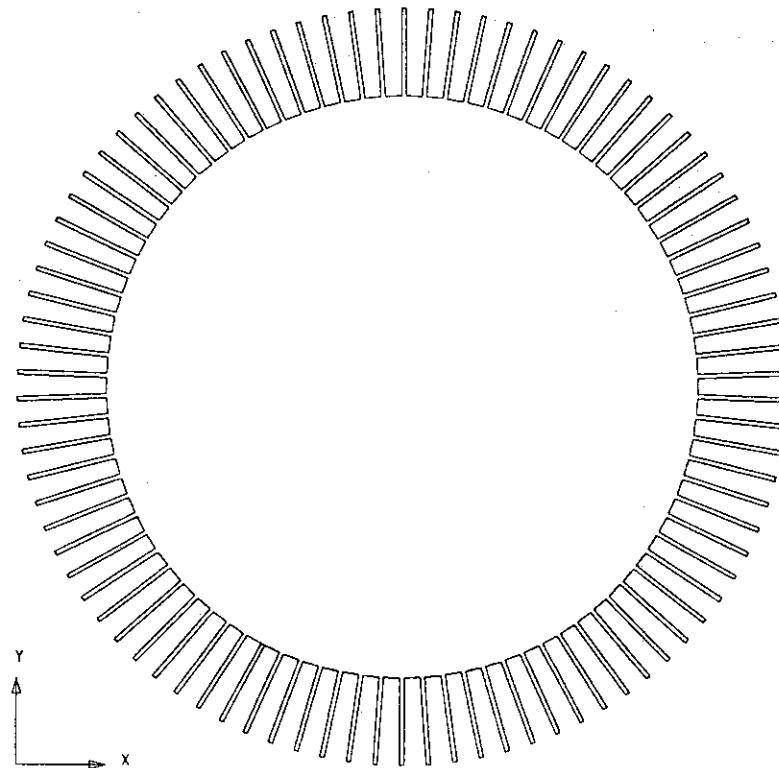
Appendix B (Continued)

FINCRAH BENCHMARK TEST(FIN DATA ORNL)

STEP	DEPTH	ANGLE	FORCE	ENERGY	ACCELERATION
51	12.7500	9.86	659774.81	5432897.60	36.86
52	13.0000	9.95	658702.49	5586584.48	36.80
53	13.2500	10.05	657676.83	5740271.36	36.74
54	13.5000	10.14	656694.85	5893958.24	36.69
55	13.7500	10.24	655753.80	6047645.12	36.63
56	14.0000	10.33	654851.16	6201332.00	36.58
57	14.2500	10.42	653984.63	6355018.88	36.54
58	14.5000	10.51	653152.07	6508705.76	36.49
59	14.7500	10.60	652351.51	6662392.64	36.44
60	15.0000	10.69	651581.14	6816079.52	36.40
61	15.2500	10.78	650839.28	6969766.40	36.36
62	15.5000	10.87	650124.36	7123453.28	36.32
63	15.7500	10.96	649434.95	7277140.16	36.28
64	16.0000	11.04	648769.70	7430827.04	36.24
65	16.2500	11.13	648127.35	7584513.92	36.21
66	16.5000	11.22	647506.75	7738200.80	36.17
67	16.7500	11.30	646906.79	7891887.68	36.14
68	17.0000	11.38	646326.47	8045574.56	36.11
69	17.2500	11.47	645764.84	8199261.44	36.08
70	17.5000	11.55	645221.00	8352948.32	36.05
71	17.7500	11.63	644694.12	8506635.20	36.02
72	18.0000	11.72	644183.41	8660322.08	35.99
73	18.2500	11.80	643688.15	8814008.96	35.96
74	18.5000	11.88	642193.88	8957364.82	35.88
75	18.7500	11.96	640442.97	9097381.46	35.78
76	19.0000	12.04	900462.18	9269377.81	50.31
77	19.2500	12.12	898854.75	9476280.06	50.22
78	19.5000	12.20	897312.31	9683182.32	50.13
79	19.7500	12.27	895830.86	9890084.57	50.05
80	20.0000	12.35	894406.73	10096986.82	49.97
81	20.0539	12.43	894033.21	10140000.00	49.95

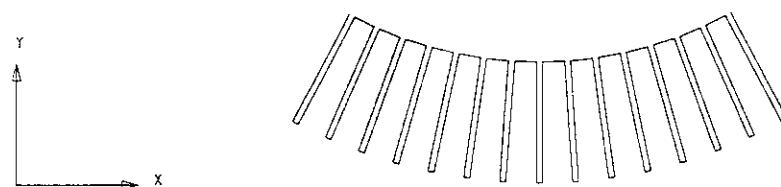
MAX. ACCELERATION = 50.31(G)

Appendix C Graphical Output



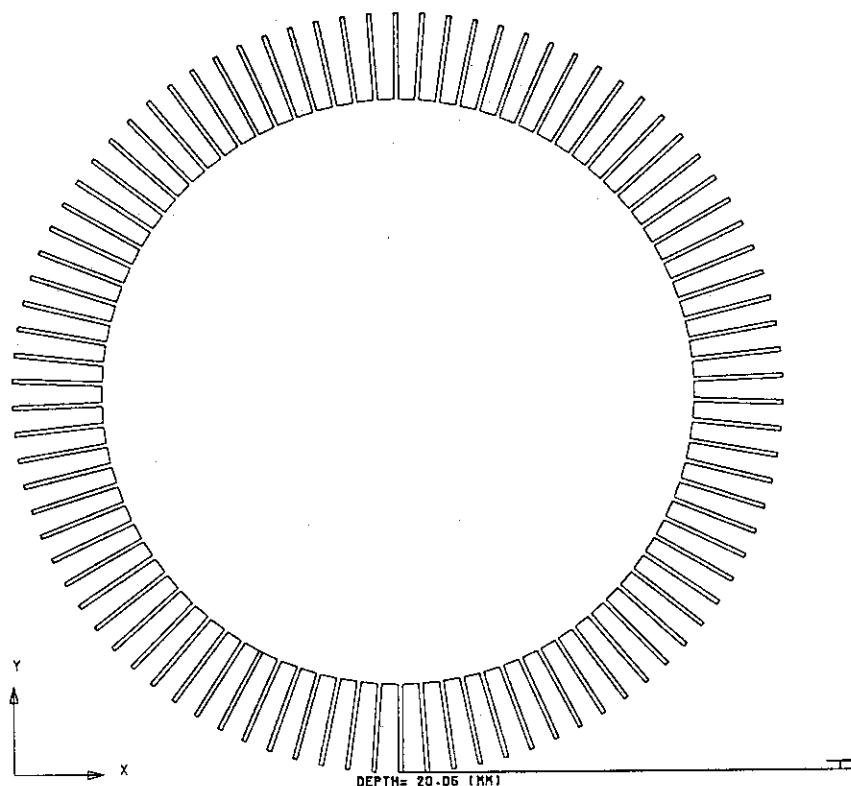
FINCRUSH BENCHMARK TEST(FIN DATA ORNL)

Fig. C.1 Graphical Output of FINCRUSH(1)



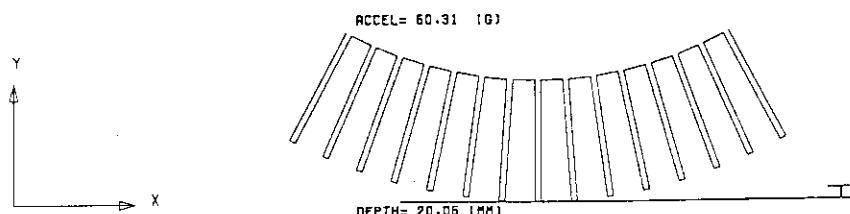
FINCRUSH BENCHMARK TEST(FIN DATA ORNL)

Fig. C.2 Graphical Output of FINCRUSH(2)



FINCRUSH BENCHMARK TEST(FIN DATA DRNL)

Fig. C.3 Graphical Output of FINCRUSH(3)



FINCRUSH BENCHMARK TEST(FIN DATA DRNL)

Fig. C.4 Graphical Output of FINCRUSH(4)

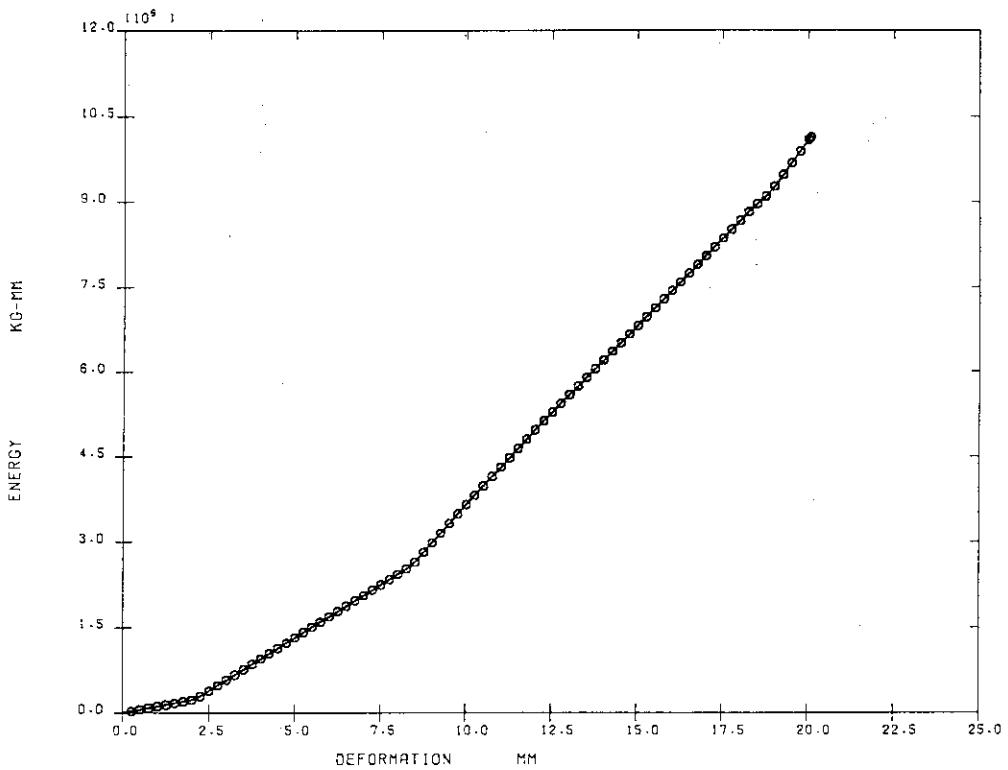


Fig. C.5 Graphical Output of FINCRUSH(5)

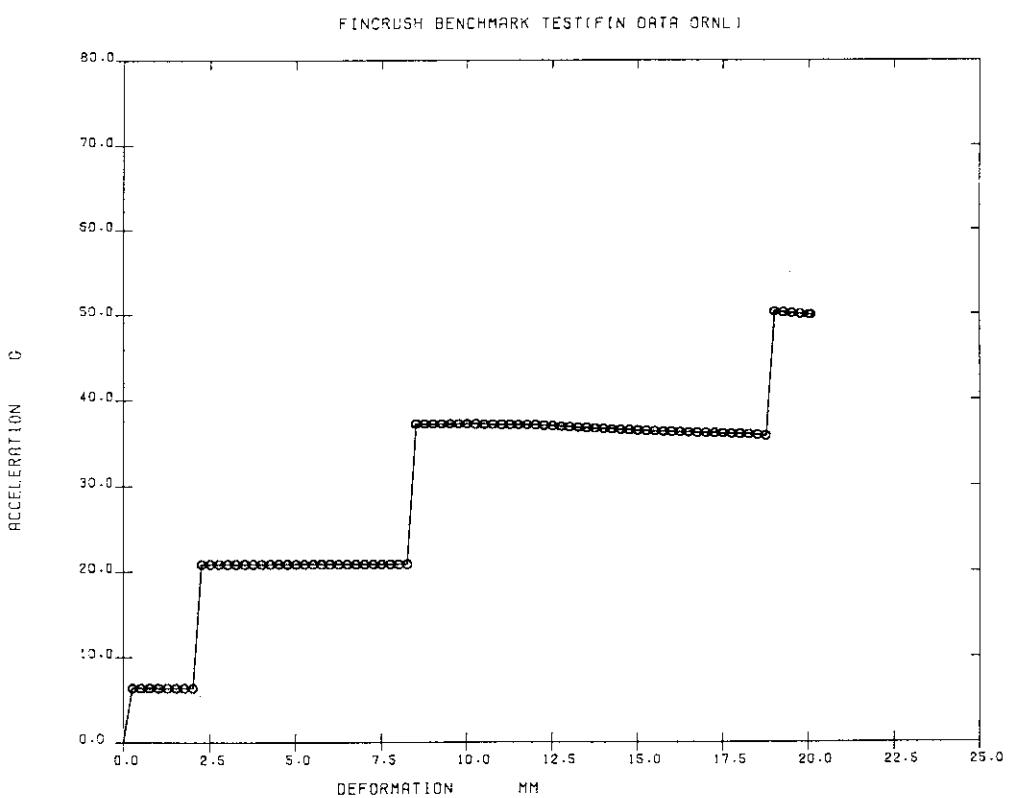


Fig. C.6 Graphical Output of FINCRUSH(6)

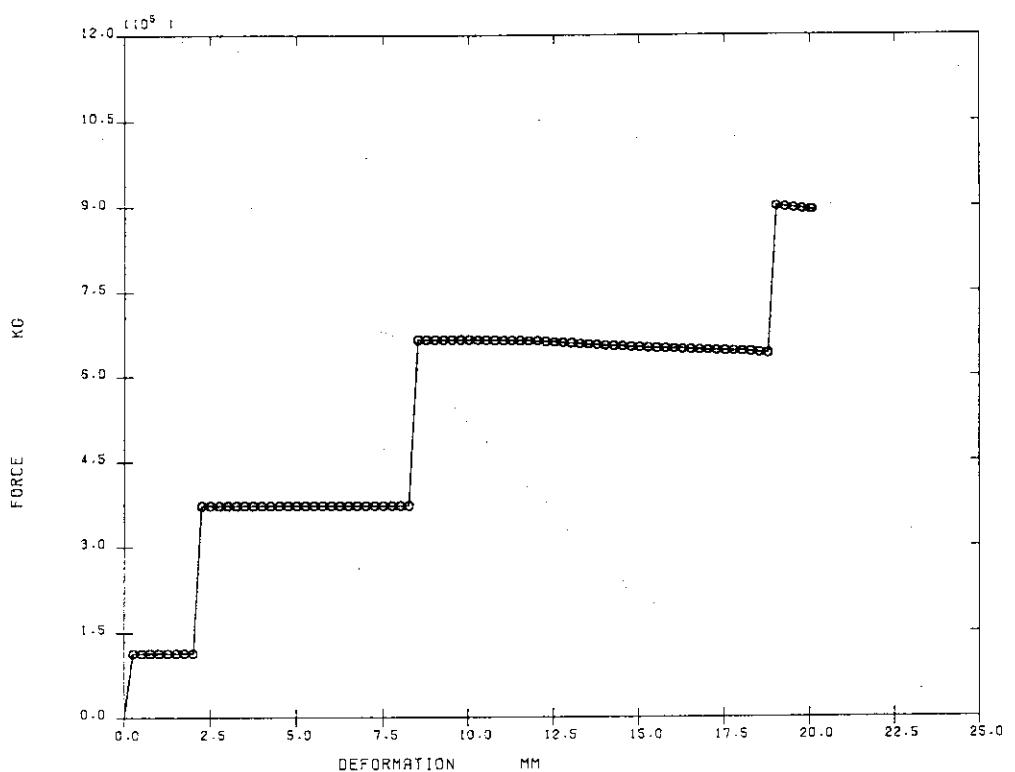


Fig. C.7 Graphical Output of FINCRUSH(7)

Appendix D Job Control Data

The job control data for FINCRUSH execution on the computer FACOM M-780 in JAERI is as follows:

```
//JCLG JOB  
// EXEC JCLG  
//SYSIN DD DATA,DLM='++'  
// JUSER XXXXXXXX.XX,XXXXXXXX,XXXX.XX,FINCRUSH  
// T.03 C.02 W.01 I.02 CLS GRP  
// OOPTP MSGCLASS=A,MSGLEVEL=(2,0,1),CLASS=B,NOTIFY=JXXXX  
// OOPTP PASSWORD=XXXXXXXX  
// EXEC LMGOEX,LM=J2322.LMFINCRU,PNM=FINCRUSH  
// EXPAND GRNLP  
//FT55F001 DD DSN=JXXXX.DTFINCRU.DATA,DISP=SHR  
//FT02F001 DD DSN=SPACE=(TRK,(5,5)),UNIT=TSSWK  
//FT2CF001 DD DSN=JXXXX.DTFINDAT.DATA,DISP=SHR  
++  
//
```

Appendix E Program Abstract

1. Name :

FINCRUSH.

2. Computer for which the program is designed and others upon which it is possible:

FACOM M-780, SUN4 or IBM-PC.

3. Nature of physical problem solved:

Drop impact analysis of radioactive material transport casks.

4. Method of solutions:

One dimensional static analysis.

5. Restrictions on the complexity of the problem:

None.

6. Typical running time:

FACOM-M780 : 1 seconds.

SUN4 : 2 seconds.

IBM-PC : 3 seconds.

7. Unusual features of the program:

None.

8. Related and auxiliary program:

None.

9. Status:

-

10. References:

- (1)Ikushima,T. and Hode S., "Simplified Analysis Computer Program and Their Adequacy for Radioactive Materials Shipping casks", PATRAM'89, pp.1202-1209, Washington DC, USA , June 11-16, (1989).
- (2)Ikushima,T. et al., "Simplified Computer Codes for Cask Impact Analysis", PATRAM'92, pp.1419-1426, Yokohama, Japan, September 13-18, (1992).
- (3)Ikushima,T., Ohshika,J. and Ishiwata,T., "Computer Code System for Structural Analysis of Radioactive Materials Transport", PATRAM'95, pp.1174-1181, Las Vegas, USA, December 3-8, (1995).

11. Machine requirement:

Required 1100 k bytes of core memory.

12. Program language used:

FORTRAN-77.

13. Operating system or monitor under which the program is executed:

FACOM M-780 : MSP.

SUN4 : Solaris 2.1.

IBM PC : Windows 3.1.

14. Any other programming or operating information or restrictions:

The program is approximately 2200 source steps (include comment lines). The graphical programs are as follows:

FACOM M-780 : CALCOMP plttter or the compatible ones.

SUN4 : X-windows.

IBM PC : windows 3.1.

15. Name and establishment of author:

T. Ikushima

Japan Atomic Energy Research Institute,

Tokai Research Establishment,

Department of Fuel Cycle Safety Research,

Tokai-mura, Naka-gun, Ibaraki-ken, 319-11

Japan

16. Material available:

Source.

Appendix F Program Source List

Appendix F (Continued)

```

*****C
C      9010 FORMAT(1H1/5X,18A4/)
C
C      C
C      WRITE(MTOUT,9030)          DEPTH ,9X,6H ANGLE ,9X,6H FORCE,
C      C
C      9030 FORMAT(1OX,4HSTEP,12H
C      +   9X,6HENERGY,3X,12HACCELERATION )
C
C      ACCMAX = 0.0D0
C      DO 5200 J= 1, MXSTEP
C      ACCELJ = ACCEL(J)
C      IF ( ACCELJ .GE. ACCMAX ) ACCMAX = ACCELJ
C      WRITE(MTOUT,9040) J, DEPTH(J), ANGLE(J), FORCE(J),
C      +   ENERGY(J), ACCELJ
C
C      IF ( MOD(J,50) .NE. 0 ) GO TO 5200
C      WRITE(MTOUT,9050) NTITLE
C
C      5200 CONTINUE
C      WRITE(MTOUT,9090) ACCMAX
C      9040 FORMAT(1OX,14,F12.4,3X,F12.2,3X,F12.2,3X,F12.2)
C      9050 FORMAT(1H1/5X,18A4/
C      +   10X,4HSTEP,12H
C      +   DEPTH ,9X,6H ANGLE ,9X,6H FORCE,
C      +   10X,6HENERGY 3X,12HACCELERATION )
C      9090 FORMAT(1H0!10X,20H MAX. ACCELERATION = ,F10.2, 3H(G) )
C
C      C... EACH FIN RESULT
C      C
C      WRITE(MTOUT,9010) NTITLE
C
C      5500 J= 1, MXSTEP
C      WRITE(MTOUT,9070) J, DEPTH(J), ANGLE(J)
C      9070 FORMAT(//2H,6HSTEP = 14,5X,HDEPTH = ,F10.4
C      +   /10X,4H NO,12H
C      +   DEPTH ,9X,6HENERGY,9X,6H FORCE )
C      DO 5400 I= 1, MXPHI
C      IF ( NUSEPHI(I).GT.J ) GO TO 5400
C      WRITE(MTOUT,9040) I, DISPHI(I,J), ERPHI(I,J), FORPHI(I,J)
C
C      5400 CONTINUE
C
C      5500 CONTINUE
C
C      C... PLOT RESULT
C      C
C      IF ( IFLAG.EQ.0 ) GO TO 100
C      KSWPLT = KSWPLT + 1
C      IF ( KSWPLT .EQ. 1 )
C      C
C      IF ( INPFIN.EQ.0 )
C      +CALL UPLOT ( DEPTH(MXSTEP), ACCMAX,
C      CALL UPLOT ( DEPTH(MXSTEP), ACCMAX,
C      +CALL UPLOT ( DEPTH(MXSTEP), ACCMAX,
C      CALL UPLOT ( DEPTH(MXSTEP), ACCMAX,
C
C      C
C      CALL DPLOT ( NTITLE, DEPTH, ENERG, MXSTEP, 1 )
C      CALL DPLOT ( NTITLE, DEPTH, ACCEL, MXSTEP, 2 )
C      CALL DPLOT ( NTITLE, DEPTH, FORCE, MXSTEP, 3 )
C      GO TO 100
C
C      8000 CONTINUE
C      IF ( KSWPLT .GT. 0 ) CALL PLTEND
C
C      END
C
C      1000 CONTINUE
C      END OF ANALYSIS
C      WRITE(MTOUT,9010) NTITLE

```

Appendix F (Continued)

Appendix E (Continued)

```

SUBROUTINE CARDIN (MEOF, INPFIN)
C*** /PURPOSE/
C   READ MODEL DATA
C
C*** /OUTPUT/
C   MEOF      = 0 : NORMAL RUN
C   MEOF      = 1 : END OF INPUT DATA
C   INPFIN    : INPUT VARIABLE FIN DATA KEY
C
C*** PROGRAMMED BY JAERI 1989.03.09
C*** MODIFIED BY JAERI 1989.05.30
C
C   IMPLICIT REAL*8 (A-H,O-Z)
COMMON /FINDAT/ WEIGHT, HEIGHT, WIDEL, THICK,
DANGLE, DISP, SIGN, ENERGY, DRATIO,
MTINN, MTOU, IFLAG, KMODEL,
+ NTITLE(18), PH(100), HET(100), WID(100),
+ COMMON /FINGEM/ MXPHI, TTAB(20),
+ COMMON /MATDAT/ XTAB(11,10,20),
+ COMMON /RESULT/ DEPTH(500),
+ COMMON /TABLE/ TEMP(10,20,5),
+ COMMON /DATEOF/ MLENG(10,20,5),
+ COMMON /KSWPLT/ KEOF,
C
C   DIMENSION LABEL(2,8),
+   NCARD(20),
C
C   DATA NCARD/ 2044H /
DATA LABEL/ 4H11TH, 4HE /
+ 4H0ISP, 4H /
+ 4HNLGL, 4HE /
+ 4HEND /
+ DATA MEND/ 4HEND /
DATA MFIN/ 4HF1N /
DATA MMFILE/ 4HF1N /
DATA KEY/ 4H /
DATA LCOMM/ 4H** /
DATA HNPLOT, 4HNPU, 4HPLAT/
C...
FUNCTION ABS(Z) = DABS(Z)
C...
INITIAL VALUES
C   MTINN = 2
C
C   Mfout = 6
C   MXSTEP = 0
C   MXPFI = 0
C   C... CARD IMAGE
C   LINE = 0
IFC KEOF.NE.0 ) GO TO 160
C
REWIND MTINN
C
110 CONTINUE
READ(55,120,END=150)
120 FORMAT(20A4)
IFC (NCARD(1).EQ.MFIN) GO TO 160
NCARD
C
LINE = LINE+1
IFC MOD(LINE,55).NE.1 ) GO TO 130
WRITE(Mfout,100) (I,I=1,8)
100 FORMAT(1H1 //34X,37HF1NCUSH, MODEL, DATA...,0)
+
10X,B110/10/,10H...,0,7

```

Appendix F (Continued)

Appendix F (Continued)

```

      KMODEL = 1          GO TO 240
      225 IF( INPFIN.EQ.0 )          GO TO 280
C.  (2A)          NAME, AG, HH, AL
      230 READ(MTINN,231)          NAME, AG, HH, AL
      231 FORMAT(2A4,2X,5F10.0)
      LINE = LINE+1
      IF( NAME(1) .EQ. MEND )      GO TO 240
      IF( NAME(1) .NE. LABEL(1,8) ) GO TO 999
C.          MXPHI = MXPHI+1
      IF( MXPHI.GT.100 )          GO TO 992
      IF( KMODEL.NE.0 )           GO TO 233
      IF( AG.LT.-30.0 )          GO TO 993
      IF( AG.GT. 30.0 )          GO TO 993
C.          233 PHI(MXPHI) = AG
      HET(MXPHI) = HH
      WID(MXPHI) = AL
      TIK(MXPHI) = THICK
      IF( HH.GT.HEIGHT )         HEIGHT = HH
      GO TO 230
C.  (3)          NAME, ANGO, DISP, SIGY, ENERGY, DRATIO,
      240 READ(MTINN,241)          NAME1, NAME2
      +          NAME1, NAME2
      241 FORMAT(2A4,2X,5F10.0,A4,1X,A4)
      LINE = LINE+1
      IF( NAME(1) .NE. LABEL(1,3) ) GO TO 999
      IF( NAME(2) .NE. LABEL(2,3) ) GO TO 999
C.          IFLAG = 0
      IF( NAME1.EQ.KEY(1) )       IFLAG = 0
      IF( NAME1.EQ.KEY(2) )       IFLAG = 1
      JFLAG = 0
      IF( NAME2.EQ.KEY(1) )       JFLAG = 0
      IF( NAME2.EQ.KEY(2) )       JFLAG = 1
C.          DRATIO = 100.0
      IF( DRATIO.LE.0.0 )         DRATIO = 100.0
      IF( DRATIO.GT.100.0 )        DRATIO = 0.01*DRATIO
C.          MXPHI = MXPHI+1
      PHI(MXPHI) = THE
      HET(MXPHI) = HEIGHT
      WID(MXPHI) = WDEL
      TIK(MXPHI) = THICK
      THE = THE+DANGLE
      GO TO 250
C.  (4)          NAME, KHEAD, NOT
      260 IF( THE.GT.30.0 )        GO TO 280
      MXPHI = MXPHI+1
      PHI(MXPHI) = -THE
      HET(MXPHI) = HEIGHT
      WID(MXPHI) = WDEL
      TIK(MXPHI) = THICK
      THE = THE+DANGLE
      GO TO 260
C.          265 CONTINUE
      DO 270 J=1,MXPHI
      270 PHI(J) = PHI(J)+ANGO
C.          280 CONTINUE
      DO 285 J=1,MXPHI
      285 NUSEPH(J) = 0
C.          291 FORMAT(2A4,2X,2A4,2X,15)
      LINE = LINE+1
      IF( NAME(1).NE.LABEL(1,4) ) GO TO 999
      IF( NAME(2).NE.LABEL(2,4) ) GO TO 999
C.          (KHEAD = FILE)
      292 READ(MTINN,291)          NAME, KHEAD, NOT
      C.          MTINN = LINE+1
      LINE = LINE+1
      IF( NAME(1).NE.LABEL(1,4) ) GO TO 999
      IF( NAME(2).NE.LABEL(2,4) ) GO TO 999
C.          (KHEAD = FILE)
      293 READ(MTINN,292)          NAME, KHEAD, NOT
      C.          MTINN = 20
      LINE = 0
      REWIND MTINN
      READ(MTINN,291)              NAME, KHEAD, NOT
      LINE = LINE+1
      GO TO 295
C.          295 IF( NOT.LE.0 )        GO TO 997
      IF( NOT.GT.5 )              GO TO 997
      NT = 0
      TDO = -10.0
C.          300 CONTINUE
      NT = NT+1
      IF( NT.GT.NOT )             READ(MTINN,301)          NAME, TD
      301 FORMAT(2A4,2X,F10.0)
      LINE = LINE+1
      IF( NAME(1).NE.LABEL(1,7) ) GO TO 999
      IF( NAME(2).NE.LABEL(2,7) ) GO TO 999
C.          302 IF( TD.LE.TDO )        GO TO 265
      TDO = TD
      TDATA(NT) = TD
      NA = 0
C.          THEAO = -10.0
C.          310 CONTINUE
C.  (5)          THE = DANGLE-ANGO
      255 THE = DANGLE-ANGO

```

Appendix E (Continued)

Appendix E (Continued)

```

      READ(MTINN,311) NAME, THETA, NOF
311  FORMAT(2A4,2X,F10.0,15)
      LINE = LINE+1
      IF( NAME(1).NE.LABEL(1,5) ) GO TO 312
      IF( NAME(2).NE.LABEL(2,5) ) GO TO 999
C
      IF( THETA.LT. 0.0 ) GO TO 994
      IF( THETA.GT.45.0 ) GO TO 994
      IF( THETA.LE.-THETA0 )
     THETA0 = THETA
      FINHO = -10.0
      NA = NA+1
      THET(NA,NT) = THETA
C
      IF( NOF.LE.0 ) GO TO 995
      IF( NOF.GT.10 ) GO TO 995
      NO = 0
      MTNOF(NA,NT) = NOF
      GO TO 320
C
312  IF( NAME(1).NE.MEND ) GO TO 999
      MTHE(TNT) = NA
      GO TO 300
C
      C (7)
320  CONTINUE
      NO = ND+1
      IF( NO.GT.NOF )
C
      READ(MTINN,321) NAME, FINH1, NOR
321  FORMAT(2A4,2X,F10.0,15)
      LINE = LINE+2
      IF( NAME(1).NE.LABEL(1,6) ) GO TO 999
      IF( NAME(2).NE.LABEL(2,6) ) GO TO 999
C
      IF( FINH1.LE.FINHO ) GO TO 996
      FINHO = FINH1
      IF( NOR.LE.1 ) GO TO 996
      IF( NOR.GT.10 ) GO TO 996
      TEMPH(NA,NT) = FINH1
      MLENG(NA,NT) = NOR
      KLINE = (NOR-1)/B+1
C
      C. (8) READ(MTINN,325)
      C. (9) READ(MTINN,325)
      LINE = LINE+KLINE
      GO TO 320
C
      C... PLOT (MATERIAL DATA)
C
      READ(MTINN,325)
      LINE = LINE+KLINE
      GO TO 600
C
      C... END OF INPUT CARD.
C
      600  CONTINUE
      IF( JFLAG.EQ.0 ) GO TO 630
      IF( KSWPLT = KSWPLT + 1 )
     IF( KSWPLT .EQ. 1 )
C
      DO 440 J2=1,NOT
      NOA = MTHET(J2)
      DO 430 J1=1,NOR
      CALL LPLOT ( TDATA(J2), THET(J1,J2), MTNOF(J1,J2),
     MLENG(1,J1,J2), XD(1,1,J1,J2), YD(1,1,J1,J2),
     TEMPH(1,J1,J2), X1 )
      +
      430  CONTINUE
      440  CONTINUE
C
      C... GET (THICK)
      C
      C... CONTINUE
      C
      IF( NOT.EQ.1 ) GO TO 500
      DO 480 J2=2,NOT
      IF( THICK.LT.TDATA(JJ) )
     480  CONTINUE
      J2 = NOT
      490  CONTINUE
      J1 = J2-1
      DELTA = (THICK-TDATA(J1))/(TDATA(J2)-TDATA(J1))
      CALL TTABLE (J1,J2,DELTA)
C
      C... CONTINUE
      MXTAB = MTHET(1)
C
      500  CONTINUE
      00 530 M=1,MXTAB
      TTAB(M) = THET(M,1)
      LNGTAB(M) = MTNOF(M,1)
      NOF = MTNOF(M,1)
      DO 520 J=1,NOF
      NOR = MLENG(J,M,1)
      LNHAB(J,M) = NOR
      THAB(J,M) = TEMPH(J,M,1)
      DO 510 I=1,NOR
      XTABL(I,J,M) = XD(I,J,M,1)
      S10 YTABL(I,J,M) = YD(I,J,M,1)
      520  CONTINUE
      530  CONTINUE
C
      C... END OF INPUT CARD.
C
      600  CONTINUE
      IF( JFLAG.EQ.0 ) GO TO 630
      DO 610 J=1,MXTAB
      CALL LPLOT ( THICK, TTAB(J1), LNGTAB(J1), LNHAB(1,J1),
     XTAB(1,1,J1), YTAB(1,1,J1), THAB(1,J1), 2 )
      +
      610  CONTINUE
C

```

JAERI-Data/Code 97-018

Appendix F (Continued)

```

      WEIGHT, HEIGHT, WIDEL, THICK, ROUT,
      DANGLE, DISP, SIGY, ENERGY
      + F10.2,2X,4H(KG) /
      640 FORMAT(//11X,22H..... MODEL HEIGHT =F10.2,X,4H(KM)
      11X,22H..... FIN WIDTH =F10.2,2X,4H(KM)
      + F11.2,22H..... FIN THICKNESS=F10.2,2X,4H(MM)
      + F11.2,22H..... OUTER RADIUS =F10.2,2X,4H(CMM)
      + F11.2,22H..... FIN PITCH =F10.2,2X,4H(ANGLE)
      + F11.2,22H..... INCREMENT DISP=,F10.2,2X,4H(CMM)
      + F11.2,22H..... YIELD STRESS =F10.2,2X,10H(KG/MM*MM) /
      + 11X,22H..... TOTAL ENERGY =,F12.1 /4H /
      + 11X,22H..... ERROR NOT VALUE.
      CALL EXIT
      RETURN
      C
      WRITE(MTOUT,660)
      DO 690 J=1,MXPHI
      WRITE(MTOUT,670)
      690 CONTINUE
      C
      660 FORMAT(//11X,15H NO. PHI HEIGHT WIDTH /)
      670 FORMAT(11X,15,F10.3)
      C
      700 CONTINUE
      RETURN
      C
      C... ERROR ANGLE
      991 WRITE(MTOUT,9921)
      9921 FORMAT(0H *** ERROR
      CALL EXIT
      RETURN
      C
      C... ERROR FIN ANGLE
      992 WRITE(MTOUT,9922)
      9922 FORMAT(0H *** ERROR
      CALL EXIT
      RETURN
      C
      C... ERROR NOF
      994 WRITE(MTOUT,9924)
      9924 FORMAT(0H *** ERROR
      CALL EXIT
      RETURN
      C
      C... ERROR NOR
      995 WRITE(MTOUT,9925)
      9925 FORMAT(0H *** ERROR
      CALL EXIT
      RETURN
      C
      C... FUNCTION
      ABS(Z)=ABS(Z)
      COS(Z)=COS(Z)
      DATA RAD/ 0.01745329 /
      DATA DEG/ 57.2957795 /
      NOR=15
      C
      9926 FORMAT(0H *** ERROR
      CALL EXIT
      RETURN
      C... ERROR NOT VALUE.
      997 WRITE(MTOUT,9927)
      9927 FORMAT(0H *** ERROR
      CALL EXIT
      RETURN
      C
      C... ERROR FORMAT CARD.
      998 WRITE(MTOUT,9928)
      9928 FORMAT(0H *** ERROR
      TD T VALUE.
      CALL EXIT
      RETURN
      C
      C... ERROR FORMAT CARD.
      999 WRITE(MTOUT,9991)
      9991 FORMAT(0H *** ERROR CRAD FOUND.
      + 13HCOLUMN (1-8)=,2A4)
      CALL EXIT
      RETURN
      END
      C
      SUBROUTINE SOLV
      C*** PURPOSE/
      C*** CALCULATION ENERGY OF CYLINDRICAL FIN
      C*** PROGRAMMED BY JAERI
      1989.03.09
      C
      IMPLICIT REAL*8 (A-H,O-Z)
      COMMON /FINDAT/ MFINN, MTOUT, NITTLE(18),
      + MFLG, MFLAG, MTHICK, MROUT, MENERGY,
      + MDANGLE, MWT, MWTDEL, MDRATIO, MKMODEL,
      + MANGLE, MHEIGHT, MWEIGHT, MWIDTH, MSIGY,
      + MDISP, MDANGLE, MWTDEL, MDRATIO, MKMODEL,
      + MANGLE, MHEIGHT, MWEIGHT, MWIDTH, MSIGY,
      + MDISP, MFLG, MFLAG, MTHICK, MROUT, MENERGY,
      + MFINM, MFINPHI, MTTAB(20),
      + MFINMATD, XTAB(11,10,20), LNGTAB(20),
      + MXTAB
      + COMMON /RESLT/
      FORCE(500), DEPTH(500),
      + ANGLE(500), ENERG(500),
      + DISPL(100,500),
      + ERPHIC(100,500),
      + NUSEPH(100),
      + MYSTEP,
      + FFDATA(100),
      + DIMENSION EPDATA(100),
      C
      C... ERROR THETA
      994 WRITE(MTOUT,9924)
      9924 FORMAT(0H *** ERROR
      CALL EXIT
      RETURN
      C
      C... ERROR NOF
      995 WRITE(MTOUT,9925)
      9925 FORMAT(0H *** ERROR
      CALL EXIT
      RETURN
      C
      C... ERROR NOR
      996 WRITE(MTOUT,9926)
      9926 FORMAT(0H *** ERROR
      CALL EXIT
      RETURN
      C
      C... FUNCTION
      ABS(Z)=ABS(Z)
      COS(Z)=COS(Z)
      DATA RAD/ 0.01745329 /
      DATA DEG/ 57.2957795 /
      NOR=15
      C

```

Appendix F (Continued)

Appendix F (Continued)

```

ACOS(Z) =DACOS(Z)
C... INITIAL STATUS
C MXSTEP = 0
TODISP = 0.0
FORCEX = 0.0
MINI = 1
DISPX = DISP
T2 = THICK**2/4.0
HLIMIT = HEIGHT*D_RATIO
C ENERGYB = 0.0
DO 50 JJ=1,MXPHI
DISPO(JJ) = 0.0
EPDATA(JJJ) = 0.0
50 FFDATA(JJJ) = 0.0
C C... GET CURRENT FORCE
C 100 CONTINUE
MXSTEP = MXSTEP+1
IF( MXSTEP.GT.500 ) GO TO 1000
TODISP = TODISP + DISPX
C C. (THETA)
RSIZE = ROUT-TODISP
THE = RSIZE/ROUT
THETA = ACOS(THE)
THETA = THETA*DEG
IF( THETA.GE.30.0 ) GO TO 900
IF( TODISP.GT.HLIMIT ) GO TO 900
C C... LOOP OF FIN
C SUM = 0.0
FOR = 0.0
DO 500 JJ=1,MXPHI
THET = ABS(PHI(JJJ))
IF( THET.GT.THETA ) GO TO 500
IF( NUSEPH(JJJ).GT.0 ) GO TO 200
NUSEPH(JJJ) = MXSTEP
C 200 DELTA = RSIZE*COS(RAD*PHI(JJJ))
HIGT = HET(JJ)
H = DELTA*H
CALL GETE ( HIGT, THET, R, EPS )
TMP = SIG*T2
EP = EPS*TMP*WID(JJJ)
FF = EP / DELTA
EPDATA(JJJ) = EP
FFDATA(JJJ) = FF
DISPO(JJJ) = DELTA
C OISPHI(J,J,MXSTEP) = DELTA
C... SUM OF EACH ENERGY
C SUM = SUM + EP
FOR = FOR + FF
500 CONTINUE
C FORCEX = FORCEX + FOR
FORCEX = FOR
C ANGLE(MXSTEP) = THETA
DEPTH(MXSTEP) = TODISP
FORCE(MXSTEP) = FORCEX
ACCEL(MXSTEP) = FORCEX/WEIGHT
ENERG(MXSTEP) = SUM
C IFC SUM.LT.ENERGY ) GO TO 100
IF( MINI.NE.0 ) GO TO 800
MINI = 1
TODISP = TODISP - DISPX
MXSTEP = MXSTEP-1
DISPX = 0.1*DISP
GO TO 100
C... INTERPOLATION OF LAST STEP
C 800 CONTINUE
CALL FITSIP
GO TO 1000
C C... INTERPOLATION OF LAST STEP
C 900 IFC MINI.NE.0 )
MINI = 1
TODISP = TODISP - DISPX
MXSTEP = MXSTEP-1
DISPX = 0.1*DISP
GO TO 100
C 950 MXSTEP = MXSTEP-1
C C... END OF CALCULATION
C 1000 CONTINUE
IFC MXSTEP.GT.500 )
RETURN
END
C SUBROUTINE SOLV2
C *** PURPOSE /
C C*** CALCULATION ENERGY OF FIN ON CIRCULAR PLATE
C

```

Appendix F (Continued)

Appendix E (Continued)

Appendix F (Continued)

Appendix F (Continued)

```

C   950 MXSTEP = MXSTEP-1
C   END OF CALCULATION
C...
1000 CONTINUE
IFC MXSTEP.GT.500 )      MXSTEP = 500
RETURN
END

SUBROUTINE GETE ( HEIGHT, THETA, R, EPS )
C*** /PURPOSE/
C   GET EPSILON VALUE
C...
C*** /OUTPUT/
C   EPS :          :
C...
C*** /INPUT/
C   HEIGHT = FIN HEIGHT
C   THETA = FIN ANGLE
C   R = RATIO OF DEFORMATION
C...
C*** /PROGRAMMED BY JAERI    1989.03.09
C*** /MODIFIED BY JAERI    1989.05.31
C...
C   IMPLICIT REAL*8 (A-H,O-Z)
COMMON /MATTR/ TTAB(10,20),
+               XTAB(11,10,20),
+               LNGTAB(10,20),
+               MXTTAB,
+               MINDEX(2),
+               RDATA(2),
+               DATA_DL(1.0E-20),
C...
FUNCTION ABS(Z) = DABS(Z)
C...
ANGLE RANGE
C...
DO 100 J2= 2, MXTTAB
IFC THETA.LT.TTAB(J2) )      60 TO 200
100 CONTINUE
J2 = MXTTAB
200 CONTINUE
J1 = J2-1
MINDEX(1) = J1
MINDEX(2) = J2
C...
HEIGHT RANGE
C...
DO 900 JJ=1,2
ID = MINDEX(JJ)
NOFINH = LNGTAB(ID)
C...

```

Appendix F (Continued)

Appendix F (Continued)

```

XX = X0+20.0*HH
YY = 0.6*YO
CALL PSYM ( XX, YY, HH, MHEAD(1, 1), 0.000, 36 )
C. (Y-TITLE)
XX = 0.4*X0
YY = Y0+15.0*HH
CALL PSYM ( XX, YY, HH, MHEAD(1, 2), 90.000, 36 )
C
C... XYPILOT
C 600 CONTINUE
CALL PLPEN( 2 )
PX = DX* 10.0**NEXPX
PY = DY* 10.0**NEXPY
XFACT = DH/PX
YFACT = DH/PY
C
R = 1.0
DO 900 JJ= 1, NOF
LENGTH = MLENG(JJ)
X(1) = X0
Y(1) = Y0
C
DO 700 J= 1, LENGTH
X(2) = XFACT*XD(J,JJ) + X0
Y(2) = YFACT*YD(J,JJ) + Y0
CALL PLINES ( X, Y, 2 )
CALL PLMARK ( X(2), Y(2), R )
X(1) = X(2)
Y(1) = Y(2)
C
700 CONTINUE
C
X(2) = X(2)+2.0*H2
CALL PSTM ( X(2), Y(2), H2, 4H H =, 0.000, 4 )
X(2) = X(2)+4.0*H2
CALL PNUMB ( X(2), Y(2), H2, FINH(JJ), 0.000, 2 )
900 CONTINUE
C
CALL PLTFOR
1000 CONTINUE
RETURN
END

SUBROUTINE MPLOT ( KEYALL )
C*** PURPOSE/
C*** GEOMETRY PLOT
C*** INPUT/
C*** KEYALL = 0, PLOT SMALL MODEL
C*** KEYALL = 1, PLOT TOTAL MODEL
C*** PROGRAMMED BY JAERI 1989.03.20
C
C
C IMPLICIT REAL*8 (A-H,O-Z)
COMMON /FINDAT/ WEIGHT, HEIGHT, WIDEL,
+ DANGLE, DISP, SIGY, IFLAG,
+ MTINN, MTOUT, NTITLE(18)
COMMON /FINGEM/ PHIC(100), HET(100), WID(100),
+ MXPHI
COMMON /RESULT/
+ DEPTH(500),
FORCE(500),
+ ENERGY(500),
+ DISPHI(100,500),
+ NUSEPH(100),
MXSTEP
C
DIMENSION LDIR(2), ANGFIN(360)
DIMENSION X(1450), Y(1450), XV(10),
+ DATA LDIR/ 4HX, 4HY /
DATA XL,YL/ 3.8637, 1.0353 /
DATA X0,Y0/ 40.0, 20.0 /
DATA HH/ 2.5 /
DATA RAD/ 0.01745329 /
C...
FUNCTION
SQR(Z) = DSQRT(Z)
COS(Z) = DCOS(Z)
SIN(Z) = DSIN(Z)
C
C... GET EACH FIN LOCATION
C
IF ( KMODEL.NE.0 ) GO TO 600
C
DO 100 J= 1,MXPHI
100 ANGFIN(J) = PHIC(J)+270.0
C
DO 200 J= 1,MXPHI
ANG = ANGFIN(J)
LOC = J
DO 150 I= J,MXPHI
IF ( ANGFIN(I).GE.ANG ) GO TO 150
ANG = ANGFIN(I)
LOC = I
150 CONTINUE
ANG = ANGFIN(J)
ANGFIN(J) = ANGFIN(LOC)
ANGFIN(LOC) = ANG
C
200 CONTINUE
MXALL = MXPHI
IF ( KEYALL.EQ.0 ) GO TO 270
ANG = ANGFIN(MXPHI)
M = 0
C
C
210 ANG = ANG+DANGLE
IF ( ANG.LT.360.0 ) GO TO 220
M = 1
ANG = ANG-360.0
C

```

Appendix F (Continued)

Appendix F (Continued)

```

220 IF( M.EQ.0 )          60 TO 230
   IF( ANG.GT.ANGFIN(1) ) 60 TO 270
230 MXALL = MXALL+1
ANGFIN(MXALL) = ANG
GO TO 210

C... GET GEOMETRY
C 270 T = 0.5*THICK
XV(1) = ROUT-HEIGHT
XV(2) = ROUT
XV(3) = ROUT-HEIGHT
XV(4) = ROUT-HEIGHT
YV(1) = -T
YV(2) = -T
YV(3) = T
YV(4) = T

C MM = 0
DO 400 J=1,MXPHI
   YV(1) = -T
   YV(2) = -T
   YV(3) = T
   YV(4) = T
C
MM = 0
DO 400 J=1,MXALL
   ANG = ANGFIN(J)
   C = COS(RAD*ANG)
   S = SIN(RAD*ANG)
DO 300 I=1,4
   MM = MN+1
   X(MM) = C*XV(I)-S*YV(I)
   Y(MM) = S*XV(I)+C*YV(I)
300 Y(MM) = S*XV(I)+C*YV(I)
400 CONTINUE
IF( KEYALL.EQ.0 ) GO TO 500
MM = MN+1
X(MM) = X(1)
Y(MM) = Y(1)

C 500 CONTINUE
NN = MM
C MM = MN+4
X(MN+1) = -ROUT
X(MN+2) = -ROUT+HEIGHT
X(MN+3) = -ROUT
X(MN+4) = -ROUT
Y(MN+1) = -ROUT
Y(MN+2) = -ROUT
Y(MN+3) = -ROUT+HEIGHT
GO TO 1000

C... FIN ON CIRCULAR PLATE
C 600 CONTINUE
   MM = MN+4
   T = 0.5*THICK
   XX = 0.0
C
XV(1) = 0.0
XV(2) = 0.0
XV(3) = 0.0
XV(4) = 0.0

```

```

YV(1) = -T
YV(2) = -T
YV(3) = T
YV(4) = T
C
MM = 0
DO 900 J=1,MXPHI
   ANG = PHI(J)
   C = COS(RAD*ANG)
   S = SIN(RAD*ANG)
   XV(1) = -HET(J)
   XV(2) = -HET(J)
DO 700 I=1,4
   X(MM+1) = S*XV(I)+C*YV(I)
   Y(MM+1) = -C*YV(I)+S*XV(I)
700 Y(MM+1) = Y(MM+2)
   YY = Y(MM+2)
DO 800 I=1,4
   X(MM+1) = X(MM+1) + XX
   Y(MM+1) = Y(MM+1) - YY
800 YY = Y(MM+2)
C
XX = XX+HEIGHT
MM = MM+4
900 CONTINUE
NN = MM
C
MM = MN+4
XX = -3.0*HEIGHT
X(NN+1) = XX
X(NN+2) = XX+0.5*HEIGHT
X(NN+3) = XX
X(NN+4) = XX
Y(NN+1) = 0.0
Y(NN+2) = 0.0
Y(NN+3) = 0.0
Y(NN+4) = 0.5*HEIGHT
C
C... GEOMETRY SCALING
C
1000 CONTINUE
   CALL GOSCAL( MM, X, Y, XMN, YMN, XMX, YMX, FACTOR )
C
C... PLOT COORDINATES
C
DO 1100 J=1, MM
   X(J) = FACTOR*(X(J)-XMN) + X0
   Y(J) = FACTOR*(Y(J)-YMN) + Y0
1100 CONTINUE
C
C... GEOMETRY PLOT
C
CALL PLPEN( 1 )
CALL PLINES( X, Y, NN )
C
C... AXES PLOT
C
DO 1200 J=1, 2
   XV(1) = X(NN+1)

```

Appendix F (Continued)

Appendix F (Continued)

```

YV(1) = Y(NN+1)
XV(2) = X(NN+2)
YV(2) = Y(NN+2)
XV(5) = X(NN+2)
YV(5) = Y(NN+2)
NN = NN+2
C
X(1) = XV(2)-XV(1)
Y(1) = YV(2)-YV(1)
DLL = SQRT(X(1)*X(2)+Y(1)*Y(2))
F1 = (DLL-XL)/DLL
F2 = (DLL+XL)/DLL
X(2) = X(1) + F1*X(1)
Y(2) = Y(1) + F1*Y(1)
XV(6) = XV(1) + F2*X(1)
YV(6) = YV(1) + F2*Y(1)
X(1) = X(1)/DLL
Y(1) = Y(1)/DLL
C
XV(3) = X(2) - Y(1)*YL
XV(4) = X(2) + Y(1)*YL
YV(3) = Y(2) + X(1)*YL
YV(4) = Y(2) - X(1)*YL
CALL PLINES ( XV, YY, 5 )
CALL PSYM ( XV(6), YV(6), HH, LDIR(J), 0.000, 1 )
1200 CONTINUE
C...
HEADER PLOT
C
XX = 10.0
YY = 0.25*YO
CALL PSYM ( XX, YY, HH, NTITLE, 0.000, 70 )
C...
CALL PLTEOR
RETURN
END
C*** / INPUT /
C*** NTITLE = MODEL TITLE MESSAGE
C*** XVAL = X VARIABLES
C*** YVAL = Y VARIABLES
C*** LENGTH = NO. OF VARIABLES
C*** KTYPE = 1 ENERGY PLOT
C*** = 2 ACCELERATION PLOT
C*** = 3 FORCE PLOT
C*** PROGRAMMED BY JAERI 1989.03.10
C*** IMPLICIT REAL*8 (A-H,O-Z)
C
DIMENSION NTITLE(18)
DIMENSION XVAL(1), YVAL(1)
DIMENSION X(5), Y(5), NP(2,3),
MHEAD(2,4), KSCL(2), KHEAD(3,4),
NP(2,3), KSCL(2), KHEAD(3,4),
+ DATA NP/ 1, 2, 1, 3, 1, 4 /
+ DATA MHEAD/ 4HDEF0, 4HION,
DATA KHEAD/ 4HENER, 4HGY, 4H,
+ 4HACCE, 4HTION,
+ 4HFORC, 4HE, 4H,
+ DATA MHEAD/ 4H MM, 4H,
+ 4H KG-, 4HMM /
+ DATA KSCL/ 4HC10, 4H )
+ DATA NPARY, NPARTX, 10, 8 /
+ DATA XLYL, 200.0, 160.0 /
+ DATA X0, Y0, DH, 40.0, 30.0 /
+ DATA HH, H2, H3, 2.5, 2.0,
+ 1.5 /
C... DATA RANGE
C
CALL GOSCAL ( LENGTH, XVAL, YVAL, XMN, YMN, XMX, YMX, FACT )
C
CALL XYSCL ( XMN, YMN, NPARTX, DX, NEXPX )
CALL XYSCL ( YMN, YMX, NPARTY, DY, NEXPY )
C
C... GRID MESH
C
CALL PLPEN( 1 )
X(1) = X0
X(2) = X0+XL
X(3) = X0+XL
X(4) = X0
X(5) = X0
Y(1) = Y0
Y(2) = Y0
Y(3) = Y0+YL
Y(4) = Y0+YL
Y(5) = Y0
CALL PLINES ( X, Y, 5 )
C. (X) SCALE
Y(1) = Y0-2.0
Y(2) = Y0+2.0
Y(3) = Y0-5.0
Y(4) = Y0+YL-2.0
Y(5) = Y0+YL
X(1) = X0
X(2) = X0
DNO = 0.0
LPARTX = NPARTX+1
DO 300 J=1, LPARTX
    CALL PLINES ( X, Y, 2 )
    CALL PLINES ( X, Y(4), 2 )
    X(3) = X(1)-H2
    CALL PNUMB ( X(3), Y(3), H2, DNO, 0.000, 1 )
    X(1) = X(1)+DH
    X(2) = X(2)+DH
    DNO = DNO+DX
300 CONTINUE
IF ( NEXPX.EQ.0 ) GO TO 350

```

Appendix E (Continued)

```

X(3) = X0+XL+4.0*H2
CALL PSYM ( X(3), Y(3), H2, KSCL, 0.0D0, 6 )
X(3) = X0+XL+7.0*H2
Y(3) = Y(3)+H3
CALL PNUMBR ( X(3), Y(3), H3, NEXPY, 0.0D0 )

C. (Y) SCALE
350 X(1) = X0-2.0
X(2) = X0+2.0
X(3) = X0-5.0*H2
X(4) = X0+XL-2.0
X(5) = X0+XL
Y(1) = Y0
Y(2) = Y0
DND = 0.0
LPARTY = NPARTY+1
DO 400 J=1, LPARTY
CALL PLINES ( X, Y, 2 )
CALL PLINES ( X(4), Y, 2 )
Y(3) = Y(1)
CALL PNUMB ( X(3), Y(3), H2, DNO, 0.0D0, 1 )
Y(1) = Y(1)+DH
Y(2) = Y(2)+DH
DNO = DNO+DY
400 CONTINUE
IF (NEXY.EQ.0 ) GO TO 500
X(3) = X0
Y(3) = Y0+YL+H2
CALL PSYM ( X(3), Y(3), H2, KSCL, 0.0D0, 6 )
X(3) = X0+3.0*H2
Y(3) = Y(3)+H3
CALL PNUMBR ( X(3), Y(3), H3, NEXPY, 0.0D0 )
C...
C... HEADER PLOT
C
500 CONTINUE
XX = X0+20.0*HH
YY = Y0+YL+3.0*HH
CALL PSTM ( XX, YY, HH, NTITLE, 0.0D0, 70 )
C. (X-TITLE)
IPX = NP(1,KTYPE)
XX = X0+20.0*HH
YY = 0.6*YO
CALL PSYM ( XX, YY, HH, KHEAD(1,IPX), 0.0D0, 12 )
XX = XX+15.0*HH
CALL PSYM ( XX, YY, HH, MHEAD(1,IPX), 0.0D0, 8 )
C. (Y-TITLE)
IPY = NP(2,KTYPE)
XX = 0.4*X0
YY = Y0+20.0*HH
CALL PSYM ( XX, YY, HH, KHEAD(1,IPY), 90.0D0, 12 )
YY = YY+15.0*HH
CALL PSYM ( XX, YY, HH, MHEAD(1,IPY), 90.0D0, 8 )
C...
C... XYPLOT
C
600 CONTINUE
CALL PLPENC ( 2 )

```

Appendix F (Continued)

Appendix F (Continued)

```

DATA KKMCM/ 4H(MM)/
DATA KKACCG/ 4H(G) /
DATA XL,YL/ 3.8637, 1.0353 /
DATA XD,YD/ -40.0, 20.0 /
DATA HH/ 2.5 /
DATA H2/ 2.0 /
DATA RAD/ 0.01745329 /

C... FUNCTION
      SQRT(Z) = DSQRT(Z)
      COS(Z) = DCOS(Z)
      SIN(Z) = DSIN(Z)

C... GET EACH FIN LOCATION
      IF( KMODEL .NE. 0 ) GO TO 600
      DO 100 J=1,MXPHI
      100 ANGFIN(J) = PHI(J)+270.0

C... CONTINUE
      DO 200 J=1,MXPHI
      ANG = ANGFIN(J)
      LOC = J
      DO 150 I=J,MXPHI
      1F( ANGFIN(I).GE.ANG ) GO TO 150
      ANG = ANGFIN(I)
      LOC = I
      150 CONTINUE
      ANG = ANGFIN(J)
      ANGFIN(LOC) = ANG
      ANGFIN(LOC) = ANG

      200 CONTINUE
      IF( KEYALL.EQ.0 ) GO TO 270
      ANG = ANGFIN(MXPHI)
      M = 0
      GO TO 210

C... GET GEOMETRY
      C... GET FIN ON CIRCULAR PLATE
      DO 900 J=1,MXPHI
      ANG = PHI(J)
      C = COS(RAD*ANG)
      S = SIN(RAD*ANG)
      XV(1) = ROUT
      XV(2) = -HEI(J)
      XV(3) = -ROUT+HEIGHT
      XV(4) = -HEI(J)
      DO 700 I=1,4
      XV(1) = S*XV(1)+C*YV(1)
      XV(2) = S*YV(1)+C*XV(1)
      XV(3) = -C*XV(1)+S*YV(1)
      XV(4) = -S*YV(1)-C*XV(1)
      700 Y(MM+I) = -C*XV(1)+S*YV(1)

      C... GET FIN ON CIRCULAR PLATE
      600 CONTINUE
      MM = 0
      T = 0.5*THICK
      XX = 0.0
      XV(1) = 0.0
      XV(2) = 0.0
      XV(3) = 0.0
      XV(4) = 0.0
      YV(1) = -T
      YV(2) = -T
      YV(3) = T
      YV(4) = T
      MM = 0
      DO 900 J=1,MXPHI
      ANG = PHI(J)
      C = COS(RAD*ANG)
      S = SIN(RAD*ANG)
      XV(1) = ROUT
      XV(2) = -HEI(J)
      XV(3) = -ROUT+HEIGHT
      XV(4) = -HEI(J)
      DO 700 I=1,4
      XV(1) = S*XV(1)+C*YV(1)
      XV(2) = S*YV(1)+C*XV(1)
      XV(3) = -C*XV(1)+S*YV(1)
      XV(4) = -S*YV(1)-C*XV(1)
      700 Y(MM+I) = -C*XV(1)+S*YV(1)

      C... GET FIN ON CIRCULAR PLATE
      600 CONTINUE
      MM = 0
      T = 0.5*THICK
      XX = 0.0
      XV(1) = 0.0
      XV(2) = 0.0
      XV(3) = 0.0
      XV(4) = 0.0
      YV(1) = -T
      YV(2) = -T
      YV(3) = T
      YV(4) = T
      MM = 0
      DO 900 J=1,MXPHI
      ANG = PHI(J)
      C = COS(RAD*ANG)
      S = SIN(RAD*ANG)
      XV(1) = ROUT
      XV(2) = -HEI(J)
      XV(3) = -ROUT+HEIGHT
      XV(4) = -HEI(J)
      DO 700 I=1,4
      XV(1) = S*XV(1)+C*YV(1)
      XV(2) = S*YV(1)+C*XV(1)
      XV(3) = -C*XV(1)+S*YV(1)
      XV(4) = -S*YV(1)-C*XV(1)
      700 Y(MM+I) = -C*XV(1)+S*YV(1)

```

Appendix F (Continued)

Appendix F (Continued)

```

      YY = Y(MM+2)
DO 800 I=1,4
      X(MM+I) = X(MM+I) + XX
      Y(MM+I) = Y(MM+I) - YY
C     XX = XX+HEIGHT
      MM = MM+4
  900 CONTINUE
      NN = MM
C     MM = MM+4
      XX = -3.0*HEIGHT
      X(NN+1)= XX
      X(NN+2)= XX+0.5*HEIGHT
      X(NN+3)= XX
      X(NN+4)= XX
      Y(NN+1)= 0.0
      Y(NN+2)= 0.0
      Y(NN+3)= 0.0
      Y(NN+4)= 0.5*HEIGHT
C...  GEOMETRY SCALING
C...  PLOT COORDINATES
  1000 CONTINUE
      CALL GOSCAL ( MM, X, Y, XMN, YMN, XMX, YMx, FACTOR )
      DO 1100 J= 1, MM
          X(J) = FACTOR*(X(J)-XMN) + XO
          Y(J) = FACTOR*(Y(J)-YMN) + YO
  1100 CONTINUE
C...  GEOMETRY PLOT
C...  AXES PLOT
  DO 1200 J= 1, 2
      XV(1) = X(NN+1)
      YV(1) = Y(NN+1)
      XV(2) = X(NN+2)
      YV(2) = Y(NN+2)
      XV(5) = X(NN+2)
      YV(5) = Y(NN+2)
      NN = NN+2
C     XV(1) = XV(2)-XV(1)
      Y(1) = YV(2)-YV(1)
      DLL = SQRT( X(1)*X(1)+Y(1)*Y(1)*2 )
      IF( DLL .LE. 1.0D-2 ) DLL = 1.0D-2
      F1 = (DLL-X1)/DLL
      F2 = (DLL+X1)/DLL
      X(2) = XV(1) + F1*X(1)
      Y(2) = YV(1) + F1*Y(1)
      XV(6) = XVC(1) + F2*X(1)
      YV(6) = YVC(1) + F2*Y(1)
      X(1) = X(1)/DLL
      Y(1) = Y(1)/DLL
C     XV(3) = X(2) - Y(1)*YL
      XV(4) = X(2) + Y(1)*YL
      YV(3) = Y(2) + X(1)*YL
      YV(4) = Y(2) - X(1)*YL
      CALL PLINES ( XV, YV, 5 )
      CALL PSYM ( XV(6), YV(6), HH, LDIR(J), 0.0D0, 1 )
  1200 CONTINUE
C...  DISPLACEMENT VALUE PLOT
C     DLL = 0.1*DEPTHX*FACTOR
      X(1) = 130.0
      X(2) = 236.0
      X(3) = 230.0
      X(4) = 232.0
      X(5) = 235.0
      X(6) = 237.0
      X(7) = X(6)
      X(8) = X(6)-0.25*YL*DLL
      X(9) = X(6)+0.25*YL*DLL
      Y(1) = Y(0)
      Y(2) = Y(1)
      Y(3) = Y(1)+DEPTHX*FACTOR
      Y(4) = Y(3)
      Y(5) = Y(6)-0.25*XL*DLL
      Y(6) = Y(7)-0.25*XL*DLL
      Y(7) = YO-1.*H2
      Y(8) = YX+7.*H2
      Y(9) = YX+7.*H2
      CALL PLPEN (2)
      CALL PLINES ( X(1), Y(1), 2 )
      CALL PLINES ( X(3), Y(3), 2 )
      CALL PLINES ( X(5), Y(5), 4 )
      XX = X(1)-10.0
      YY = Y(1)-10.0
      CALL PSYM ( XX, YY, H2, KDEPTH, 0.0D0, 7 )
      CALL PNUMB ( XX, YY, H2, DEPTHX, 0.0D0, 2 )
      FXU = 6.0
      IF( DEPTHX.GE.100.0 ) FXU = 7.0
      IF( DEPTHX.GE.1000.0 ) FXU = 8.0
      XX = XX+FXU+H2
      CALL PSYM ( XX, YY, H2, KKMC, 0.0D0, 4 )
      XX = 120.0
      YY = YO+H2+FACTOR*(YMX-YMN)
      CALL PSYM ( XX, YY, H2, KACCEL, 0.0D0, 7 )
      XX = YX+7.*H2
      CALL PNUMB ( XX, YY, H2, ACCELX, 0.0D0, 2 )
      XX = XX+7.*H2
      CALL PSYM ( XX, YY, H2, KKACCG, 0.0D0, 3 )
C...  HEADER PLOT
C...

```

Appendix F (Continued)

Appendix F (Continued)

```

XX      = 10.0
YY      = 0.25*Y0
CALL PSTM ( XX, YY, HH, NTITLE, 0.0D0, 70 )
C...
CALL PLTEOR
RETURN
END

SUBROUTINE GOSCAL ( ND, X, Y, XMN, YMN, XMX, YMx, SCALEG )
C*** PURPOSE/ GET SCALING FACTOR OF THE GEOMETRY PLOT
C*** /OUTPUT/
C     XMN      = X MINIMUM
C     YMN      = Y MINIMUM
C     XMX      = X MAXIMUM
C     YMx      = Y MAXIMUM
C     SCALEG   = SCALING FACTOR
C*** /INPUT/
C     ND       = NO. OF NODES
C     X        = X COORDINATES
C     Y        = Y COORDINATES
C...
C*** PROGRAMMED BY JAERI          1989.03.10
C
C IMPLICIT REAL*8 (A-H,O-Z)
C DIMENSION X(1), Y(1)
C DATA PAPER/ 180.0 /
C...
C FUNCTION AMIN1 (Z1,Z2) = DMIN1 (Z1,Z2)
C           AMAX1 (Z1,Z2) = DMAX1 (Z1,Z2)
C...
C...  GEOMETRY RANGE
C     XMN      = 1.0D20
C     YMN      = -1.0D20
C     XMX      = -1.0D20
C     YMx      = 1.0D20
C
C DO 100 I= 1, ND
C     XI      = X(I)
C     XMN    = AMIN1 (XMN,XI)
C     XMX    = AMAX1 (XMX,XI)
C     YI      = Y(I)
C     YMN    = AMIN1 (YMN,YI)
C     YMx    = AMAX1 (YMX,YI)
C 100 CONTINUE
C
C     XS      = XMX-XMN
C     YS      = YMx-YMN
C     AS      = AMAX1 (XS,YS)

SUBROUTINE GSCAL2 ( NOF, MLENG, XD, YD,
                    XMN, YMN, XMX, YMx, SCALEG )
C*** PURPOSE/ GET SCALING FACTOR OF THE GEOMETRY PLOT
C*** /OUTPUT/
C     XMN      = X MINIMUM
C     YMN      = Y MINIMUM
C     XMX      = X MAXIMUM
C     YMx      = Y MAXIMUM
C     SCALEG   = SCALING FACTOR
C*** /INPUT/
C     NOF     = NO. OF LINES
C     MLENG   = NO. OF VARIABLES AT EACH LINE
C     XD      = X COORDINATES
C     YD      = Y COORDINATES
C...
C*** PROGRAMMED BY JAERI          1989.05.30
C
C IMPLICIT REAL*8 (A-H,O-Z)
C DIMENSION MLENG(1)
C DIMENSION XD(11,1), YD(11,1)
C DATA PAPER/ 180.0 /
C...
C FUNCTION AMIN1 (Z1,Z2) = DMIN1 (Z1,Z2)
C           AMAX1 (Z1,Z2) = DMAX1 (Z1,Z2)
C...
C...  GEOMETRY RANGE
C     XMN      = 1.0D20
C     YMN      = -1.0D20
C     XMX      = -1.0D20
C     YMx      = 1.0D20
C
C DO 200 J= 1, NOF
C     ND      = MLENG(J)
C
C DO 100 I= 1, ND
C     XI      = XD(I,J)
C     XMN    = AMIN1 (XMN,XI)
C     XMX    = AMAX1 (XMX,XI)
C     YI      = YD(I,J)
C     YMN    = AMIN1 (YMN,YI)
C     YMx    = AMAX1 (YMX,YI)
C
C 100 CONTINUE
C
C     100 CONTINUE
C     200 CONTINUE

```

Appendix F (Continued)

Appendix F (Continued)

```

C      XS    = XMX-XMN
C      YS    = YMX-YMN
C      AS    = AMX1 (XS,YS)
C      SCALEG = PAPER/AS
C      RETURN
C      END

SUBROUTINE XYSCAL ( VMIN, VMAX, NPART, DSIZE, NEXP )
C
C****/XYPLOT SCALING
C
C****/OUTPUT/
C      DSIZE   = ADDITIONAL VALUE
C      NEXP    = EXPONENT NUMBER
C
C****/INPUT/
C      VMIN    = MINIMUM VALUE
C      VMAX    = MAXIMUM VALUE
C      NPART   = NO. OF DIVISION
C
C****/ PROGRAMMED BY JAERI          1989-03-10
C
C      IMPLICIT REAL*8 (A-H,O-Z)
C      DIMENSION DVAL(8)
C      DATA EPS/ 1.0E-20 /
C      DATA DVAL/ 0.5, 1.0, 1.5, 2.0, 2.5, 5.0, 10.0, 15.0 /
C
C... FUNCTION
C      ABS(Z) ≈ DABS(Z)
C      ALOG10(Z) ≈ DL0G10(Z)
C
C      DPART = NPART
C      XMIN = 0.0
C      DS = (VMAX-XMIN)/DPART
C      IF ( DS.LT.EPS ) GO TO 900
C      NEXP = ALOG10 (DS)
C      IF ( NEXP.LT.0 ) NEXP = NEXP-1
C      GVAL = 10.0*NEXP
C
C      HWIDE = DS/GVAL
C      DO 100 J= 1, 7
C      IF ( HWIDE.LE.DVAL(J) ) GO TO 200
C
C      100 CONTINUE
C      J = 7
C      200 DSIZE = DVAL(J)
C
C      RETURN
C
C      900 CONTINUE

```

Appendix F (Continued)

```

      SUBROUTINE PLUMBR ( X,Y,H,N,ANG )
      IMPLICIT REAL*8 (A-H,O-Z)
      AN = N
      CALL NUMBER (X,Y,H,AN,ANG,-1)
      RETURN

      SUBROUTINE PLMARK ( X0,Y0,R )
      IMPLICIT REAL*8 (A-H,O-Z)
      DIMENSION CR(2,9), X(9), Y(9)
      DATA CR /0.93888, 0.38268,
     +          -0.38268, 0.92388,
     +          -0.92388, -0.38268,
     +          0.38268, -0.92388,
     +          0.92388, 0.38268/
      C      DO 10 J=1,9
      C      X(J) = R*CR(1,J) + X0
      C      Y(J) = R*CR(2,J) + Y0
      C      10 CALL PLINES ( X, Y, 9 )
      C      RETURN

```

Appendix G ORNL Fin Data Library

Appendix G (Continued)

Appendix G (Continued)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
FINH	4.7400	5.0000	152.00	10	0.1000	0.1500	0.2000	0.2500	0.3000	0.3500	0.4000	0.4500	0.5000	0.5500	0.6000	0.6500	0.7000	0.7500		
ANGLE	0.0	0.0500	0.4500	0.0	1.0000	1.1500	1.3000	1.4500	1.6000	1.7500	1.9000	2.0500	2.2000	2.3500	2.5000	2.6500	2.8000	1.5700		
FINH	3.6100	3.7600	203.00	10	1.7100	2.2400	2.6700	3.0000	3.2900	3.4500	0.0	0.0500	0.1000	0.1500	0.2000	0.2500	0.3000	0.3500		
ANGLE	0.0	0.0500	0.4500	0.0	0.1000	0.1500	0.2000	0.2500	0.3000	0.3500	0.4000	0.4500	0.5000	0.5500	0.6000	0.6500	0.7000	1.2400		
FINH	3.2900	3.4100	224.000	10	1.7100	2.2400	2.5700	2.7900	3.0000	3.1400	3.1800	3.2200	3.2600	3.3000	3.3400	3.3800	3.4200	1.2400		
ANGLE	0.0	0.0500	0.4500	0.0	0.1000	0.1500	0.2000	0.2500	0.3000	0.3500	0.4000	0.4500	0.5000	0.5500	0.6000	0.6500	0.7000	1.2400		
FINH	2.9600	3.0000	1.2900	1.8600	2.1900	2.4800	2.6700	2.7600	2.8600	2.9500	3.0400	3.1300	3.2200	3.3100	3.4000	3.4900	3.5800	1.2400		
ANGLE	30.0000	4	102.00	10	0.0500	0.1000	0.1500	0.2000	0.2500	0.3000	0.3500	0.4000	0.4500	0.5000	0.5500	0.6000	0.6500	0.7000	1.2400	
FINH	0.0	0.4000	0.4500	0.0	0.5000	1.0000	1.5000	2.0000	2.4300	2.8300	3.1200	3.4100	3.7000	4.0000	4.3000	4.6000	4.9000	5.2000	1.2400	
ANGLE	3.3800	3.5700	152.00	10	0.0500	0.1000	0.1500	0.2000	0.2500	0.3000	0.3500	0.4000	0.4500	0.5000	0.5500	0.6000	0.6500	0.7000	1.2400	
FINH	0.0	0.4000	0.4500	0.0	0.5000	0.8800	1.2400	1.5700	1.8800	2.1400	2.3800	0.0	0.4000	0.5000	0.6000	0.7000	0.8000	1.2400		
ANGLE	2.6000	2.7900	203.00	10	0.0500	0.1000	0.1500	0.2000	0.2500	0.3000	0.3500	0.4000	0.4500	0.5000	0.5500	0.6000	0.6500	0.7000	1.2400	
FINH	0.0	0.4000	0.4500	0.0	0.5000	0.8300	1.1000	1.3600	1.6000	1.8200	2.0300	0.0	0.4000	0.5000	0.6000	0.7000	0.8000	1.2400		
ANGLE	2.2400	2.4300	254.000	10	0.0500	0.1000	0.1500	0.2000	0.2500	0.3000	0.3500	0.4000	0.4500	0.5000	0.5500	0.6000	0.6500	0.7000	1.2400	
FINH	0.0	0.4000	0.4500	0.0	0.5000	0.6000	0.6600	0.7900	0.8800	1.1200	1.2400	1.3600	1.4800	1.6000	1.7200	1.8400	1.9600	1.2400		
ANGLE	1.5000	1.6200	40.0000	4	102.00	10	0.0500	0.1000	0.1500	0.2000	0.2500	0.3000	0.3500	0.4000	0.4500	0.5000	0.5500	0.6000		
FINH	0.0	0.4000	0.4500	0.0	0.5000	0.6900	1.1400	1.5000	1.8300	2.1400	2.4800	0.0	0.4000	0.5000	0.6000	0.7000	0.8000	1.2400		
ANGLE	2.7400	2.9400	152.00	10	0.0500	0.1000	0.1500	0.2000	0.2500	0.3000	0.3500	0.4000	0.4500	0.5000	0.5500	0.6000	0.6500	0.7000	1.2400	
FINH	0.0	0.4000	0.4500	0.0	0.5000	0.6000	0.6600	0.7900	1.0500	1.2600	1.4500	1.6400	1.8300	2.0200	2.2100	2.4000	2.5900	1.2400		
ANGLE	1.7900	1.8800	203.00	10	0.0500	0.1000	0.1500	0.2000	0.2500	0.3000	0.3500	0.4000	0.4500	0.5000	0.5500	0.6000	0.6500	0.7000	1.2400	
FINH	0.0	0.4000	0.4500	0.0	0.5000	0.6000	0.6600	0.7900	1.0500	1.2600	1.4500	1.6400	1.8300	2.0200	2.2100	2.4000	2.5900	1.2400		
ANGLE	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8

Appendix G (Continued)

Appendix G (Continued)

1	2	3	4	5	6	7	8
-5	-0	-5	-0	-5	-0	-5	-0
0.4000	0.4500	0.4500	0.4500	0.4500	0.4500	0.4500	0.4500
0.0	4.7100	7.8600	9.2900	10.0000	10.7100	11.2900	12.0000
12.4300	13.0000	13.0000	13.0000	13.0000	13.0000	13.0000	13.0000
ANGLE	20.0000	4	10	0.1000	0.1500	0.2000	0.2500
FINH	102.00	0.0500	0.1000	0.1500	0.2000	0.3000	0.3500
0.0	0.4000	0.4500	0.4500	0.4500	0.4500	0.4500	0.4500
0.0	1.4800	2.2900	2.8100	3.3300	3.7600	4.1900	4.4800
4.7400	5.0000	10	0.1000	0.1500	0.2000	0.2500	0.3000
FINH	152.00	0.0500	0.1000	0.1500	0.2000	0.3000	0.3500
0.0	0.4000	0.4500	0.4500	0.4500	0.4500	0.4500	0.4500
0.0	1.0000	1.7100	2.2400	2.6700	3.0000	3.2900	3.4500
3.6100	3.7600	10	0.1000	0.1500	0.2000	0.2500	0.3000
FINH	203.00	0.0500	0.1000	0.1500	0.2000	0.3000	0.3500
0.0	0.4000	0.4500	0.4500	0.4500	0.4500	0.4500	0.4500
0.0	1.0000	1.7100	2.2400	2.6700	3.0000	3.2900	3.4500
3.2900	3.4100	10	0.1000	0.1500	0.2000	0.2500	0.3000
FINH	254.00	0.0500	0.1000	0.1500	0.2000	0.3000	0.3500
0.0	0.4000	0.4500	0.4500	0.4500	0.4500	0.4500	0.4500
0.0	1.2900	1.8600	2.1900	2.4800	2.6700	2.7600	2.8600
2.9600	3.0000	30.0000	4	10	0.1000	0.1500	0.2000
ANGLE	FINH	102.00	0.0500	0.1000	0.1500	0.2000	0.2500
0.0	0.4000	0.4500	0.4500	0.4500	0.4500	0.4500	0.4500
0.0	0.5000	0.5000	1.0000	1.5000	2.0000	2.4300	2.8300
3.3800	3.5700	10	0.1000	0.1500	0.2000	0.2500	0.3000
FINH	152.00	0.0500	0.1000	0.1500	0.2000	0.3000	0.3500
0.0	0.4000	0.4500	0.4500	0.4500	0.4500	0.4500	0.4500
0.0	0.5000	0.5000	0.8800	1.2400	1.5700	1.8800	2.1400
2.6000	2.7900	10	0.1000	0.1500	0.2000	0.2500	0.3000
FINH	203.00	0.0500	0.1000	0.1500	0.2000	0.3000	0.3500
0.0	0.4000	0.4500	0.4500	0.4500	0.4500	0.4500	0.4500
0.0	0.3600	0.3600	0.8300	1.1000	1.3600	1.6000	1.8200
2.2400	2.4300	10	0.1000	0.1500	0.2000	0.2500	0.3000
FINH	254.00	0.0500	0.1000	0.1500	0.2000	0.3000	0.3500
0.0	0.4000	0.4500	0.4500	0.4500	0.4500	0.4500	0.4500
0.0	1.6800	1.8600	2.0000	2.1200	2.1200	2.1200	2.1200
1.5000	40.0000	4	10	0.1000	0.1500	0.2000	0.2500
ANGLE	FINH	102.00	0.0500	0.1000	0.1500	0.2000	0.2500
0.0	0.4000	0.4500	0.4500	0.4500	0.4500	0.4500	0.4500
0.0	0.3100	0.3100	0.6900	1.1400	1.5000	1.8300	2.1400
1	2	3	4	5	6	7	8

Appendix H MONSERCO Fin Data Library

Appendix H (Continued)

MATERIAL	2	MONSERCO FIN DATA							
THICKNESS	0.0	1	2	3	4	5	6	7	8
ANGLE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FINH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.60
0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FINH	88.9	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.60
0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.60
0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	4.49	6.18	7.30	7.66	7.95	8.21	9.45	0.00	0.00
11.71	101.6	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.60
0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.60
0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	4.81	6.24	6.76	7.59	7.88	8.50	9.30	0.00	0.00
11.39	152.4	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.60
0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.60
0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	4.69	5.70	6.52	6.80	6.82	7.07	7.77	0.00	0.00
8.50	203.2	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.60
0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.60
0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	4.69	5.72	6.44	7.05	7.37	7.86	8.20	0.00	0.00
8.76	254.0	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.60
0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.60
0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	4.39	5.69	5.96	6.49	6.90	7.20	7.40	0.00	0.00
7.60	ANGLE	10.0	0.0	0.10	0.15	0.20	0.25	0.30	0.40
0.00	0.05	0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	3.56	4.27	4.95	5.37	5.80	6.11	6.62	0.50	0.50
6.58	FINH	101.6	0.10	0.15	0.20	0.25	0.30	0.40	0.50
0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.60
0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	3.93	4.26	5.06	5.66	5.83	6.18	6.33	0.00	0.00
6.70	FINH	152.4	0.10	0.15	0.20	0.25	0.30	0.40	0.50
0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.60
0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	1	2	3	4	5	6	7	8	9

Appendix H (Continued)

Appendix H (Continued)

0.0	88.9	9	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.55	0.60	0.65	0.70	0.75	0.80	
0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	
0.50	0.23	0.55	0.66	1.00	1.16	1.43	1.75	2.76	5.72	6.44	7.05	7.37	7.86	8.20	8.50	
2.03	101.6	9	0.10	0.15	0.20	0.25	0.40	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	
0.00	0.05	0.10	0.15	0.20	0.25	0.40	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85		
0.50	0.26	0.55	0.84	1.12	1.31	1.49	1.80	2.54.0	0.10	0.15	0.20	0.25	0.30	0.40	0.50	
0.0	2.07	152.4	9	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.55	0.60	0.65	0.70	0.75	0.80
0.50	0.36	0.54	0.74	0.66	0.76	0.86	1.05	4.39	5.49	5.96	6.49	6.90	7.20	7.40	7.60	
1.02	203.2	9	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.55	0.60	0.65	0.70	0.75	0.80	
0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	
0.50	0.16	0.38	0.50	0.63	0.74	0.85	1.05	6.58	101.6	9	0.10	0.15	0.20	0.25	0.30	
1.15	254.0	9	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.55	0.60	0.65	0.70	0.75	0.80	
0.00	0.05	0.11	0.26	0.39	0.51	0.62	0.71	0.87	6.70	152.4	9	0.10	0.15	0.20	0.25	
0.50	0.95	END	THICKNESS	25.4	ANGLE	6	0.0	0.05	0.0	0.05	0.0	0.05	0.0	0.05	0.0	
0.0	0.0	0.05	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.55	0.60	0.65	0.70	0.75	0.80	
0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
0.0	0.05	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	
0.50	0.49	6.18	7.30	7.66	7.95	8.21	9.45	3.22	3.91	4.10	4.30	4.49	4.64	4.88	5.07	
11.71	FINH	88.9	9	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.55	0.60	0.65	0.70	0.75	
0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	
0.50	4.81	6.24	6.96	7.59	7.88	8.50	9.30	0.05	0.10	0.15	0.20	0.25	0.30	0.40	0.50	
11.39	FINH	152.4	9	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.55	0.60	0.65	0.70	0.75	
0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.40	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	
0.50	4.69	5.70	6.52	6.80	6.82	7.07	7.77	0.05	0.10	0.15	0.20	0.25	0.30	0.40	0.50	
8.50	FINH	203.2	9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	

Appendix H (Continued)

Appendix H (Continued)

		1	2	3	4	5	6	7	8		1	2	3	4	5	6	7	8
3.26	FINH	101.6	9	0.10	0.15	0.20	0.25	0.30	0.40	0.0	0.11	0.26	0.39	0.51	0.62	0.71	0.87	
0.00	0.05	0.67	0.91	1.44	1.99	2.45	2.70	3.21	0.95	END								
0.50	3.27	152.4	9	0.10	0.15	0.20	0.25	0.30	0.40	FIN								
0.00	0.05	0.41	0.62	0.83	0.99	1.14	1.27	1.32	5	0	5	0	5	0	5	0	8	
0.50	0.0	0.81	0.99	1.32	1.56	1.75	1.90	2.04	5	1	5	2	3	4	5	6	7	
2.15	FINH	203.2	9	0.10	0.15	0.20	0.25	0.30	0.40									
0.00	0.05	0.50	0.41	0.62	0.83	0.99	1.14	1.27	0.40									
0.50	1.36	254.0	9	0.10	0.15	0.20	0.25	0.30	0.40									
0.00	0.05	0.31	0.53	0.72	0.87	1.00	1.09	1.15	0.40									
0.50	1.20	ANGLE	30.0	6	0.10	0.15	0.20	0.25	0.30	0.40								
0.00	0.05	0.50	0.0	0.0	0.10	0.15	0.20	0.25	0.30	0.40								
0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0								
0.00	0.05	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.40									
0.50	0.0	0.25	0.03	0.55	0.66	1.00	1.16	1.43	1.75									
0.00	0.05	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.40									
0.50	0.0	0.26	0.07	0.55	0.84	1.12	1.31	1.49	1.80									
0.00	0.05	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.40									
0.50	0.0	0.36	1.02	0.54	0.74	0.66	0.76	0.86	1.05									
0.00	0.05	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.40									
0.50	0.0	0.50	2.07	203.2	9	0.10	0.15	0.20	0.25	0.30	0.40							
0.00	0.05	0.0	0.16	0.38	0.50	0.63	0.74	0.85	1.05									
0.50	1.15	254.0	9	0.10	0.15	0.20	0.25	0.30	0.40									
0.00	0.05	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.40									
0.50	0.0	0.50	1	2	3	4	5	6	7	8								