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A Computer Program for Seismic Analysis of the Two-dimensional Vertical Slice HTGR Core

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SONATINA-2V
A Computer Program for Seismic Analysis of the Two-dimensional Vertical Slice HTGR Core

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Abstract

A computer program SONATINA-2V has been developed for predicting the behavior of a two-dimensional vertical slice HTGR core under seismic excitation. SONATINA-2V is a general two-dimensional computer program capable of analyzing the vertical slice HTGR core with the permanent side reflector blocks and its restraint structures. In the analytical model, each block is treated as rigid body and is restrained by dowel pins which restrict relative horizontal movement but allow vertical and rocking motions between upper and lower blocks. Coulomb friction is taken into account between blocks and between dowel pin and hole. A spring dashpot model is used for the collision process between adjacent blocks. The core support structure is represented by a single block. The computer program SONATINA-2V is capable of analyzing the core behavior for an excitation input applied simultaneously to both vertical and horizontal directions.

Analytical results obtained from SONATINA-2V are compared with experimental results and are found to be in good agreement. The computer program can thus be used to predict with a good accuracy the behavior of the HTGR core under seismic excitation.

In the present report are given, the theoretical formulation of the analytical model, a user's manual to describe the input and output format, and sample problems.

Keywords: Computer Program, Seismic Excitation, HTGR Core, Multicolumns Vibration, Seismic Response, Nonlinear Vibration, Impact Vibration, Core Structure.

+ Division of Nuclear Safety Evaluation

SONATINA-2V
高温ガス炉垂直2次元炉心の地震解析プログラム

日本原子力研究所東海研究所動力炉開発・安全性研究管理部

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1981年11月27日受理

要 旨

高温ガス炉垂直2次元炉心の地震解析プログラム SONATINA－2V を開発した．SONATINA－2V は側方反射体とその拘束構造物を含めた垂直2次元炉心モデルの解析が可能である．解析モデルでは，炉心黒鉛ブロックは剛体として取り扱い，ブロックを上下方向に拘束するダウェルピンは，水平方向変位は拘束するが，垂直方向変位とロッキングは拘束しないものとする．ブロック間およびダウェルピンとソケット間にはクーロン摩擦を考慮する．ブロック相互の衝突はスプリング－ダッシュポットによってモデル化する．炉心支持ブロックは単一のブロックとして取り扱う．SONATINA－2V は水平と垂直方向の同時地震入力に対して解析可能である．

SONATINA－2V の解析結果は実験結果と良く一致しており，本計算プログラムによって，高温ガス炉炉心の地震挙動を解析することができる．

本報告は解析モデルの数式化，入力と出力データを示したユーザマニュアルおよび計算例について記述したものである．

+ 安全解析部

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1. Introduction

In the HTGR designed by General Atomic and a very high-temperature gas-cooled reactor (VHTR) taking designed by Japan Atomic Energy Research Institute, the reactor core consists of hexagonal graphite blocks. These graphite blocks are stacked in several hundred columns. The reactor core is enclosed in a core barrel and the column is restrained horizontally at the top with a keyed orifice block of a heat-resisting alloy. The column bottoms are restrained with dowel pins placed on the core support blocks. On the periphery, fixed reflectors are restrained by the core barrel. Blocks in the core are aligned in the columns by dowel pins. Each column is separated from adjacent columns by small gaps. The gap is initially several milimeters. After residence in the core, however, the block diameter is reduced in size due to fast neutron irradiation, so that the gap increases to 4 milimeters or more.

This large gap together with the large number of columns may result in a large cumulative gap during a seismic excitation. The cumulative gap across the core diameter is significant since it may affect the capability of insertion of the control and shutdown material into the core. Moreover, because of these gaps, columns may repeatedly impact each other during a seismic excitation. The aseismic design requires the following information from analysis and/or experiments:

(1) deflections and disarrays which could cause disengagement of dowels and affect control rod insertion,

(2) collision forces of blocks, and

(3) shear forces on the dowels.

Exact modeling of the complete three-dimensional core array is not possible because of computational cost. It is realized, therefore that reasonable tools are needed; i.e. analytical methods and computer programs, which are conducted in parallel with experiments. The methods and computer programs should be verified and revised, if necessary, by using the experimental data, in order to make them usable for design purposes.

Since such a system of blocks as in the HTGR core does not constitute a structure in the usual sense, existing structural theory and experimental data cannot be applied directly. Several special computer programs have thus been developed for analysis of this system.

Muto et al.[1] proposed a two-dimensional analytical method of a vertical slice core model using a complex number representation to simplify the calculation model and to save the computer time. In the method, collision theory and momentum conservation rule are applied. However, forces of dowel which connect blocks vertically, can not be obtained from the method. Thompson[2] has developed an analytical method for interacting multi-column dynamic behavior using visco-elastic model. In the model, dowel frictional effect and dowel length are not considered.

The author has developed the computer program SONATINA-2V for analyzing the dynamic behavior of the two-dimensional vertical slice HTGR core under seismic excitation. Main features of SONATINA-2V are as follows:

(1) Blocks are rigid, and the upper and lower blocks are connected with three dowels.

(2) Blocks are allowed to rotate around the center gravity but restrict horizontal movement beyond the dowel gap.

(3) Collision forces are represented by a spring and dashpot model.

(4) Friction forces are calculated at the horizontal interfaces between blocks.

(5) Collision force between dowel pin and hole is calculated by a spring and dashpot model.

(6) Displacement, velocity, acceleration, forces and moments around block center gravity of each block are printed out.

(7) Maximum values of the above-mentioned quantities over the core, are also printed out.

(8) Two integration methods are available in the computer program, the Runge-Kutta-Gill and the Newton methods.

(9) Two-dimensional seismic excitation is available for one horizontal and one vertical directions simultaneously.

(10) Three types of one horizontal and one vertical excitations can be simulated; these are sinusoidal sweep, sinusoidal dwell and time history excitation.

(11) The time intervals for printing and graphic representation of the results can be changed, so that the computer time is saved depending on the calculation purpose.

(12) The calculation results can be represented with COM (Computer Output Microfilming) and/or a CALCOMP plotting machine.

The remainder of this report is arranged as follows. In Chapter 2, we present the mathematical model dealing with the dynamic behavior of the HTGR core including two-dimensional effects. Chapter 3 describes the formulism of the analytical mode. In Chapter 4 is given a user's manual to describe the input and output format. In addition, the applicabilities are demonstrated through comparison between experimental and analytical values.

2. Mathematical Model

2.1 Structure of HTGR core

The block-type fuel HTGR core consists of several thousand hexagonal graphite elements stacked in column and separated by small gaps. The blocks are aligned in columns by means of dowel pins which restrict relative horizontal movement but allow vertical and rocking motion between blocks. The core columns are surrounded by both replaceable reflector columns with the some hexagonal cross section and permanent side reflector columns which are larger and of varying shapes. The permanent side reflector block is connected by the core restraint structure attached to the core barrel in the pressure vessel. The core structure of an experimental HTGR is illustrated in **Fig. 1**.

2.2 Analytical Model

A vertical slice across the core is selected, and fuel columns and two permanent side reflector columns are modeled as shown in **Fig. 2**. **Figure 3** and **4** together form the complete SONATINA-2V mathematical model. The analytical method adopted for SONATINA-2V takes into account the complex nonlinear vibration associated with the multiple collisions and, in addition, the frictional forces between the block interfaces and between the dowel pins and their mating holes. In the actual core, the blocks and columns extend three-dimensionally. In SONATINA-2V, the following two-dimensional model is considered:

(1) block is treated as a rigid body,

(2) each block has three degrees-of-freedom, two translational displacements and one rotation around the block center of gravity,

(3) collision forces are represented by a spring and dashpot model located at the impact point of each block (see Appendix A),

(4) the dowels are represented as deformable members and the slipping of the interface surface between dowel holes and pins is allowed,

(5) friction forces are calculated at the horizontal interfaces between blocks, and

(6) permanent side reflector block is restraint with core restraint structure.

2.3 Representation of Collision Forces

The computer program SONATINA-2V provides the spring-dashpot collision model as shown in **Fig. 5**. At the instant of impact, when the interblock gap goes to zero or becomes negative, the interblock and damper engage thus producing a force. The spring and damping forces are calculated as followings. The initial gap between two adjacent blocks, the i-th and j-th blocks, is defined by parameter δ_{ij}. The spring and damping forces as a function of relative displacement x_i-x_j, and relative velocity $\dot{x}_i$-$\dot{x}_j$, of two impacting bodies are:

Spring force F^s;

$$F^s = K_{ij}(x_i - x_j - \delta_{ij}), \text{ if } x_j < |x_i - \delta_{ij}|,$$
$$= 0, \qquad \text{if } x_j \geq |x_i - \delta_{ij}|.$$

Damping force F^D;

$$F^D = C_{ij}(\dot{x}_i - \dot{x}_j), \text{ if } x_j < |x_i - \delta_{ij}|,$$
$$= 0, \qquad \text{if } x_j \geq |x_i - \delta_{ij}|.$$

The impact force is then

$$F = F^s + F^D.$$

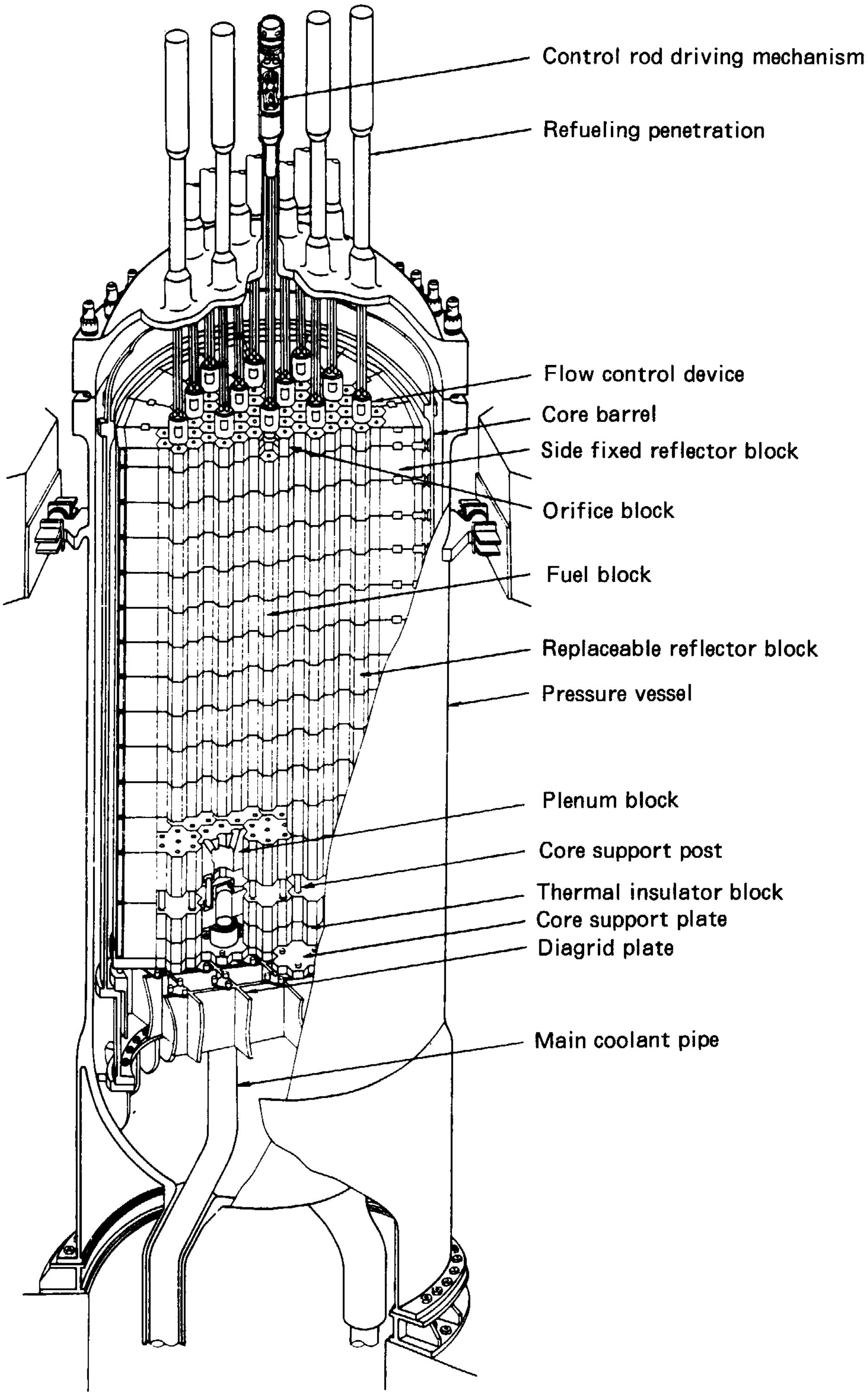


Fig. 1 Vertical view of an experimental HTGR.

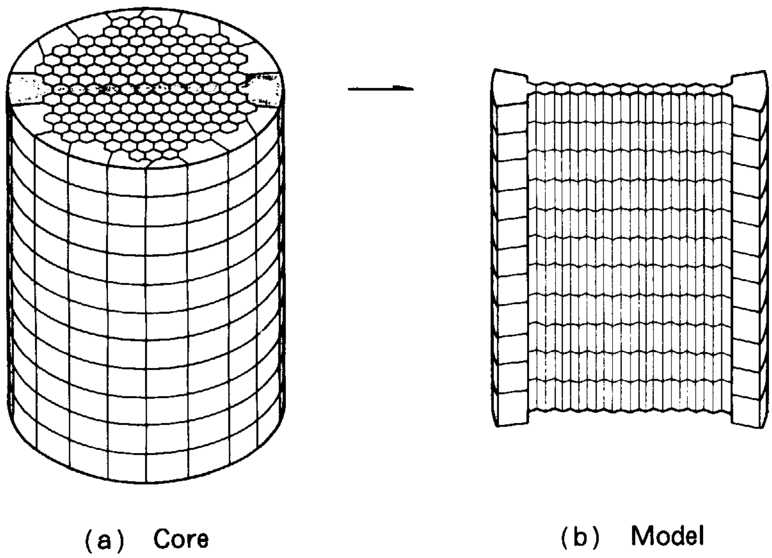


Fig. 2 HTGR core and calculation model.

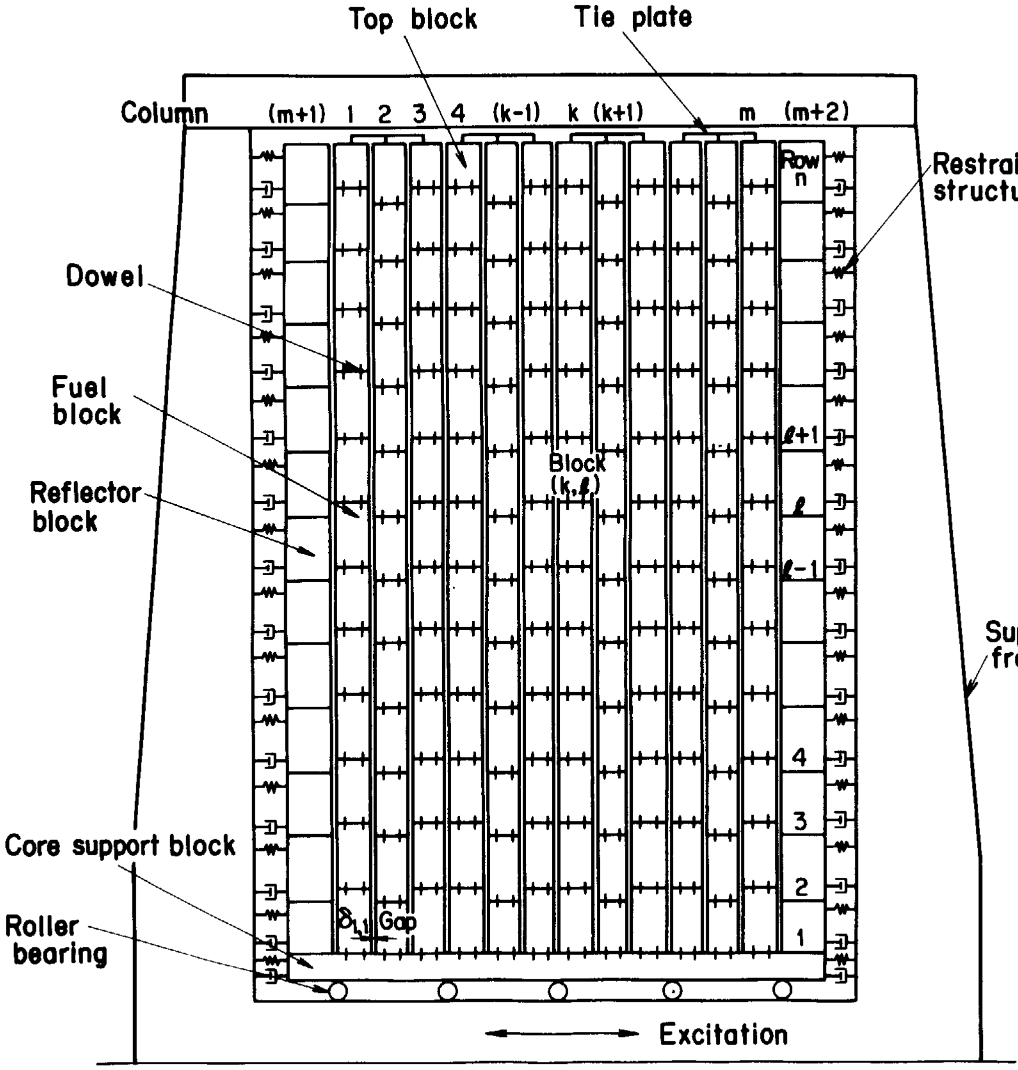
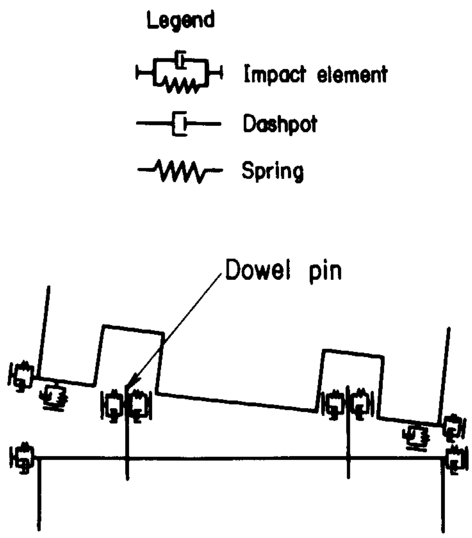
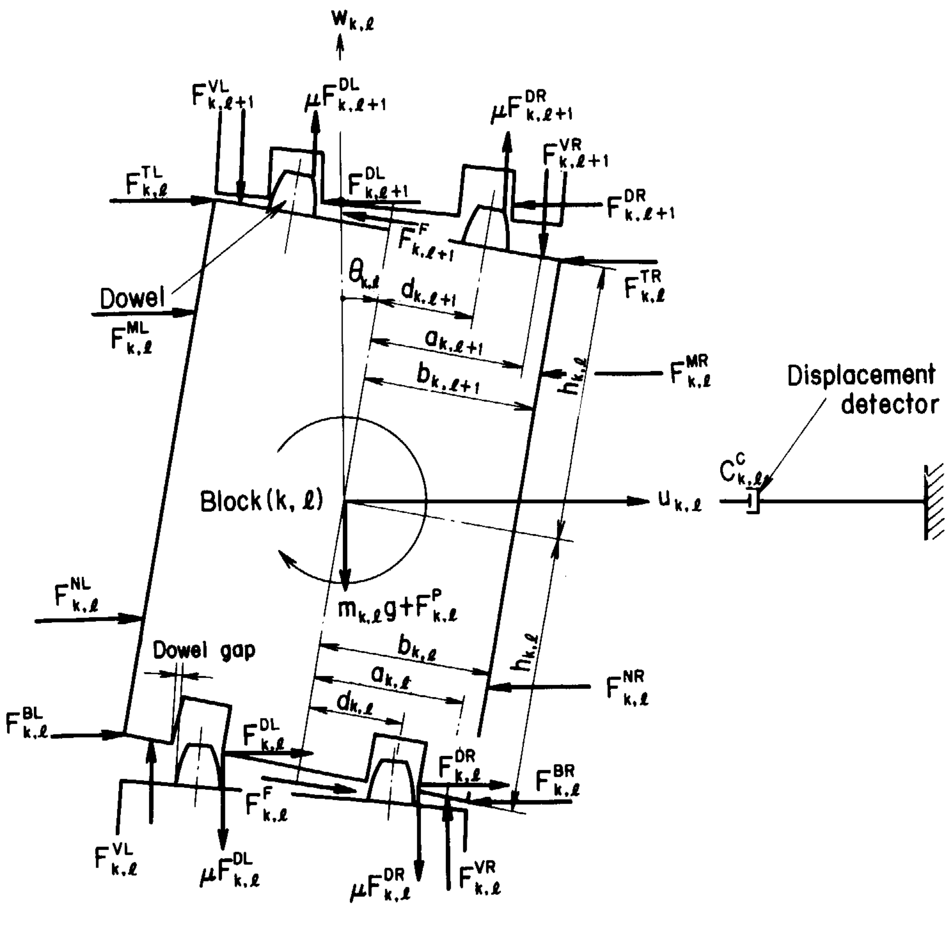


Fig. 3 Calculation model of two-dimensional vertical slice core.

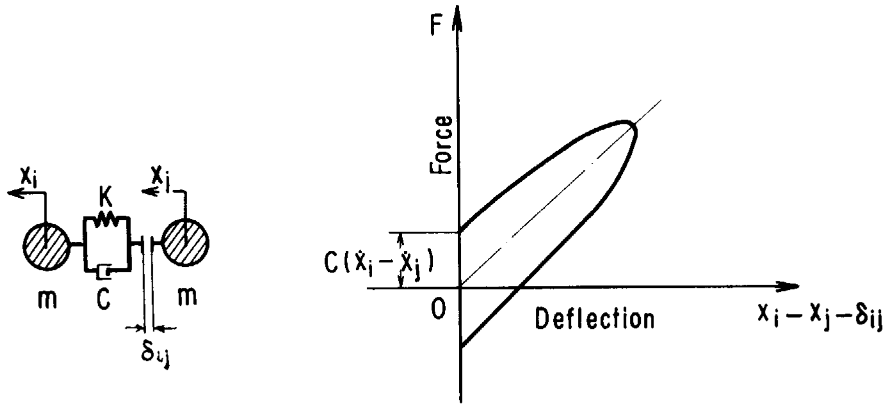


(a) Impact model



(b) Forces acting on a fuel block

Fig. 4 Impact model and forces acting on a fuel block.



(a) Mass impacting model (b) Hysteresis loop for impact

Fig. 5 Viscoelastic model with two impacting bodies.

3. Calculation Equations

3.1 Equations of Motion

The forces involved in the analysis of multi-columns of the HTGR core constrained within boundary are illustrated in **Fig. 3**.

Let the coordinate system be chosen as shown in **Fig. 4**. Each block has two translational coordinates, u and w, and one rotational coordinate θ. **Figure 4** shows the forces that act upon an individual block. The equations of motion for the row l-th block in the k-th column may be written as:

$$m_{k,l}\ddot{u}_{k,l}=F^{TL}_{k,l}+F^{ML}_{k,l}+F^{NL}_{k,l}+F^{BL}_{k,l}+F^{TR}_{k,l}+F^{MR}_{k,l}+F^{NR}_{k,l}+F^{BR}_{k,l}+F^{F}_{k,l}+F^{F}_{k,l+1}+F^{DL}_{k,l}$$
$$+F^{DR}_{k,l}+F^{DL}_{k,l+1}+F^{DR}_{k,l+1}+F^{OP}_{k,l}+C^{C}_{k,l}\dot{u}_{k,l}\ , \tag{1}$$

$$m_{k,l}\ddot{w}_{k,l}=F^{VL}_{k,l}+F^{VR}_{k,l}+F^{VL}_{k,l+1}+F^{VR}_{k,l+1}+\mu F^{DL}_{k,l}+\mu F^{DR}_{k,l}+\mu F^{DL}_{k,l+1}+\mu F^{DR}_{k,l+1}+W^{U}_{k,l}$$
$$+W^{L}_{k,l}\ , \tag{2}$$

$$I_{k,l}\ddot{\theta}_{k,l}=M(F^{TL}_{k,l})+M(F^{ML}_{k,l})+M(F^{NL}_{k,l})+M(F^{BL}_{k,l})+M(F^{TR}_{k,l})+M(F^{MR}_{k,l})+M(F^{NR}_{k,l})$$
$$+M(F^{BR}_{k,l})+M(F^{F}_{k,l})+M(F^{F}_{k,l+1})+M(F^{DL}_{k,l})+M(F^{DR}_{k,l})+M(F^{DL}_{k,l+1})$$
$$+M(F^{DR}_{k,l+1})+M(F^{VL}_{k,l})+M(F^{VR}_{k,l})+M(F^{VL}_{k,l+1})+M(F^{VR}_{k,l+1})+M(\mu F^{DL}_{k,l})$$
$$+M(\mu F^{DR}_{k,l})+M(\mu F^{DL}_{k,l+1})+M(\mu F^{DR}_{k,l+1})+M(W^{U}_{k,l})+M(W^{L}_{k,l})\ , \tag{3}$$

where $M(F)$'s are moments caused by force F. The W^U and W^L are forces due to block weights and pressure differentials acting at the upper and lower part of the block.

3.2 Friction Force between Blocks and its Associated Moment

The friction force due to surface sliding is represented by a nonlinear Coulomb element. The equations for the friction force $F^F_{k,l}$ and its associated monent $M(F^F_{k,l})$ acting on the block (k,l) are as follows. Defining $\alpha_{k,l}$ as $(\theta_{k,l}-\theta_{k,l-1})$, then, when $\alpha_{k,l}>0$

$$\left.\begin{aligned} F^F_{k,l}&=-\mathrm{sign}(v_{k,l})\,f(v_{k,l}),\\ M(F^F_{k,l})&=F^F_{k,l}(-h_{k,l}\cos\theta_{k,l}-b_{k,l}\sin\theta_{k,l}), \end{aligned}\right\} \tag{4}$$

and for block $(k,l-1)$

$$\left.\begin{aligned} F^F_{k,l-1}&=\mathrm{sign}(v_{k,l})f(v_{k,l}),\\ M(F^F_{k,l-1})&=F^F_{k,l-1}(h_{k,l-1}\cos\theta_{k,l-1}-b_{k,l-1}\sin\theta_{k,l-1}), \end{aligned}\right\} \tag{5}$$

where

$$v_{k,l}=\{\dot{u}_{k,l}-(h_{k,l}\cos\theta_{k,l}+b_{k,l}\sin\theta_{k,l})\dot{\theta}_{k,l}\}$$
$$-\{\dot{u}_{k,l-1}+(h_{k,l-1}\cos\theta_{k,l-1}-b_{k,l-1}\sin\theta_{k,l-1})\dot{\theta}_{k,l-1}\}. \tag{6}$$

For $l=1$,

$$v_{k,1}=\dot{u}_{k,1}-(h_{k,1}\cos\theta_{k,1}+b_{k,1}\sin\theta_{k,1})\dot{\theta}_{k,1}-\dot{u}_0\ , \tag{7}$$

where $u_{k,l}$ and $\dot{u}_{k,l}$ are the horizontal displacement and velocity of the center of gravity of the block, respectively. The u_0 is the horizontal velocity of the support floor.

If $\mathrm{sign}(\alpha_{k,l})\leqq 0$, then

$$\left.\begin{aligned} F^F_{k,l}&=-\mathrm{sign}(v_{k,l})f(v_{k,l}),\\ M(F^F_{k,l})&=F^F_{k,l}(-h_{k,l}\cos\theta_{k,l}+b_{k,l}\sin\theta_{k,l}), \end{aligned}\right\} \tag{8}$$

and for the block $(k,l-1)$

$$F^F_{k,l-1}=\mathrm{sign}(v_{k,l})f(v_{k,l}),$$
$$M(F^F_{k,l-1})=F^F_{k,l-1}(h_{k,l-1}\cos\theta_{k,l-1}+b_{k,l-1}\sin\theta_{k,l-1}), \qquad (9)$$

where

$$v_{k,l}=\{\dot{u}_{k,l}-(h_{k,l}\cos\theta_{k,l}+b_{k,l}\sin\theta_{k,l})\dot{\theta}_{k,l}\}$$
$$-\{\dot{u}_{k,l-1}+(h_{k,l-1}\cos\theta_{k,l-1}+b_{k,l-1}\sin\theta_{k,l-1})\dot{\theta}_{k,l-1}\}. \qquad (10)$$

For $l=1$,

$$v_{k,1}=\dot{u}_{k,1}-(h_{k,1}\cos\theta_{k,1}-b_{k,1}\sin\theta_{k,1})\dot{\theta}_{k,1}-\dot{u}_0, \qquad (11)$$

where $\dot{u}_0$ is the horizontal velocity of the support floor. The $f(v_{k,l})$ is a prescribed function for the friction characteristics which is related to the vertical contact force and the coefficient of both dynamic and static friction:

$$f(v_{k,l})=F^Q_{k,l}\{\mu_s+f_1(v_{k,l})+f_2(v^2_{k,l})+f_3(v^3_{k,l})\}, \qquad (12)$$

and, the functions $f_i(v_{k,l},\ v^2_{k,l},\ v^3_{k,l})$ are related to coefficient of friction μ_k. The vertical contact forces are obtained by summing block weights $m_{k,l}g$ and the differential pressure of a unit block length, $F^P_{k,l}$:

$$F^Q_{k,l}=\sum_{j=l}^{n} m_{k,l,j}\,g+F^P_{k,l}. \qquad (13)$$

3.3 Vertical Impact Force and its Associated Moment

The forces acting on the interface between the block (k,l) and the block $(k,l-1)$ as a result of impact are derived in term of deformation of each spring-dashpot unit. When the gap is closing, the spring deformation $\gamma_{k,l}$ and its time rate $\dot{\gamma}_{k,l}$ is

$$\gamma_{k,l}=\frac{1}{2}\{w_{k,l-1}-h_{k,l-1}(1-\cos\theta_{k,l-1})-a_{k,l}\sin\theta_{k,l-1}\}$$
$$-\frac{1}{2}\{w_{k,l}+h_{k,l}(1-\cos\theta_{k,l})-a_{k,l}\sin\theta_{k,l}\}, \qquad (14)$$

$$\dot{\gamma}_{k,l}=\frac{1}{2}\{\dot{w}_{k,l-1}-(h_{k,l-1}\sin\theta_{k,l-1}+a_{k,l}\cos\theta_{k,l-1})\dot{\theta}_{k,l-1}$$
$$-\frac{1}{2}\{\dot{w}_{k,l}+(h_{k,l}\sin\theta_{k,l}-a_{k,l}\cos\theta_{k,l})\dot{\theta}_{k,l}\}. \qquad (15)$$

For $l=1$,

$$\gamma_{k,1}=\frac{1}{2}[w_0-\{w_{k,1}+h_{k,1}(1-\cos\theta_{k,1})-a_{k,1}\sin\theta_{k,1}\}], \qquad (16)$$

$$\dot{\gamma}_{k,1}=\frac{1}{2}[\dot{w}_0-\{\dot{w}_{k,1}+(h_{k,1}\sin\theta_{k,1}-a_{k,1}\cos\theta_{k,1})\dot{\theta}_{k,1}\}], \qquad (17)$$

where w_0 and $\dot{w}_0$ are the vertical displacement and velocity of the support floor, respectively. The vertical impact forces $F^{VR}_{k,l}$ (or $F^{VL}_{k,l}$) and its associated moments $M(F^{VR}_{k,l})$ (or $M(F^{VL}_{k,l})$) acting on the block (k,l) are as follows.

If $\gamma_{k,l}>0$,

$$F^{VR}_{k,l}=-K^V_{k,l}\gamma_{k,l}-C^V_{k,l}\dot{\gamma}_{k,l},$$
$$M(F^{VR}_{k,l})=-F^{VR}_{k,l}(h_{k,l}\sin\theta_{k,l}-a_{k,l}\cos\theta_{k,l}). \qquad (18)$$

For the block $(k,l-1)$

$$F^{VR}_{k,l-1}=K^V_{k,l}\gamma_{k,l}+C^V_{k,l}\dot{\gamma}_{k,l},$$
$$M(F^{VR}_{k,l-1})=F^{VR}_{k,l-1}(h_{k,l-1}\sin\theta_{k,l-1}+a_{k,l}\cos\theta_{k,l-1}). \qquad (19)$$

When $\gamma_{k,l}\leqq 0$,

$$\left.\begin{aligned} &F^{VR}_{k,l}=F^{VR}_{k,l-1}=0\,, \\ &M(F^{VR}_{k,l})=M(F^{VR}_{k,l-1})=0\,, \end{aligned}\right\} \quad (20)$$

where $K^V_{k,l}$ and $C^V_{k,l}$ are the vertical spring and damping coefficients, respectively, for a single unit. In the more general formulation, these quantities may be represented by a polynominal function:

$$\left.\begin{aligned} &K^V_{k,l}=\sum_{j=0}^{m} K^V_{k,l,j}\,\gamma^j_{k,l}\,, \\ &C^V_{k,l}=\sum_{j=0}^{m} C^V_{k,l,j}\,\dot{\gamma}^j_{k,l}\,. \end{aligned}\right\} \quad (21)$$

3.4 Horizontal Impact Force and its Associated Moment between Columns

The forces acting on the block (k,l) as a result of impact on the adjacent column's blocks shown in **Fig. 6** are derived by deformation of each spring-dashpot unit which are located on

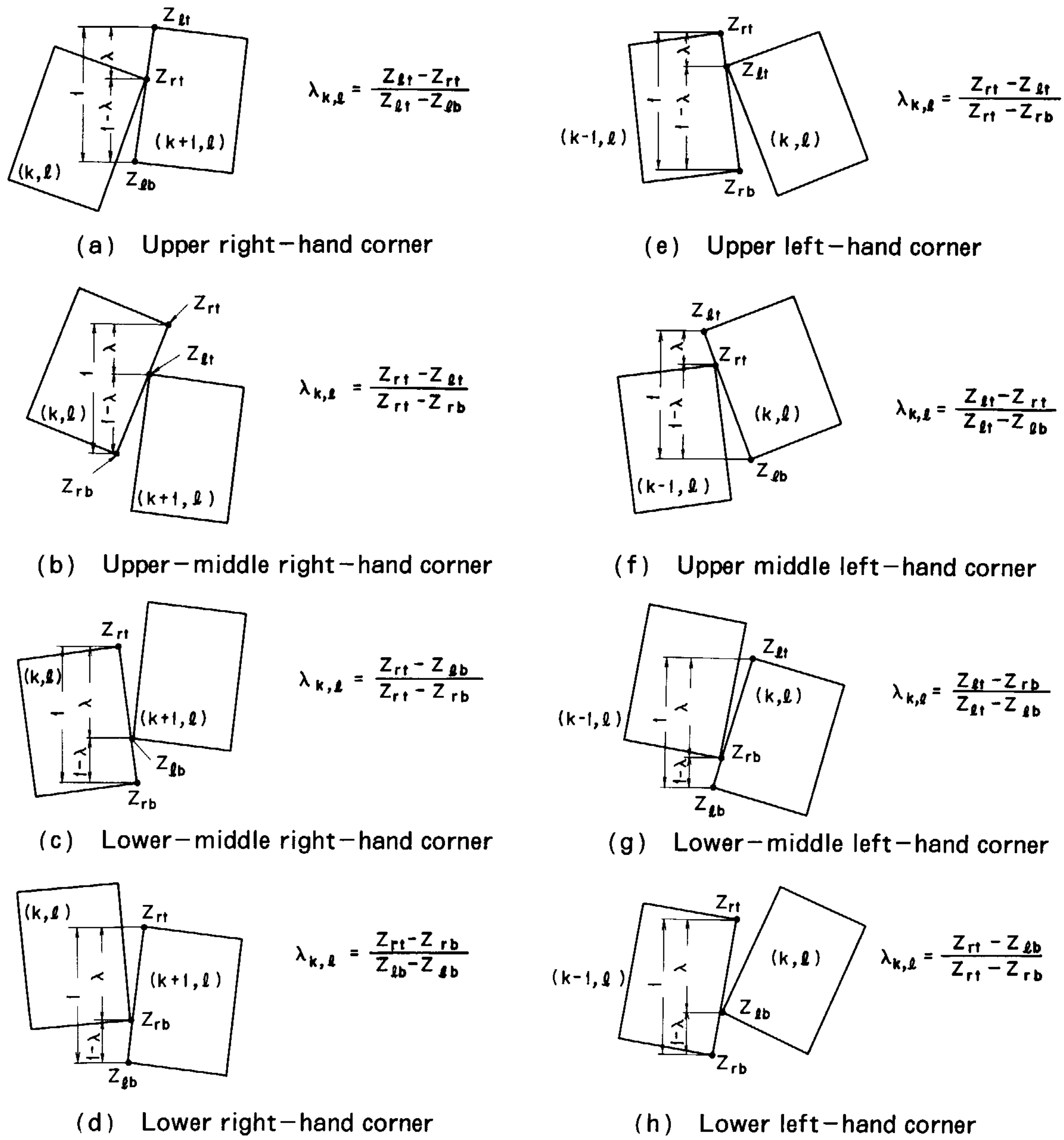


Fig. 6 Block horizontal impact model.

the upper, middle and lower, right-and left-hand corners.

(1) Impact on upper right-hand corner

During impact against adjacent block at the upper right-hand corner, the spring deformation $\varepsilon_{k,l}$ and its time rate $\dot{\varepsilon}_{k,l}$ of the block (k,l) are written as follows.

If $\varepsilon_{k,l}>0$,

$$\varepsilon_{k,l}=u_{k,l}+\{h_{k,l}\sin\theta_{k,l}-b_{k,l}(1-\cos\theta_{k,l})\}-u_{k+1,l} -\{(1-2\lambda_{k,l})h_{k+1,l}\sin\theta_{k+1,l}+b_{k+1,l}(1-\cos\theta_{k+1,l})\}-\delta_{k,l}, \tag{22}$$

$$\dot{\varepsilon}_{k,l}=\dot{u}_{k,l}+(h_{k,l}\cos\theta_{k,l}-b_{k,l}\sin\theta_{k,l})\dot{\theta}_{k,l}-\dot{u}_{k+1,l} -\{(1-2\lambda_{k,l})h_{k+1,l}\cos\theta_{k+1,l}+b_{k+1,l}\sin\theta_{k+1,l}\}\dot{\theta}_{k+1,l}, \tag{23}$$

where $\lambda_{k,l}$ is given by the following form as shown in **Fig. 6**.

$$\lambda_{k,l}=\frac{Z_{lt}-Z_{rt}}{Z_{lt}-Z_{lb}}\ . \tag{24}$$

The $u_{k+1,l}$ is the adjacent block displacement at the center gravity and $\delta^B_{k,l}$ is the gap between the block (k,l) and block $(k+1,l)$. The impact force $F^{TR}_{k,l}$ and its associated moment $M(F^{TR}_{k,l})$ acting on the block (k,l) are as follows.

If $\varepsilon_{k,l}>0$,

$$\left.\begin{aligned} F^{TR}_{k,l}&=-\{K^B_{k,l}\,\varepsilon_{k,l}+C^B_{k,l}\,\dot{\varepsilon}_{k,l}\},\\ M(T^{TR}_{k,l})&=F^{TR}_{k,l}(h_{k,l}\cos\theta_{k,l}-b_{k,l}\sin\theta_{k,l}), \end{aligned}\right\} \tag{25}$$

where $K^B_{k,l}$ and $C^B_{k,l}$ are the boundary spring and damping coefficients, respectively, and may be represented in the following general forms:

$$\left.\begin{aligned} K^B_{k,l}&=\sum_{j=0}^{m} K^B_{k,l,j}\,\varepsilon^j_{k,l}\ ,\\ C^B_{k,l}&=\sum_{j=0}^{m} C^B_{k,l,j}\,\dot{\varepsilon}^j_{k,l}\ . \end{aligned}\right\} \tag{26}$$

(2) Impact on upper-middle right-hand corner

Similarly to Eqs. (22) ~ (24), $\varepsilon_{k,l}$ and $\dot{\varepsilon}_{k,l}$ are written as

$$\varepsilon_{k,l}=u_{k,l}+\{(1-2\lambda_{k,l})h_{k,l}\sin\theta_{k,l}-b_{k,l}(1-\cos\theta_{k,l})\}-u_{k+1,l} +\{h_{k+1,l}\sin\theta_{k+1,l}+b_{k+1,l}(1-\cos\theta_{k+1,l})\}-\delta_{k,l}\ , \tag{27}$$

$$\dot{\varepsilon}_{k,l}=\dot{u}_{k,l}+\{(1-2\lambda_{k,l})h_{k,l}\cos\theta_{k,l}-b_{k,l}\sin\theta_{k,l}\}\dot{\theta}_{k,l} -\dot{u}_{k+1,l}-(h_{k+1,l}\cos\theta_{k+1,l}+b_{k+1,l}\sin\theta_{k+1,l})\dot{\theta}_{k+1,l}\ , \tag{28}$$

$$\lambda_{k,l}=\frac{Z_{rt}-Z_{lt}}{Z_{rt}-Z_{rb}}\ . \tag{29}$$

If $\varepsilon_{k,l}>0$, force and moment are given by

$$\left.\begin{aligned} F^{MR}_{k,l}&=-(K^B_{k,l}\,\varepsilon_{k,l}+C^B_{k,l}\,\dot{\varepsilon}_{k,l}),\\ M(F^{MR}_{k,l})&=F^{MR}_{k,l}\{(1-2\lambda_{k,l})h_{k,l}\cos\theta_{k,l}-b_{k,l}\sin\theta_{k,l}\}. \end{aligned}\right\} \tag{30}$$

(3) Impact on lower-middle right-hand corner

$$\varepsilon_{k,l}=u_{k,l}+\{(1-2\lambda_{k,l})h_{k,l}\sin\theta_{k,l}-b_{k,l}(1-\cos\theta_{k,l})\}-u_{k+1,l} -\{-h_{k+1,l}\sin\theta_{k+1,l}+b_{k+1,l}(1-\cos\theta_{k+1,l})\}-\delta_{k,l}\ , \tag{31}$$

$$\dot{\varepsilon}_{k,l}=\dot{u}_{k,l}+\{(1-2\lambda_{k,l})h_{k,l}\cos\theta_{k,l}-b_{k,l}\sin\theta_{k,l}\}\dot{\theta}_{k,l}-\dot{u}_{k+1,l} -(-h_{k+1,l}\cos\theta_{k+1,l}+b_{k+1,l}\sin\theta_{k+1,l})\dot{\theta}_{k+1,l} \tag{32}$$

$$\lambda_{k,l}=\frac{Z_{rt}-Z_{lb}}{Z_{rt}-Z_{rb}}\ . \tag{33}$$

If $\varepsilon_{k,l}>0$,

$$\left.\begin{aligned} F_{k,l}^{NR} &= -(K_{k,l}^{B}\,\varepsilon_{k,l}+C_{k,l}^{B}\,\dot{\varepsilon}_{k,l}), \\ M(F_{k,l}^{NR}) &= F_{k,l}^{NR}\{(1-2\lambda_{k,l})h_{k,l}\cos\theta_{k,l}+b_{k,l}\sin\theta_{k,l}\}. \end{aligned}\right\} \tag{34}$$

(4) Impact on lower right-hand corner

$$\begin{aligned} \varepsilon_{k,l} = u_{k,l} &+\{-h_{k,l}\sin\theta_{k,l}-b_{k,l}(1-\cos\theta_{k,l})\}-u_{k+1,l} \\ &-\{(1-2\lambda_{k,l})h_{k+1,l}\sin\theta_{k+1,l}+b_{k+1,l}(1-\cos\theta_{k+1,l})\}-\delta_{k,l}, \end{aligned} \tag{35}$$

$$\begin{aligned} \dot{\varepsilon}_{k,l} = \dot{u}_{k,l} &+\{-h_{k,l}\cos\theta_{k,l}-b_{k,l}\sin\theta_{k,l}\}\dot{\theta}_{k,l}-\dot{u}_{k+1,l} \\ &-\{(1-2\lambda_{k,l})h_{k+1,l}\cos\theta_{k+1,l}+b_{k+1,l}\sin\theta_{k+1,l}\}\dot{\theta}_{k+1,l}, \end{aligned} \tag{36}$$

$$\lambda_{k,l}=\frac{Z_{lt}-Z_{rb}}{Z_{lt}-Z_{lb}}\ . \tag{37}$$

If $\varepsilon_{k,l}>0$,

$$\left.\begin{aligned} F_{k,l}^{BR} &= -(K_{k,l}^{B}\,\varepsilon_{k,l}+C_{k,l}^{B}\,\dot{\varepsilon}_{k,l}), \\ M(F_{k,l}^{BR}) &= -F_{k,l}^{BR}(h_{k,l}\cos\theta_{k,l}+b_{k,l}\sin\theta_{k,l}). \end{aligned}\right\} \tag{38}$$

(5) Impact on upper left-hand corner

$$\begin{aligned} \varepsilon_{k,l} = u_{k-1,l} &+\{(1-2\lambda_{k,l})h_{k-1,l}\sin\theta_{k-1,l}-b_{k-1,l}(1-\cos\theta_{k-1,l})\}-u_{k,l} \\ &-\{h_{k,l}\sin\theta_{k,l}+b_{k,l}(1-\cos\theta_{k,l})\}-\delta_{k-1,l}, \end{aligned} \tag{39}$$

$$\begin{aligned} \dot{\varepsilon}_{k,l} = \dot{u}_{k-1,l} &+\{(1-2\lambda_{k,l})h_{k-1,l}\cos\theta_{k-1,l}-b_{k-1,l}\sin\theta_{k-1,l}\}\dot{\theta}_{k-1,l}-\dot{u}_{k,l} \\ &-(h_{k,l}\cos\theta_{k,l}+b_{k,l}\sin\theta_{k,l})\dot{\theta}_{k,l}, \end{aligned} \tag{40}$$

$$\lambda_{k,l}=\frac{Z_{rt}-Z_{lt}}{Z_{rt}-Z_{rb}}. \tag{41}$$

If $\varepsilon_{k,l}>0$,

$$\left.\begin{aligned} F_{k,l}^{TB} &= K_{k,l}^{B}\,\varepsilon_{k,l}+C_{k,l}^{B}\,\dot{\varepsilon}_{k,l}, \\ M(F_{k,l}^{TB}) &= F_{k,l}^{TB}(h_{k,l}\cos\theta_{k,l}+b_{k,l}\sin\theta_{k,l}). \end{aligned}\right\} \tag{42}$$

(6) Impact on upper-middle left-hand corner

$$\begin{aligned} \varepsilon_{k,l} = u_{k-1,l} &+\{h_{k-1,l}\sin\theta_{k-1,l}-b_{k-1,l}(1-\cos\theta_{k-1,l})\}-u_{k,l} \\ &-\{(1-2\lambda_{k,l})h_{k,l}\sin\theta_{k-1,l}+b_{k-1,l}(1-\cos\theta_{k-1,l})\}-\delta_{k-1,l}, \end{aligned} \tag{43}$$

$$\begin{aligned} \dot{\varepsilon}_{k,l} = \dot{u}_{k-1,l} &+(h_{k-1,l}\cos\theta_{k-1,l}-b_{k-1,l}\sin\theta_{k-1,l})\dot{\theta}_{k-1,l}-\dot{u}_{k,l} \\ &-\{(1-2\lambda_{k,l})\cos\theta_{k,l}+b_{k,l}\sin\theta_{k,l}\}\dot{\theta}_{k,l}, \end{aligned} \tag{44}$$

$$\lambda_{k,l}=\frac{Z_{lt}-Z_{rt}}{Z_{lt}-Z_{lb}}\ . \tag{45}$$

If $\varepsilon_{k,l}>0$,

$$\left.\begin{aligned} F_{k,l}^{MB} &= K_{k,l}^{MB}\,\varepsilon_{k,l}+C_{k,l}^{MB}\,\dot{\varepsilon}_{k,l}, \\ M(F_{k,l}^{MB}) &= F_{k,l}^{MB}\{(1-2\lambda_{k,l})h_{k,l}\cos\theta_{k,l}+b_{k,l}\sin\theta_{k,l}\}. \end{aligned}\right\} \tag{46}$$

(7) Impact on lower-middle left-hand corner

$$\begin{aligned} \varepsilon_{k,l} = u_{k-1,l} &+\{-h_{k-1,l}\sin\theta_{k-1,l}-b_{k-1,l}(1-\cos\theta_{k-1,l})\}-u_{k,l} \\ &+\{(1-2\lambda_{k,l})h_{k,l}\sin\theta_{k,l}-b_{k,l}(1-\cos\theta_{k,l})\}-\delta_{k-1,l}, \end{aligned} \tag{47}$$

$$\begin{aligned} \dot{\varepsilon}_{k,l} = \dot{u}_{k-1,l} &-(h_{k-1,l}\cos\theta_{k-1,l}+b_{k-1,l}\sin\theta_{k-1,l})\dot{\theta}_{k-1,l}-\dot{u}_{k,l} \\ &+\{(1-2\lambda_{k,l})h_{k,l}\cos\theta_{k,l}-b_{k,l}\sin\theta_{k,l}\}\dot{\theta}_{k,l}, \end{aligned} \tag{48}$$

$$\lambda_{k,l}=\frac{Z_{lt}-Z_{rb}}{Z_{lt}-Z_{lb}}\ . \tag{49}$$

If $\varepsilon_{k,l}>0$,

$$\left.\begin{array}{l} F_{k,l}^{NB}=K_{k,l}^{B}\,\varepsilon_{k,l}+C_{k,l}^{B}\,\dot{\varepsilon}_{k,l}\,, \\ M(F_{k,l}^{NB})=F_{k,l}^{NB}\{(1-2\lambda_{k,l})h_{k,l}\cos\theta_{k,l}+b_{k,l}\sin\theta_{k,l}\}. \end{array}\right\} \quad (50)$$

(8) Impact on lower left-hand corner

$$\varepsilon_{k,l}=u_{k-1,l}+\{(1-2\lambda_{k,l})h_{k-1,l}\sin\theta_{k-1,l}-b_{k-1,l}(1-\cos\theta_{k-1,l})\}-u_{k,l}$$
$$-\{h_{k,l}\sin\theta_{k,l}+b_{k,l}(1-\cos\theta_{k,l})\}-\delta_{k-1,l}\,, \quad (51)$$

$$\dot{\varepsilon}_{k,l}=\dot{u}_{k-1,l}\{(1-2\lambda_{k,l})h_{k-1,l}\cos\theta_{k-1,l}-b_{k-1,l}\sin\theta_{k-1,l}\}\dot{\theta}_{k-1,l}-\dot{u}_{k,l}$$
$$-(h_{k,l}\cos\theta_{k,l}+b_{k,l}\sin\theta_{k,l})\dot{\theta}_{k,l}\,, \quad (52)$$

$$\lambda_{k,l}=\frac{Z_{rt}-Z_{lb}}{Z_{rt}-Z_{rb}}\,. \quad (53)$$

If $\varepsilon>0$,

$$\left.\begin{array}{l} F_{k,l}^{BL}=-K_{k,l}^{B}\,\varepsilon_{k,l}+C_{k,l}^{B}\,\dot{\varepsilon}_{k,l}\,, \\ M(F_{k,l}^{BL})=-F_{k,l}^{BL}(h_{k,l}\cos\theta_{k,l}-b_{k,l}\sin\theta_{k,l}). \end{array}\right\} \quad (54)$$

(9) No-impact case

When $\varepsilon_{k,l}\leq 0$,

$$\left.\begin{array}{l} F_{k,l}^{TR}=F_{k,l}^{MR}=F_{k,l}^{NR}=F_{k,l}^{BR}=0\,, \\ F_{k,l}^{TL}=F_{k,l}^{ML}=F_{k,l}^{NL}=F_{k,l}^{BL}=0\,, \\ M(F_{k,l}^{TL})=M(F_{k,l}^{ML})=M(F_{k,l}^{NL})=M(F_{k,l}^{BL})=0\,, \\ M(F_{k,l}^{TR})=M(F_{k,l}^{MR})=M(F_{k,l}^{NR})=M(F_{k,l}^{BR})=0\,. \end{array}\right\} \quad (55)$$

3.5 Horizontal Impact Force and its Associated Moment between Column and Side Reflector

The forces acting on the block of the m-th column and the last column as a result of impact on the adjacent reflector blocks shown in **Fig. 7** are derived by deforming each spring-dashpot unit which are located on the upper and lower, right-and left-hand corners.

(1) Impact on upper right-hand corner of the l-th block in the m-th column

During impact against adjacent reflector block on the upper right-hand corner, the spring deformation $\varepsilon_{m,l}$ and its time rate $\dot{\varepsilon}_{m,l}$ of the block (m,l) are written as

$$\varepsilon_{m,l}=u_{m,l}+\{h_{m,l}\sin\theta_{m,l}-b_{m,l}(1-\cos\theta_{m,l})\}-u_{m+2,l}-\delta_{m,l}\,, \quad (56)$$

$$\dot{\varepsilon}_{m,l}=\dot{u}_{m,l}+(h_{m,l}\cos\theta_{m,l}-b_{m,l}\sin\theta_{m,l})\dot{\theta}_{m,l}-\dot{u}_{m+2,l}\,, \quad (57)$$

where $u_{m+2,l}$ and $\dot{u}_{m+2,l}$ are the adjacent block displacement of the right reflector column and its velocity at the contact point, respectively. The $\delta_{m,l}$ is the gap between the block (m, l) and the reflector block. The impact force $F_{m,l}^{TR}$ and its associated moment $M(F_{m,l}^{TR})$ acting on the block (m, l) are written for $\varepsilon_{m,l}>0$ as follows:

$$\left.\begin{array}{l} F_{m,l}^{TR}=-(K_{m,l}^{B}\,\varepsilon_{m,l}+C_{m,l}^{B}\,\varepsilon_{m,l}), \\ M(F_{m,l}^{TR})=F_{m,l}^{TR}(h_{m,l}\cos\theta_{m,l}-b_{m,l}\sin\theta_{m,l}) \end{array}\right\} \quad (58)$$

(2) Impact on lower right-hand corner of the l-th block in the m-th column

$$\varepsilon_{m,l}=u_{m,l}-\{h_{m,l}\sin\theta_{m,l}+b_{m,l}(1-\cos\theta_{m,l})\}-u_{m+2,l}-\delta_{m,l}\,, \quad (59)$$

$$\dot{\varepsilon}_{m,l}=\dot{u}_{m,l}-(h_{m,l}\cos\theta_{m,l}+b_{m,l}\sin\theta_{m,l})\dot{\theta}_{m,l}-\dot{u}_{m+2,l}\,. \quad (60)$$

If $\varepsilon_{m,l}>0$,

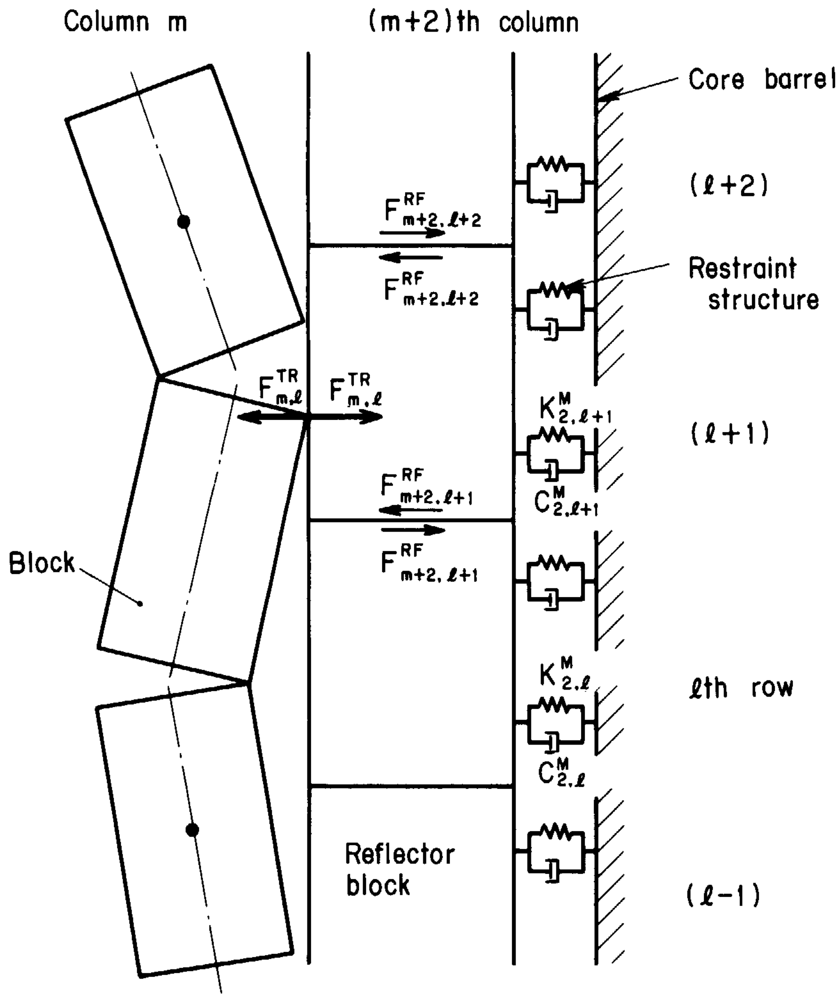


Fig. 7 Side reflector block model.

$$\left.\begin{aligned} F^{BR}_{m,l} &= -(K^{B}_{m,l}\,\varepsilon_{m,l} + C^{B}_{m,l}\,\dot{\varepsilon}_{m,l}) \\ M(F^{BR}_{m,l}) &= -F^{BR}_{m,l}\,(h_{m,l}\cos\theta_{m,l} + b_{m,l}\sin\theta_{m,l}). \end{aligned}\right\} \tag{61}$$

(3) Impact on upper left-hand corner of the l-th block in the first column

$$\varepsilon_{1,l} = -u_{1,l} - h_{1,l}\sin\theta_{1,l} + b_{1,l}(1-\cos\theta_{1,l})\} + u_{m+1,l} - \delta_{1,l}\,, \tag{62}$$

$$\dot{\varepsilon}_{1,l} = -\dot{u}_{1,l} - (h_{1,l}\cos\theta_{1,l} + b_{1,l}\sin\theta_{1,l})\dot{\theta}_{1,l} + \dot{u}_{m+1,l}\,, \tag{63}$$

where $u_{m+1,l}$ and $\dot{u}_{m+1,l}$ are the adjacent block displacement of the left reflector column and its velocity at the contact point, respectively. The $\delta_{1,l}$ is the gap between the block $(1, l)$ and the reflector block.

If $\varepsilon_{1,l} > 0$,

$$\left.\begin{aligned} F^{TL}_{1,l} &= K^{B}_{1,l}\,\varepsilon_{1,l} + C^{B}_{1,l}\,\dot{\varepsilon}_{1,l}\,, \\ M(F^{TR}_{1,l}) &= F^{TL}_{1,l}\,(h_{1,l}\cos\theta_{1,l} + b_{1,l}\sin\theta_{1,l}). \end{aligned}\right\} \tag{64}$$

(4) Impact on lower left-hand corner of the l-th block in the first column

$$\varepsilon_{1,l} = -u_{1,l} + \{h_{1,l}\sin\theta_{1,l} - b_{1,l}(1-\cos\theta_{1,l})\} + u_{m+1,l} - \delta_{1,l}\,, \tag{65}$$

$$\dot{\varepsilon}_{1,l} = -\dot{u}_{1,l} + (h_{1,l}\cos\theta_{1,l} - b_{1,l}\sin\theta_{1,l})\dot{\theta}_{1,l} + \dot{u}_{m+1,l}\,. \tag{66}$$

If $\varepsilon_{1,l} > 0$,

$$\left.\begin{aligned}&F_{1,l}^{BL}=K_{1,l}^{B}+C_{1,l}^{B}\,\dot{\varepsilon}_{1,l}\,,\\&M(F_{1,l}^{BL})=-F_{1,l}^{BL}(h_{1,l}\cos\theta_{1,l}-b_{1,l}\sin\theta_{1,l})\,.\end{aligned}\right\}\quad(67)$$

(5) No-impact case

When $\varepsilon_{1,l}=\varepsilon_{m,l}=0$,

$$\left.\begin{aligned}&F_{m,l}^{TR}=F_{m,l}^{BR}=F_{1,l}^{TL}=F_{1,l}^{BL}=0\,,\\&M(F_{m,l}^{TR})=M(F_{m,l}^{BR})=M(F_{1,l}^{TL})=M(F_{1,l}^{BL})=0\,.\end{aligned}\right\}\quad(68)$$

3.6 Dowel Forces in the Horizontal Direction and its Associated Moments

The dowel forces in the horizontal direction are derived from the contact condition between dowel pins and mating holes. When a dowel pin and its mating hole are in contact, the dowel spring deformation $\beta_{k,l}$ and its time rate $\dot{\beta}_{k,l}$ of the block interface are given by

$$\begin{aligned}\beta_{k,l}=&\{u_{k,l-1}+h_{k,l-1}\sin\theta_{k,l-1}-d_{k,l-1}(1-\cos\theta_{k,l-1})\\&-\{u_{k,l}-h_{k,l}\sin\theta_{k,l}-d_{k,l}(1-\cos\theta_{k,l})\}\mp\delta_{R,L}\,,\end{aligned}\quad(69)$$

$$\begin{aligned}\dot{\beta}_{k,l}=&\dot{u}_{k,l-1}+(h_{k,l-1}\cos\theta_{k,l-1}-d_{k,l-1}\sin\theta_{k,l-1})\dot{\theta}_{k,l-1}\\&-\{\dot{u}_{k,l}-(h_{k,l}\cos\theta_{k,l}+d_{k,l}\sin\theta_{k,l})\dot{\theta}_{k,l}\}\,.\end{aligned}\quad(70)$$

For $l=1$,

$$\beta_{k,1}=u_0-\{u_{k,1}-h_{k,1}\sin\theta_{k,1}-d_{k,1}(1-\cos\theta_{k,1})\}\mp\delta_{R,L}\,,\quad(71)$$

$$\dot{\beta}_{k,1}=\dot{u}_0-\{\dot{u}_{k,1}-(h_{k,1}\cos\theta_{k,1}+d_{k,1}\sin\theta_{k,1})\dot{\theta}_{k,1}\}\,,\quad(72)$$

where δ_R and δ_L are the gaps between dowel pin and hole on the right and left sides, respectively. The dowel force $F_{k,l}^{DR}$ and its associated moment $M(F_{k,l}^{DR})$ in horizontal direction acting on the right-hand dowel are written as follows. If $\beta_{k,l}>0$ on the right gap and $\beta_{k,l}<0$ on the left gap,

$$\left.\begin{aligned}&F_{k,l}^{DR}=K_{k,l}^{D}\,\beta_{k,l}+C_{k,l}^{D}\,\dot{\beta}_{k,l}\,,\\&M(F_{k,l}^{DR})=-F_{k,l}^{DR}(h_{k,l}\cos\theta_{k,l}+d_{k,l}\sin\theta_{k,l})\,,\end{aligned}\right\}\quad(73)$$

and for the block $(k,l-1)$,

$$\left.\begin{aligned}&F_{k,l}^{DR}=-K_{k,l}^{D}\,\beta_{k,l}-C_{k,l}^{D}\,\dot{\beta}_{k,l}\,,\\&M(F_{k,l-1}^{DR})=F_{k,l-1}^{DR}(h_{k,l-1}\cos\theta_{k,l-1}-d_{k,l}\sin\theta_{k,l-1})\,,\end{aligned}\right\}\quad(74)$$

If $\beta_{k,l}<0$ on the right gap and $\beta_{k,l}>0$ on the left gap,

$$\left.\begin{aligned}&F_{k,l}^{DR}=F_{k,l-1}^{DR}=0\,,\\&M(F_{k,l}^{DR})=M(F_{k,l-1}^{DR})=0\,,\end{aligned}\right\}\quad(75)$$

where $K_{k,l}^{D}$ and $C_{k,l}^{D}$ are the dowel spring and damping coefficients, respectively, and may be represented in the following general forms:

$$\left.\begin{aligned}&K_{k,l}^{D}=\sum_{j=0}^{m}K_{k,l,j}^{D}\,\beta_{k,l}^{j}\,,\\&C_{k,l}^{D}=\sum_{j=0}^{m}C_{k,l,j}^{D}\,\dot{\beta}_{k,l}^{j}\,.\end{aligned}\right\}\quad(76)$$

Similarly, the dowel forces $F_{k,l}^{DL}$ and its associated moments $M(F_{k,l}^{DL})$ in the horizontal direction acting on the left-hand dowel are written in the same equations as (73) through (76) above.

3.7 Dowel Friction Forces in the Vertical Direction and its Associated Moments

The dowel friction forces in the vertical direction are derived from the dowel forces and the friction factor. When dowel pin and mating hole are in sliding contact, the relative velocity between pin and hole on the block (k, l) interface is given by

$$\omega_{k,l}=\dot{w}_{k,l}+(h_{k,l}\sin\theta_{k,l}-d_{k,l}\cos\theta_{k,l})\dot{\theta}_{k,l} -\{\dot{w}_{k,l-1}-(h_{k,l-1}\sin\theta_{k,l-1}+d_{k,l}\cos\theta_{k,l-1})\dot{\theta}_{k,l-1}\}\,, \qquad (77)$$

and for $l=1$,

$$\omega_{k,1}=\dot{w}_{k,1}+(h_{k,1}\sin\theta_{k,1}-d_{k,1}\cos\theta_{k,1})\dot{\theta}_{k,1}-\dot{w}_0\,. \qquad (78)$$

The dowel friction force on the right-hand dowel in the vertical direction $\mu F^{DR}_{k,l}$ and its associated moment $M(\mu F^{DR}_{k,l})$ for the block (k,l) are written as follows:

$$\left.\begin{aligned}&\mu F^{DR}_{k,l}=-\mathrm{sign}(\omega_{k,l})\cdot|F^{DR}_{k,l}|\cdot f(\mu)\,,\\&M(\mu F^{DR}_{k,l})=-\mu F^{DR}_{k,l}(h_{k,l}\sin\theta_{k,l}+d_{k,l}\cos\theta_{k,l})\,,\end{aligned}\right\} \qquad (79)$$

and for the block $(k, l-1)$,

$$\left.\begin{aligned}&\mu F^{DR}_{k,l-1}=\mathrm{sign}(\omega_{k,l})\cdot|F^{DR}_{k,l}|\cdot f(\mu)\,,\\&M(\mu F^{DR}_{k,l-1})=-\mu F^{DR}_{k,l-1}(-h_{k,l-1}\sin\theta_{k,l-1}+d_{k,l}\cos\theta_{k,l-1})\,,\end{aligned}\right\} \qquad (80)$$

where $f(\mu)$ is a function of the friction factors both static and dynamic. Similarly, the friction force $\mu F^{DL}_{k,l}$ on the left-hand side and its moment $M(\mu F^{DL}_{k,l})$ are written as follows.

For the block (k,l),

$$\left.\begin{aligned}&\mu F^{DL}_{k,l}=-\mathrm{sign}(\omega_{k,l})\cdot|F^{DL}_{k,l}|\cdot f(\mu)\,,\\&M(\mu F^{DL}_{k,l})=-\mu F^{DL}_{k,l}(h_{k,l}\sin\theta_{k,l}+d_{k,l}\cos\theta_{k,l})\,,\end{aligned}\right\} \qquad (81)$$

and for the block $(k, l-1)$,

$$\left.\begin{aligned}&\mu F^{DL}_{k,l-1}=\mathrm{sign}(\omega_{k,l})\cdot|F^{DL}_{k,l}|\cdot f(\mu)\,,\\&M(\mu F^{DL}_{k,l-1})=-\mu F^{DL}_{k,l-1}(h_{k,l-1}\sin\theta_{k,l-1}+d_{k,l}\cos\theta_{k,l-1})\,,\end{aligned}\right\} \qquad (82)$$

$$f(\mu)=f(\mu_k,\mu_s)\,. \qquad (83)$$

3.8 Moment due to Block Weight and Pressure Difference

The moments acting on the block as a result of the block weight and pressure difference are given as follows. If $\alpha_{k,l+1}>0$,

$$M(W^U_{k,l})=W^U_{k,l}(h_{k,l}\sin\theta_{k,l}+b_{k,l}\cos\theta_{k,l})\,. \qquad (84)$$

If $\alpha_{k,l+1}=0$,

$$M(W^U_{k,l})=W^U_{k,l}\cdot h_{k,l}\cdot\sin\theta_{k,l}\,. \qquad (85)$$

and if $\alpha_{k,l+1}<0$,

$$M(W^U_{k,l})=W^U_{k,l}(h_{k,l}\sin\theta_{k,l}-b_{k,l}\cos\theta_{k,l})\,, \qquad (86)$$

where

$$W^U_{k,l}=\sum_{j=l+1}^{n}W_{k,l,j}+F^P_{k,l}\,. \qquad (87)$$

When $j=n$, $M(W^U_{n,l})=0$. Similarly, if $\alpha_{k,l}>0$.

If $\alpha_{k,l}=0$,

$$M(W^L_{k,l})=W^L_{k,l}\,h_{k,l}\sin\theta_{k,l}\ , \tag{88}$$

and if $\alpha_{k,l}<0$,

$$M(W^L_{k,l})=W^L_{k,l}(h_{k,l}\sin\theta_{k,l}+b_{k,l}\cos\theta_{k,l})\ , \tag{89}$$

where

$$W^L_{k,l}=\sum_{j=l}^{n}W_{k,l,j}+F^P_{k,l}\ . \tag{90}$$

3.9 Restraint Force between Top Orifice Blocks

The top blocks of columns are restrained each other in regionwise as shown in **Fig. 1**. The restraint force $F^{OP}_{k,l}$ is given by

$$F^{OP}_{k,l}=K^{OP}_{k,l}(u_{k+1,l}-u_{k,l})-K^{OP}_{k-1,l}(u_{k,l}-u_{k-1,l})\ , \tag{91}$$

where $K^{OP}_{k,l}$ is the spring constant of tie plate between the block $(k+1,l)$ and the block (k,l).

3.10 Equation of Motion for Side Reflector Block

Each reflector block has one translational coordinate u. For the reflector block on right-hand side, the equation of motion is written as:

$$m_{m+2,l}\,\ddot{u}_{m+2,l}=F^{RF}_{m+2,l}+F^{RF}_{m+2,l+1}+F^{TR}_{m,l}+F^{MR}_{m,l}+F^{NR}_{m,l}+F^{BR}_{m,l}+F^{M}_{2,l}\ , \tag{92}$$

where $F^{RF}_{m+2,l}$ is friction force at the block interface. The F^M is the force of core restraint structure given by $(i=m+1,m+2)$

$$\left.\begin{aligned}
&F^M_{i,l}=K^M_{i,l}\,\psi_{i,l}+C^M_{i,l}\,\dot{\psi}_{i,l}\ ,\\
&\psi_{i,l}=u_0-u_{i,l}\ ,\\
&\dot{\psi}_{i,l}=\dot{u}_0-\dot{u}_{i,l}\ ,\\
&K^M_{i,l}=\sum_{j=0}^{m}K^M_{i,l,j}\,\psi^j_{i,l}\ ,\\
&C^M_{i,l}=\sum_{j=0}^{m}C^M_{i,l,j}\,\dot{\psi}^j_{i,l}\ .
\end{aligned}\right\} \tag{93}$$

Friction force acting on the l-th row reflector block is written as follows $(i=m+1,m+2)$:

$$\left.\begin{aligned}
&F^{RF}_{i,l}=-\operatorname{sign}(v_{i,l})f(v_{i,l})\ ,\\
&v_{i,l}=\dot{u}_{i,l}-\dot{u}_{i,l-1}\ ,\\
&f(v_{i,l})=F_{i,l}\{\mu_s+f(v_{i,l})+f(v^2_{i,l})+f(v^3_{i,l})\ ,
\end{aligned}\right\} \tag{94}$$

and, for the $(l-1)$-th row reflector block,

$$F^{RF}_{i,l-1}=\operatorname{sign}(v_{i,l})f(v_{i,l})\ , \tag{95}$$

and velocity $v_{i,l}$ for $l=1$,

$$v_{i,1}=\dot{u}_{i,1}-\dot{u}_0\ .$$

Similarly, for the reflector block on the left-hand side, the equation of motion is written as:

$$m_{m+1,l}\,\ddot{u}_{m+1,l}=F^{RF}_{m+1,l}+F^{RF}_{m+1,l+1}+F^{TL}_{1,l}+F^{ML}_{1,l}+F^{NL}_{1,l}+F^{BL}_{1,l}+F^{M}_{1,l} \tag{96}$$

3.11 Equation of Motion for Core Support Block

The core support block has one translational coordinate u. For this block, the equation of motion is written as follows:

$$m_s \ddot{u}_s = F_S^{MR} + F_S^D + F_S^F, \tag{97}$$

where F_S^{MR}, F_S^D and F_S^F are respectively side support forces, dowel forces and friction forces, which are given by

$$\left.\begin{aligned} &F_S^{MR} = 2\,K_{1,1}^M\,\psi_{1,1}^M + 2\,C_{1,1}^M\,\dot{\psi}_{1,1}\,,\\ &\psi_{1,1} = u_s - u_0\,,\\ &\dot{\psi}_{1,1} = \dot{u}_s - \dot{u}_0\,, \end{aligned}\right\} \tag{98}$$

$$F_S^D = \sum_{k=1}^{m} (F_{k,1}^{DR} + F_{k,1}^{DL})\,, \tag{99}$$

$$F_S^F = \sum_{k=1}^{m} F_{k,1}^F + \sum_{k=1}^{2} F_{k,1}^{RF}\ . \tag{100}$$

3.12 Numerical Intergration Method

The governing equations given above can be numerically solved by using the fourth-order Runge-Kutta-Gill and the Newton methods.

4. Computer Program

The computer program SONATINA-2V performs the dynamic analysis for a two-dimensional vertical slice HTGR core subjected to seismic excitation. The program is capable of solving nonlinear impact problems.

4.1 Program Description

The computer program SONATINA-2V consists of 20 subroutines that are MAIN, SETARY, ROC, CRDINP, DTAPR, JULY31, FUN, BLOCK, DOWEL, MOMENT, VSPRNG, FRIC, XPR, FMPR, MXCL, MXPR, FUNBO, FUNUO, FUNWO and TITLE. Overall structure of SONATINA-2V is shown in **Fig. 8**. In the figure, line from one box to another indicates that the right subroutine is called by the left one. Functions of subroutines are as follows:

MAIN : initializes the start of run,
SETARY : sets memory core size,
ROC : controls the flow of program and stores the output,
CRDINP : reads input data,
DTAPR : prints out input data,
JULY31 : integrates system of differential equations using the Runge-Kutta-Gills and/or the Newton numerical methods,
FUN : sets up equations for given time,
BLOCK : determines horizontal impact force and its associated moment,
DOWEL : determines dowel force and its associated moment,
MOMENT: determines moment due to block weight and gas pressure difference,
VSPRNG : determines vertical impact force and its associated moment,
FRIC : determines friction force between blocks,
XPR : prints out displacement, velocity acceleration at each print step,

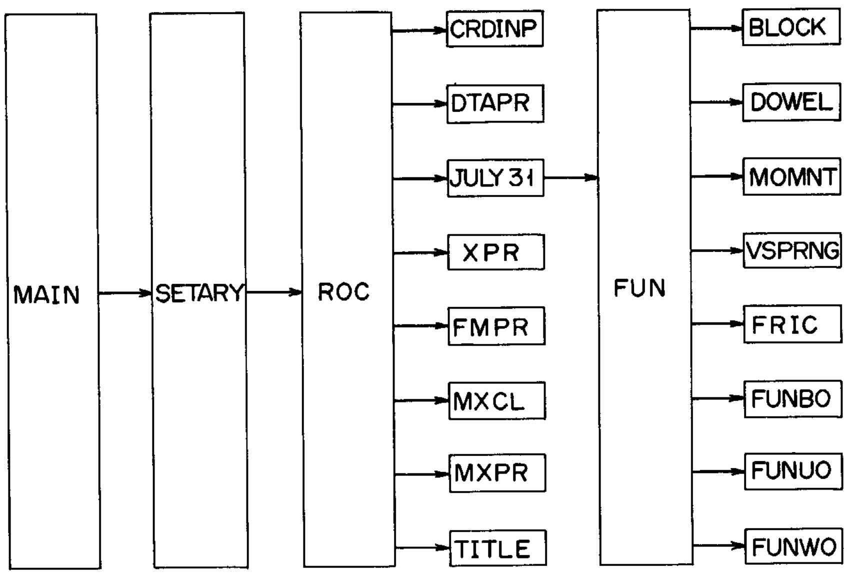


Fig. 8 Structure of computer program SONATINA-2V.

FMPR : prints out force and moment at each print step,
MXCL : searches maximum displacement, velocity, acceleration, force and moment,
MXPR : prints out maximum displacement, velocity, acceleration, force and moment,
FUNBO : determines boundary displacement and velocity,
FUNUO : determines base horizontal displacement and velocity,
FUNWO : determines base vertical displacement and velocity,
TITLE : prints out the job description.

A macroscopic flow chart of SONATINA-2V is shown in **Fig. 9**.

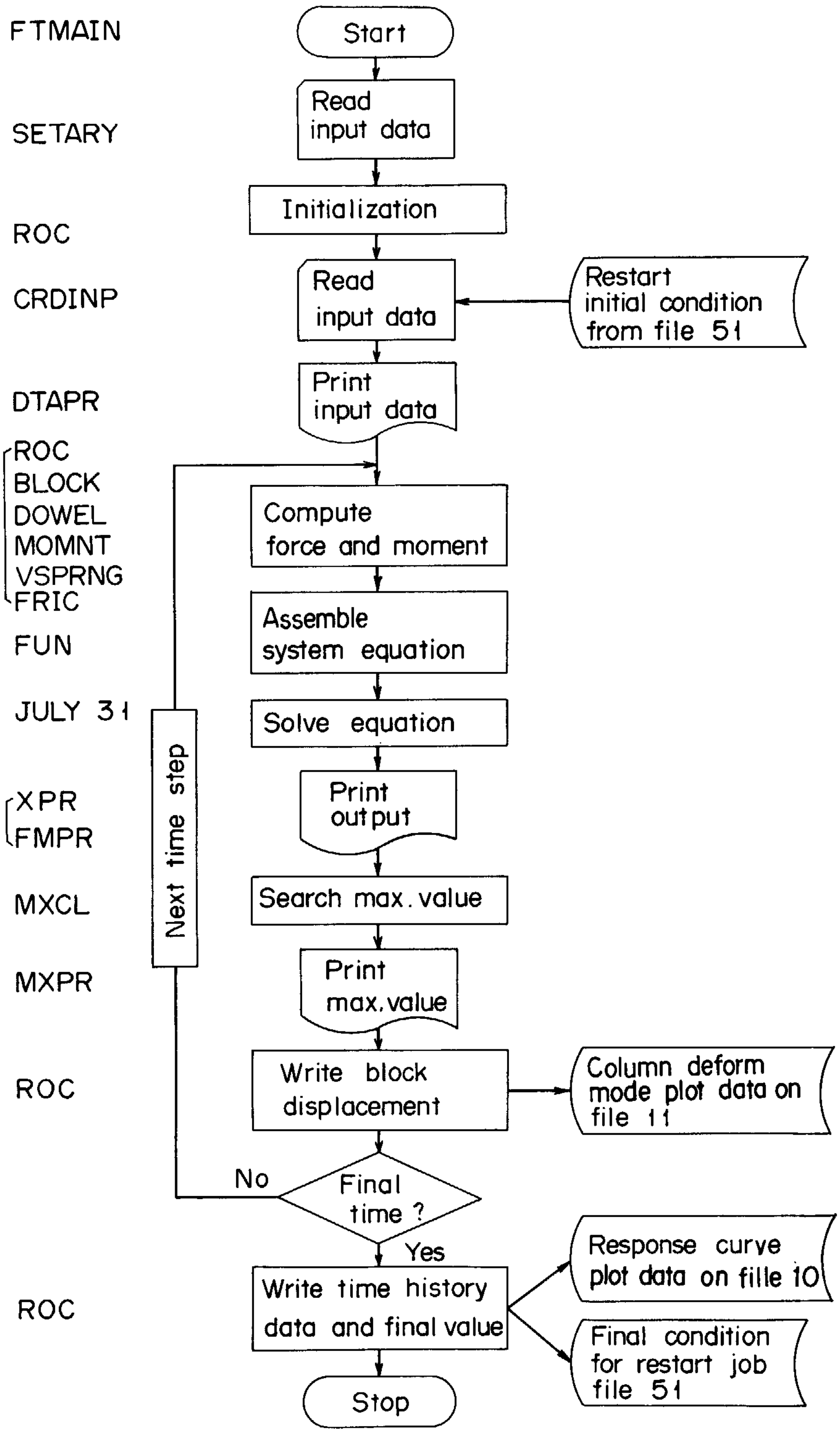


Fig. 9 Program flow and subroutines.

4.2 Description of Input Data

This section describes the input data required by SONATINA-2V. The input data consists of the job description, number of columns, number of blocks in a column, block weight and geometry, spring constant, damping constant, integral step, and options for printing and plotting. The input instruction are simple and easy to follow. The computer program SONATINA-2V contains a number of options which are available to the user. The input data forms are presented in **Table 1**;

Card group 1
Problem title card,
Card group 2
Master control card,
Card group 3
Mass and moment of inertia,
Card group 4
Height and width of block,
Card group 5
Distance of dowel,
Card group 6
Block rocking spring distance,
Card group 7
Gap width between blocks,
Card group 8
Gap width of right side dowel,
Card group 9
Gap width of left side dowel,
Card group 10
Spring constant of vertical impact,
Card group 11
Damping coefficient of vertical impact,
Card group 12
Spring constant of dowel pin,
Card group 13
Damping coefficient of dowel pin,
Card group 14
Spring constant of horizontal impact,
Card group 15
Damping coefficient of horizontal impact,
Card group 16
Damping coefficient of displacement detector,
Card group 17
Spring constant and damping coefficient of side reflector restraint structure,
Card group 18
Spring constant of top orifice block keyway,
Card group 19
Mass of core support block and its restraint structure spring constant and damping coefficient,
Card group 20
Initial displacement,
Card group 21
Initial velocity,
Card group 22
Gap pressure difference force,
Card group 23
Factor according to friction force,
Card 24
Coefficient of friction,
Card 25
Restart data,
Card 26
Solution time,
Card group 27
Option for calculation results printing and plotting,
Card group 28
Seismic data,
Card group 29
Option for response curve plotting.

Table 1 Input data for SONATINA-2V

Column	Format	Variable	Description
Card 1:	Problem title		
1-80	20A4	ITIT	Title or job description.
Card 2:	Master control		
1-10	I10	JSEQ	Identification number = 100.
11-20	F10.0	M	Number of columns.
21-30	F10.0	N	Number of blocks in a column.
31-40	F10.0	FUNGE	Option for solving equation. RUNGE = 0.0: Runge-Kutta-Gill integration method. RUNGE = 1.0: Newton integration method.
41-50	F10.0	DOWH	Effective length of dowel pin. If DOWH = 0.0, the effective length of dowel pin is infinite.
Card 3:	Mass and moment of inertia		
Card 3A:	One point data of mass and moment of inertia		
1-10	I10	JSEQ	Identification number = 200.
11-20	F10.0	K	Column number.
21-30	F10.0	L	Row number.
51-60	F10.0	WG	Weight of block WG (K, L).
61-70	F10.0	AMS	Mass of block AMS (K, L).
71-80	F10.0	ROI	Mass moment of inertia of block ROI (K, L).
Card 3B:	Array data of mass and moment of inertia		
1-10	I10	JSEQ	Identification number = 210.
11-20	F10.0	KDMY 1	First column number.
21-30	F10.0	KDMY 2	Last column number.
31-40	F10.0	LDMY 1	First row number.
41-50	F10.0	LDMY 2	Last row number.
51-60	F10.0	WG	Weight of blocks WG (KDMY 1, LDMY 2) ≀ WG (KDMY 2, LDMY 2).
61-70	F10.0	AMS	Mass of blocks AMS (KDMY 1, LDMY 1) ≀ AMS (KDMY 2, LDMY 2).
71-80	F10.0	ROI	Mass moment of inetia of block ROI (KDMY 1, LDMY 1) ≀ ROI (KDMY 2, LDMY 2).
Card 4:	Height and width of block		
Card 4A:	One point data of height and width		
1-10	I10	JSEQ	Identification number = 250.
11-20	F10.0	K	Column number
21-30	F10.0	L	Row number.
51-60	F10.0	H	Half height of block H (K, L).
61-70	F10.0	B	Half width of block B (K, L).

Table 1 Continued

Column	Format	Variable	Description
Card 4B: Array data of height and width			
1-10	I10	JSEQ	Identification number = 260.
11-20	F10.0	KDMY1	First column number.
21-30	F10.0	KDMY2	Last column number.
31-40	F10.0	LDMY1	First row number.
41-50	F10.0	LDMY2	Last row number.
51-60	F10.0	H	Half height of blocks H (KDMY1, LDMY1) ~ H (KDMY2, LDMY2).
61-70	F10.0	B	Half width of blocks B (KDMY1, LDMY1) ~ B (KDMY2, LDMY2).
Card 5: Distance of dowel			
Card 5A: One point data of dowel distance			
1-10	I10	JSEQ	Identification number = 300.
11-20	F10.0	K	Column number.
21-30	F10.0	L	Row number.
51-60	F10.0	D	Distance of left dowel from block center line D (K, L, 1).
61-70	F10.0	D	Distance of right dowel from block center line D (K, L, 2).
Card 5B: Array data of dowel distance			
1-10	I10	JSEQ	Identification number = 310.
11-20	F10.0	KDMY1	First column number.
21-30	F10.0	KDMY2	Last column number.
31-40	F10.0	LDMY1	First row number.
41-50	F10.0	LDMY2	Last row number.
51-60	F10.0	D	Distance of left dowel from block center line D (KDMY1, LDMY1, 1) ~ D (KDMY2, LDMY2, 1).
61-70	F10.0	D	Distance of right dowel from block center line D (KDMY1, LDMY1, 2) ~ D (KDMY2, LDMY2, 2).
Card 6: Block rocking spring distance			
Card 6A: One point data of block rocking spring half width			
1-10	I10	JSEQ	Identification number = 350.
11-20	F10.0	K	Column number.
21-30	F10.0	L	Row number.
51-60	F10.0	A	Block rocking spring half width A (K, L, 1).
61-70	F10.0	A	Block rocking spring half width A (K, L, 2).
Card 6B: Array data of block rocking spring half width			
1-10	I10	JSEQ	Identification number = 360.
11-20	F10.0	KDMY1	First column number.
21-30	F10.0	KDMY2	Last column number.
31-40	F10.0	LDMY1	First row number.
41-50	F10.0	LDMY2	Last row number.
51-60	F10.0	A	Block rocking spring half width for left side A (KDMY1, LDMY1, 1) ~ A (KDMY2, LDMY2, 1).

Table 1 Continued

Column	Format	Variable	Description
61-70	F10.0	A	Block rocking spring half width for right side A (KDMY1, LDMY1, 2) ≀ A (KDMY2, LDMY2, 2).
Card 7: Gap width between blocks			
Card 7A: One point data of gap width between blocks			
1-10	I10	JSEQ	Identification number = 400.
11-20	F10.0	K	Column number.
21-30	F10.0	L	Row number.
51-60	F10.0	DLT	Gap width between block (K, L) and block (K+1, L): DLT (K, L).
Card 7B: Array data of gap width between blocks			
1-10	I10	JSEQ	Identification number = 410.
11-20	F10.0	KDMY1	First column number.
21-30	F10.0	KDMY2	Last column number.
31-40	F10.0	LDMY1	First row number.
41-50	F10.0	LDMY2	Last row number.
51-60	F10.0	DLT	Gap width between blocks. DLT (KDMY1, LDMY1) ≀ DLT (KDMY2, LDMY2).
Card 8: Gap width of right side dowel			
Card 8A: One point data of gap width of right side dowel			
1-10	I10	JSEQ	Identification number = 450.
11-20	F10.0	K	Column number.
21-30	F10.0	L	Row number.
51-60	F10.0	DLTDWR	Gap on right side of right dowel DLTDWR (K, L, 1).
61-70	F10.0	DLTDWL	Gap on left side of right dowel DLTWL (K, L, 1).
Card 8B: Array data of gap width of right side dowel			
1-10	I10	JSEQ	Identification number = 460.
11-20	F10.0	KDMY1	First column number.
21-30	F10.0	KDMY2	Last column number.
31-40	F10.0	LDMY1	First row number.
41-50	F10.0	LDMY2	Last row number.
51-60	F10.0	DLTDWR	Gap on right side of right dowel DLTDWR (KDMY1, LDMY1, 1) ≀ DLTDWR (DKMY2, LDMY2, 1).
61-70	F10.0	DLTDWL	Gap on left side of right dowel DLTDWL (KDMY1, LDMY1, 1) ≀ DLTDWL (KDMY2, LDMY2, 1).
Card 9: Gap width of left side dowel			
Card 9A: One point data of gap width of left side dowel			
1-10	I10	JSEQ	Identification number = 500.
11-20	F10.0	K	Column number.
21-30	F10.0	L	Row number.
51-60	F10.0	DLTDWR	Gap on right side of left dowel DLTDWR (K, L, 2).
61-70	F10.0	DLTDWL	Gap on left side of left dowel DLTDWL (K, L, 2).

Table 1 Continued

Column	Format	Variable	Description
Card 9B: Array data of gap width of left side dowel			
1-10	I10	JSEQ	Identification number = 510.
11-20	F10.0	KDMY1	First column number.
21-30	F10.0	KDMY2	Last column number.
31-40	F10.0	LDMY1	First row number.
41-50	F10.0	LDMY2	Last row number.
51-60	F10.0	DLTDWR	Gap on right side of left dowel DLTDWR (KDMY1, LDMY1, 2) ~ DLTDWR (KDMY2, LDMY2, 2).
61-70	F10.0	DLTDWL	Gap on left side of left dowel DLTDWL (KDMY1, LDMY1, 2) ~ DLTDWL (KDMY2, LDMY2, 2).
Card 10: Spring constant of vertical impact			
Card 10A: One point data of spring constant of vertical impact			
1-10	I10	JSEQ	Identification number = 550.
11-20	F10.0	K	Column number.
21-30	F10.0	L	Row number.
51-60	F10.0	SPKVRA	Spring constant of vertical impact SPKVRA (K, L, 1).
61-70	F10.0	SPKVRA	Spring constant of vertical impact SPKVRA (K, L, 2).
71-80	F10.0	SPKVRA	Spring constant of vertical impact SPKVRA (K, L, 3).
Total spring constant = SPKVRA (K, L, 1) + SPKVRA (K, L, 2) * γ + SPKVRA (K, L, 3) * γ^2 γ: Vertical impact spring deformation.			
Card 10B: Array data of spring constant of vertical impact			
1-10	I10	JSEQ	Identification number = 560.
11-20	F10.0	KDMY1	First column number.
21-30	F10.0	KDMY2	Last column number.
31-40	F10.0	LDMY1	First row number.
41-50	F10.0	LDMY2	Last row number.
51-60	F10.0	SPKVRA	Spring constant of vertical impact SPKVRA (KDMY1, LDMY1, 1) ~ SPKVRA (KDMY2, LDMY2, 1).
61-70	F10.0	SPKVRA	Spring constant of vertical impact SPKVRA (KDMY1, LDMY1, 2) ~ SPKVRA (KDMY2, LDMY2, 2).
71-80	F10.0	SPKVRA	Spring constant of vertical impact SPKVRA (KDMY1, LDMY1, 3) ~ SPKVRA (KDMY2, LDMY2, 3)
Card 11: Damping coefficient of vertical impact			
Card 11A: One point data of damping coefficient of vertical impact			
1-10	I10	JSEQ	Identification number = 600.
11-20	F10.0	K	Column number.
21-30	F10.0	L	Row number.
51-60	F10.0	SPCVRA	Damping coefficient of vertical impact SPCVRA (K, L, 1).
61-70	F10.0	SPCVRA	Damping coefficient of vertical impact SPCVRA (K, L, 2).
71-80	F10.0	SPCVRA	Damping coefficient of vertical impact SPCVRA (K, L, 3).
Total damping coefficient = SPCVRA (K, L, 1) + SPCVRA (K, L, 2) * $\dot{\gamma}$ + SPCVRA (K, L, 3) * $\dot{\gamma}^2$ $\dot{\gamma}$: Time rate of vertical impact spring deformation.			

Table 1 Continued

Column	Format	Variable	Description
Card 11B: Array data of damping coefficient of vertical impact			
1-10	I10	JSEQ	Identification number = 610.
11-20	F10.0	KDMY1	First column number.
21-30	F10.0	KDMY2	Last column number.
31-40	F10.0	LDMY1	First row number.
41-50	F10.0	LDMY2	Last row number.
51-60	F10.0	SPCVRA	Damping coefficient of vertical impact SPCVRA (DKMY1, LDMY1, 1) ~ SPCVRA (KDMY2, LDMY2, 1).
61-70	F10.0	SPCVRA	Damping coefficient of vertical impact SPCVRA (KDMY1, LDMY1, 2) ~ SPCVRA (DKMY2, LDMY2, 2).
71-80	F10.0	SPCVRA	Damping coefficient of vertical impact SPCVRA (KDMY1, LDMY1, 3) ~ SPCVRA (DKMY2, LDMY2, 3).
Card 12: Spring constant of dowel pin			
Card 12A: One point data of spring constant of dowel pin			
1-10	I10	JSEQ	Identification number = 650.
11-20	F10.0	K	Column number.
21-30	F10.0	L	Row number.
51-60	F10.0	SPKDWA	Spring constant of dowel pin SPKDWA (K, L, 1).
61-70	F10.0	SPKDWA	Spring constant of dowel pin SPKDWA (K, L, 2).
71-80	F10.0	SPKDWA	Spring constant of dowel pin SPKDWA (K, L, 3).
Total spring constant = SPKDWA (K, L, 1) + SPKDWA (K, L, 2) $*\beta$ + SPKDWA (K, L, 3) $*\beta^2$			
β: Dowel pin spring deformation.			
Card 12B: Array data of spring constant of dowel pin			
1-10	I10	JSEQ	Identification number = 660.
11-20	F10.0	KDMY1	First column number.
21-30	F10.0	KDMY2	Last column number.
31-40	F10.0	LDMY1	First row number.
41-50	F10.0	LDMY2	Last row number.
51-60	F10.0	SPKDWA	Spring constant of dowel pin SPKDWA (KDMY1, LDMY1, 1) ~ SPKDWA (KDMY2, LDMY2, 1).
61-70	F10.0	SPKDWA	Spring constant of dowel pin SPKDWA (KDMY1, LDMY 1, 2) ~ SPKDWA (KDMY2, LDMY2, 2).
71-80	F10.0	SPKDWA	Spring constant of dowel pin SPKDWA (KDMY1, LDMY1, 3) ~ SPKDWA (KDMY2, LDMY2, 3).
Card 13: Damping coefficient of dowel pin			
Card 13A: One point data of damping coefficient of dowel pin			
1-10	I10	JSEQ	Identification number = 700.
11-20	F10.0	K	Column number.
21-30	F10.0	L	Row number.
51-60	F10.0	SPCDWA	Damping coefficient of dowel pin SPCDWA (K, L, 1).

Table 1 Continued

Column	Format	Variable	Description
61-70	F10.0	SPCDWA	Damping coefficient of dowel pin SPCDWA (K, L, 2).
71-80	F10.0	SPCDWA	Damping coefficient of dowel pin SPCDWA (K, L, 3).
Total damping coefficient = SPCDWA (K, L, 1) + SPCDWA (K, L, 2) $*\dot{\beta}$ + SPCDWA (K, L, 3) $*\dot{\beta}^2$			
$\dot{\beta}$: Time rate of dowel pin spring deformation.			
Card 13B: Array data of damping coefficient of dowel pin			
1-10	I10	JSEQ	Identification number = 710.
11-20	F10.0	KDMY1	First column number.
21-30	F10.0	KDMY2	Last column number.
31-40	F10.0	LDMY1	First row number.
41-50	F10.0	LDMY2	Last row number.
51-60	F10.0	SPCDWA	Damping coefficient of dowel pin SPCDWA (KDMY1, LDMY1, 1) ~ SPCDWA (KDMY2, LDMY2, 1).
61-70	F10.0	SPCDWA	Damping coefficient of dowel pin SPCDWA (KDMY1, LDMY1, 2) ~ SPCDWA (KDMY2, LDMY2, 2).
71-80	F10.0	SPCDWA	Damping coefficient of dowel pin SPCDWA (KDMY1, LDMY1, 3) ~ SPCDWA (KDMY2, LDMY2, 3).
Card 14: Spring constant of horizontal impact			
Card 14A: One point data of spring constant of horizontal impact			
1-10	I10	JSEQ	Identification number = 750.
11-20	F10.0	K	Column number.
21-30	F10.0	L	Row number
51-60	F10.0	SPKBKA	Spring constant of horizontal impact SPKBKA (K, L, 1).
61-70	F10.0	SPKBKA	Spring constant of horizontal impact SPKBKA (K, L, 2).
71-80	F10.0	SPKBKA	Spring constant of horizontal impact SPKBKA (K, L, 3).
Total spring constant = SPKBKA (K, L, 1) + SPKBKA (K, L, 2) $*\varepsilon$ + SPKBKA (K, L, 3) $*\varepsilon^2$			
ε: Horizontal impact spring deformation.			
Card 14B: Array data of spring constant of horizontal impact			
1-10	I10	JSEQ	Identification number = 760.
11-20	F10.0	KDMY1	First column number.
21-30	F10.0	KDMY2	Last column number.
31-40	F10.0	LDMY1	First row number.
41-50	F10.0	LDMY2	Last row number.
51-60	F10.0	SPKBKA	Spring constant of horizontal impact SPKBKA (KDMY1, LDMY1, 1) ~ SPKBKA (KDMY2, LDMY2, 1).
61-70	F10.0	SPKBKA	Spring constant of horizontal impact SPKBKA (KDMY1, LDMY1, 2) ~ SPKBKA (KDMY2, LDMY2, 2)
71-80	F10.0	SPKBKA	Spring constant of horizontal impact SPKBKA (KDMY1, LDMY1, 3) ~ SPKBKA (KDMY2, LDMY2, 3).

Table 1 Continued

Column	Format	Variable	Description
Card 15: Damping coefficient of horizontal impact			
Card 15A: One point data of damping coefficient of horizontal impact			
1-10	I10	JSEQ	Identification number = 800.
11-20	F10.0	K	Column number.
21-30	F10.0	L	Row number.
51-60	F10.0	SPCBKA	Damping coefficient of horizontal impact SPCBKA (K, L, 1).
61-70	F10.0	SPCBKA	Damping coefficient of horizontal impact SPCBKA (K, L, 2).
71-80	F10.0	SPCBKA	Damping coefficient of horizontal impact SPCBKA (K, L, 3).
Total damping coefficient = SPCBKA (K, L, 1) + SPCBKA (K, L, 2) $*\dot{\varepsilon}$ + SPCBKA (K, L, 3) $*\dot{\varepsilon}^2$ $\dot{\varepsilon}$: Time rate of horizontal impact spring deformation.			
Card 15B: Array data of damping coefficient of horizontal impact			
1-10	I10	JSEQ	Identification number = 810.
11-20	F10.0	KDMY1	First column number.
21-30	F10.0	KDMY2	Last column number.
31-40	F10.0	LDMY1	First row number.
41-50	F10.0	LDMY2	Last row number.
51-60	F10.0	SPCBKA	Damping coefficient of horizontal impact SPCBKA (KDMY1, LDMY1, 1) ~ SPCBKA (KDMY2, LDMY2, 1).
61-70	F10.0	SPCBKA	Damping coefficient of horizontal impact SPCBKA (KDMY1, LDMY1, 2) ~ SPCBKA (KDMY2, LDMY2, 2).
71-80	F10.0	SPCBKA	Damping coefficient of horizontal impact SPCBKA (KDMY1, LDMY1, 3) ~ SPCBKA (KDMY2, LDMY2, 3).
Card 16: Damping coefficient of displacement detector			
Card 16A: One point data of damping coefficient of displacement detector			
1-10	I10	JSEQ	Identification number = 830.
11-20	F10.0	K	Column number.
21-30	F10.0	L	Row number.
51-60	F10.0	CXX	Damping coefficient of displacement detector CXX (K, L).
Card 16B: Array data of damping coefficient of displacement detector			
1-10	I10	JSEQ	Identification number = 840.
11-20	F10.0	KDMY1	First column number.
21-30	F10.0	KDMY2	Last column number.
31-40	F10.0	LDMY1	First row number.
41-50	F10.0	LDMY2	Last row number.
51-60	F10.0	CXX	Damping coefficient of displacement detector CXX (KDMY1, LDMY1) ~ CXX (KDMY2, LDMY2).
Card 17: Spring constant and damping coefficient of side reflector restraint structure			
Card 17A: One point data of spring constant and damping coefficient of side reflector restraint structure			
1-10	I10	JSEQ	Identification number = 850.
11-20	F10.0	K	Column number.
21-30	F10.0	L	Row number.

Table 1 Continued

Column	Format	Variable	Description
51-60	F10.0	SPKSR	Spring constant of side reflector restraint structure SPKSR (K, L, 1).
61-70	F10.0	SPCSR	Damping coefficient of side reflector restraint structure SPCSR (K, L).
Card 17B: One point data of second and third stage spring constant			
1-10	I10	JSEQ	Identification number = 855.
11-20	F10.0	K	Column number.
21-30	F10.0	L	Row number.
51-60	F10.0	SPKSR	Second stage spring constant of side reflector restraint structure SPKSR (K, L, 2).
61-70	F10.0	SPKSR	Third stage spring constant of side reflector restraint structure SPKSR (K, L, 3).
Card 17C: Array data of spring constant and damping coefficient of side reflector restraint structure			
1-10	I10	JSEQ	Identification number = 860.
11-20	F10.0	KDMY1	First column number.
21-30	F10.0	KDMY2	Last column number.
31-40	F10.0	LDMY1	First row number.
41-50	F10.0	LDMY2	Last row number.
51-60	F10.0	SPKSR	Spring constant of side reflector restraint structure SPKSR (KDMY1, LDMY1, 1) SPKSR (KDMY2, LDMY2, 1).
61-70	F10.0	SPCSR	Damping coefficient of side reflector restraint structure SPCSR (KDMY1, LDMY1) SPCSR (KDMY2, LDMY2).
Card 17D: Array data of second and third stage spring constant			
1-10	I10	JSEQ	Identification number = 865.
11-20	F10.0	KDMY1	First column number.
21-30	F10.0	KDMY2	Last column number.
31-40	F10.0	LDMY1	First row number.
41-50	F10.0	LDMY2	Last row number.
51-60	F10.0	SPSKSR	Second stage spring constant of side reflector restraint structure SPKSR (KDMY1, LDMY1, 2) SPKSR (KDMY2, LDMY2, 2).
61-70	F10.0	SPKSR	Third stage spring constant of side reflector restraint structure SPKSR (KDMY1, LDMY1, 3) SPKSR (KDMY2, LDMY2, 3)
Card 17E: Distance from first to second stage spring			
1-10	I10	JSEQ	Identification number = 867.
51-60	F10.0	DEL1	Distance from zero to first stage spring. If DEL1 is zero, DEL1 is infinite.
61-70	F10.0	DEL2	Distance from first to second stage spring.
Card 18: Spring constant of top orifice block keyway			
Card 18A: Identification of connecting column number			
1-10	I10	JSEQ	Identification number = 870.
11-20	F10.0	K1	First column number.
21-30	F10.0	K2	Last column number.,
51-60	F10.0	NOTOP	Number of spring constant data NOTOP (K1) ~ NOTOP (K2).

Table 1 Continued

Column	Format	Variable	Description
Card 18B: Spring constant of top orifice block keyway			
1-10	I10	JSEQ	Identification number = 880.
11-20	F10.0	K1	First data.
21-30	F10.0	K2	Last data.
51-60	F10.0	EKTOP	Spring constant of top orifice block keyway EKTOP (K1) ~ EKTOP (K2).
Card 19: Mass of core support block and its restraint structure spring constant and damping coefficient			
Card 19A: Mass, friction factor and weight of core support block			
1-10	I10	JSEQ	Identification number = 900.
51-60	F10.0	AMSBP	Mass of core support block.
61-70	F10.0	EMUBP	Friction factor between core support block and base plate.
71-80	F10.0	WGBP	Weight of core support block.
Card 19B: Spring constant and damping coefficient of core support block restraint structure			
1-10	I10	JSEQ	Identification number = 910.
51-60	F10.0	BPK	Spring constant of core support block restraint structure.
61-70	F10.0	BPC	Damping coefficient of core support block restraint structure.
Card 19C: Second and third stage spring constant of core support block restraint structure			
1-10	I10	JSEQ	Identification number = 915.
51-60	F10.0	BPK2	Second stage spring constant of core support block restraint structure.
61-70	F10.0	BPK3	Third stage spring constant of core support block restraint structure.
Card 20: Initial displacement			
Card 20A: One point data of initial displacement			
1-10	I10	JSEQ	Identification number = 950.
11-20	F10.0	K	Column number.
21-30	F10.0	L	Row number.
51-60	F10.0	X	Initial angle X (K, L, 1).
61-70	F10.0	X	Initial horizontal displacement X (K, L, 3).
71-80	F10.0	X	Initial vertical displacement X (K, L, 5).
Card 20B: Array data of initial displacement			
1-10	I10	JSEQ	Identification number = 960.
11-20	F10.0	KDMY1	First column number.
21-30	F10.0	KDMY2	Last column number.
31-40	F10.0	LDMY1	First row number.
41-50	F10.0	LDMY2	Last row number.
51-60	F10.0	X	Initial angle X (KDMY1, LDMY1, 1) ~ X (KDMY2, LDMY2, 1).
61-70	F10.0	X	Initial horizontal displacement X (KDMY1, LDMY1, 3) ~ X (KDMY2, LDMY2, 3).
71-80	F10.0	X	Initial vertical displacement X (KDMY1, LDMY1, 3) ~ X (KDMY2, LDMY2, 3).

Table 1 Continued

Column	Format	Variable	Description
Card 21: Initial velocity			
Card 21A: One point data of initial velocity			
1-10	I10	JSEQ	Identification number = 1000.
11-20	F10.0	K	Column number.
21-30	F10.0	L	Row number.
51-60	F10.0	X	Initial velocity X (K, L, 2).
61-70	F10.0	X	Initial horizontal velocity X (K, L, 4).
71-80	F10.0	X	Initial vertical velocity X (K, L, 6).
Card 21B: Array data of initial velocity			
1-10	I10	JSEQ	Identification number = 1010.
11-20	F10.0	KDMY1	First column number.
21-30	F10.0	KDMY2	Last column number.
31-40	F10.0	LDMY1	First row number.
41-50	F10.0	LDMY2	Last row number.
51-60	F10.0	X	Initial velocity X (KDMY1, LDMY1, 2) ~ X (KDMY2, LDMY2, 2).
61-70	F10.0	X	Initial horizontal velocity X (KDMY1, LDMY1, 4) ~ X (KDMY2, LDMY2, 4).
71-80	F10.0	X	Initial horizontal velocity X (KDMY1, LDMY1, 6) ~ X (KDMY2, LDMY2, 6).
Card 22: Gap pressure difference force			
Card 22A: One point data of gas pressure difference force			
1-10	I10	JSEQ	Identification number = 1050.
11-20	F10.0	K	Column number.
21-30	F10.0	L	Row number
51-60	F10.0	GSF	Gap pressure difference force GSF (K, L).
61-70	F10.0	GSPK	Spring constant simulating gas pressure effect GSPK (K, L).
Card 22B: Array data of gas pressure difference force			
1-10	I10	JSEQ	Identification number = 1060.
11-20	F10.0	KDMY1	First column number.
21-30	F10.0	KDMY2	Last column number.
31-40	F10.0	LDMY1	First row number.
41-50	F10.0	LDMY2	Last row number.
51-60	F10.0	GSF	Gap pressure difference force GSF (KDMY1, LDMY1) ~ GSF (KDMY2, LDMY2).
61-70	F10.0	GSPK	Spring constant simulating gas pressure effect GSPK (KDMY1, LDMY1) ~ GSPK (KDMY2, LDMY2).

Table 1 Continued

Column	Format	Variable	Description
Card 23: Factor according to friction force			
Card 23A: One point data of factor according to friction force			
1-10	I10	JSEQ	Identification number = 1100.
11-20	F10.0	K	Column number.
21-30	F10.0	L	Row number.
51-60	F10.0	FI1	Coefficient of static friction FI1 (K, L).
61-70	F10.0	FI2	Related number to coefficient of dynamic friction FI2 (K, L).
Card 23B: Array data of factor according to friction force			
1-10	I10	JSEQ	Identification number = 1110.
11-20	F10.0	KDMY1	First column number.
21-30	F10.0	KDMY2	Last column number.
31-40	F10.0	LDMY1	First row number.
41-50	F10.0	LDMY2	Last row number.
51-60	F10.0	FI1	Coefficient of static friction FI1 (KDMY1, LDMY1) ≀ FI1 (KDMY2, LDMY2)
61-70	F10.0	FI2	Related to coefficient of dynamic friction FI2 (KDMY1, LDMY1) ≀ FI2 (KDMY2, LDMY2).
Card 24: Coefficient of friction			
1-10	I10	JSEQ	Identification number = 1130.
51-60	F10.0	FICOF	Coefficient of static friction.
61-70	F10.0	FICOFK	Coefficient of dynamic friction.
Card 25: Restart data			
1-10	I10	JSEQ	Identification number = 1200.
11-20	F10.0	JREINP	Initial condition option. If JREINP = 0, initial displacement and velocity set by card input. If JREINP = 1, initial displacement and velocity read from file No. 51 generated from previous run.
21-30	F10.0	JREOUT	Final condition option. If JREOUT = 0, no final conditions saved. If JREOUT = 1, final conditions saved on file No. 51 for a restart run.
31-40	F10.0	JTIMAX	Maximum computer time (CPU second).
41-50	F10.0	IPRINT	Result print option. If IPRINT = 0, all input and output data are printed. If IPRINT = 1, maximum values of calculation results are printed.
Card 26: Solution time			
1-10	I10	JSEQ	Identification number = 1250.
11-20	F10.0	TIMS	Starting time.
21-30	F10.0	TIMEND	Ending time.
31-40	F10.0	TIMSP	Integral time step.
41-50	F10.0	TIMOP1	Option for integration method.

TIMS ~ TIMOP1 ~ TIMEND
⇧ Runge-Kutta-Gill ⇧ Newton method

Table 1 Continued

Column	Format	Variable	Description
Card 27: Option for calculation results printing and plotting			
Card 27A: First step number for calculation results printing and plotting			
1-10	I10	JSEQ	Identification number = 1300.
11-20	F10.0	JCPRBG	First step number for displacement, velocity and acceleration printing.
21-30	F10.0	JCFMBG	First step number for force and moment printing.
31-40	F10.0	JCMXBG	First step number for maximum value printing.
41-50	F10.0	JCPLBG	First step number for vibration mode plotting.
51-60	F10.0	JCP2BG	First step number for time history curve plotting.
Card 27B: Interval step number for calculation results printing and plotting			
1-11	F10.0	JSEQ	Identification number = 1310.
11-20	F10.0	JCPRSP	Interval step number for displacement, velocity and acceleration printing.
21-30	F10.0	JCFMSP	Interval step number for force and moment printing.
31-40	F10.0	JCMXSP	Interval step number for maximum value printing.
41-50	F10.0	JCPLSP	Interval step number for vibration mode plotting.
51-60	F10.0	JCP2SP	Interval step number for time history curve plotting.
Card 28: Seismic data.			
Card 28A: Sinusoidal excitation data			
1-11	I10	JSEQ	Identification number = 3000.
11-20	F10.0	COF1	Amplitude of horizontal input wave. If KIK = 0, COF1 is displacement. If KIK = 1, COF1 is acceleration. If KIK = 2, COF1 is acceleration. If KIK = 3, COF1 is displacement. If KIK = 4, COF1 is dummy data.
21-30	F10.0	COF2	Angular velocity or frequency of horizontal input wave. If KIK = 0, COF2 is circular frequency (Hertz) If KIK = 2, COF2 is circular frequency (Hertz) If KIK = 3, COF2 is circular frequency (Hertz) If KIK = 4, COF2 is dummy data.
31-40	F10.0	COF3	Phase shift of horizontal input wave (radian).
41-50	F10.0	COF4	Amplitude of vertical input wave COF4 is same as COF1.
51-60	F10.0	COF5	Angular velocity or frequency of vertical input wave. COF4 is same as COF2.
61-70	F10.0	COF6	Phase shift of vertical input wave. COF6 is same as COF3.

Horizontal input displacement:

KIK = 0: (t = time)

$$u_0 = \mathrm{COF1} * \sin(\mathrm{COF2} * t - \mathrm{COF3})$$

KIK = 1:

$$u_0 = \frac{\mathrm{COF1}}{(2\pi * \mathrm{COF})^2} * \sin(2\pi * \mathrm{COF} * t - \mathrm{COF3})$$

$$\mathrm{COF} = Z1 + Z2 * t + Z3 * t + Z4 * t + Z5 * t + Z6 * t$$

Frequency COF is sweeping up or down from Z1 to COF2.

KIK = 2:

$$u_0 = \frac{\mathrm{COF1}}{(2\pi * \mathrm{COF2})^2} * \sin(2\pi * \mathrm{COF2} * t - \mathrm{COF3})$$

KIK = 3:

$$u_0 = \mathrm{COF1} * \sin(2\pi * \mathrm{COF} * t - \mathrm{COF3})$$

$$\mathrm{COF} = Z1 + Z2 * t + Z3 * t + Z4 * t + Z5 * t + Z6 * t$$

Frequency COF is sweeping up or down from Z1 to COF2.

Table 1 Continued

Column	Format	Variable	Description

Vertical input displacement:

KIK = 0:

$$w_0 = COF4 * \sin(COF5 * t - COF6)$$

KIK = 1:

$$w_0 = \frac{COF4}{(2\pi * COF)^2} * \sin(2\pi * COF * t - COF6)$$

$$COF = Z1 + Z2*t + Z3*t \ + Z4*t \ + Z5*t \ + Z6*t$$

Frequency COF is sweeping up or down from Z1 to COF2.

KIK = 2:

$$w_0 = \frac{COF4}{(2\pi * COF5)^2} * \sin(2\pi * COF5 * t - COF6)$$

KIK = 3:

$$w_0 = COF4 * \sin(2\pi * COF * t - COF6)$$

$$COF = Z1 + Z2*t + Z3*t \ + Z4*t \ + Z5*t \ + Z6*t$$

Frequency COF is sweeping up or down from Z1 to COF2.

Card 28B: Option for input wave data

Column	Format	Variable	Description
1-10	I10	KIK	Option for input wave data (See card 28A).
11-20	F10.0	Z1	Coefficient of polynominal function (See card 28A).
21-30	F10.0	Z2	
31-40	F10.0	Z3	
41-50	F10.0	Z4	
51-60	F10.0	Z5	
61-70	F10.0	Z6	

Card 28C: Seismic data (Random wave)

Column	Format	Variable	Description
1- 5	I5	KXK(1)	Option for horizontal data input.
6-10	I5	KXK(2)	Dummy.
11-15	I5	KXK(3)	Option for vertical data input.
21-30	F10.0	ALP	Multiplication factor for displacement.
31-40	F10.0	BET	Multiplication factor of velocity. KXK (I) = 0 : No-data. KXK (I) = 1 : Data input.

Card 28D: Number of seismic data and time step of data

Column	Format	Variable	Description
1- 4	I4	KIN(1, 1)	Number of horizontal displacement data.
21-30	F10.0	DDT(1, 1)	Time step.
	Next		
21-60	5F10.0	VX(1, 1, KXN(1, 1))	Horizonta displacement
	Next		
1- 4	I4	KXN(1, 2)	Number of horizontal velocity data.
21-30	F10.0	DDT(1, 2)	Time step.
	Next		
21-60	5F10.0	VS(1, 2, KXN(1, 2))	Horizontal velocity. If KXK(1) is zero, above four cards are not necessary.
	Next		
1- 4	I4	KXN(3, 1)	Number of vertical displacement data.
21-30	F10.0	DDT(3, 1)	Time step.
	Next		
21-60	5F10.0	VX(3, 1, KXN(3, 1))	Vertical displacement.

Table 1 Continued

Column	Format	Variable	Description
	Next		
1- 4	I4	KXN(3, 2)	Number of vertical velocity data.
21-30	F10.0	DDT(3, 2)	Time step.
	Next		
21-60	5F10.0	VX(3, 2, KXN(3, 2))	Vertical velocity. If KXK(3) is zero, above four cards are not necessary.
Card 29: Option for response curve plotting			
Card 29A: Plot option and maximum number of plot curves			
1-10	I10	JPLOT	Plot option. JPLOT = 0, no action. If JPLOT = 1, time history data are stored in the file 10 for response curve plotting using the post-processor SONWV-2V.
11-20	I10	MAXPLOT	Maximum number of plot curves.
Card 29B: Block number and kind of response curve plotting			
1-10	I10	KK	Column number of block to be plotted.
11-20	I10	LL	Row number of block to be plotted.
21-30	I10	JJ	Kind of response curve plotting. JJ = 1 : Rotation angle. JJ = 2 : Rotation angular velocity. JJ = 3 : Horizontal displacement. JJ = 4 : Horizontal velocity. JJ = 5 : Vertical displacement. JJ = 6 : Vertical velocity. JJ = 7 : Rotation angular acceleration. JJ = 8 : Horizontal acceleration. JJ = 9 : Friction force between blocks. JJ = 10: Friction force between blocks. JJ = 11: Moment due to friction force between blocks. JJ = 12: Vertical impact force. JJ = 13: Moment due to vertical impact force. JJ = 14: Dowel force. JJ = 15: Moment due to dowel force. JJ = 16: Horizontal impact force. JJ = 17: Moment due to horizontal impact force. JJ = 18: Weight and pressure difference force. JJ = 19: Moment due to weight and pressure difference force.

4.3 Description of Output Data

This section describes the output data from SONATINA-2V. SONATINA-2V prints out all of the input data as well as various time history results. To minimize the amount of output produced by the program, the user can choose options to select the output data. If print option IRRINT = 1 in the input card 25 in **Table 1**, only maximum displacement, velocity, acceleration, force and moment are printed out. If IRRINT = 0, the output consists of input data, displacement, velocity, acceleration, force and moment at a determined step interval, in addition to maximum displacement, velocity, acceleration, force and moment. The contents of these various output quantities are described in the followings.

(1) Input data

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

(2) Time history response value

Time history response values are printed at every print interval steps, which describe the response history as a function of time. The title of the analysis is printed at the top of the various output quantities for an easy identification to the problem. The following is a summary of the output data.

Time

- TIME – Current value of time (sec),

Displacement

- THA – Angular displacement (rad),
- U – Horizontal displacement,
- W – Vertical displacement,

Velocity

- THADF1 – Angular velocity (rad/s),
- UDF1 – Horizontal velocity,
- WDF1 – Vertical velocity,

Acceleration

- THADF2 – Angular acceleration,
- UDF2 – Horizontal acceleration,
- WDF2 – Vertical acceleration,

Force and moment

- WGM – Moment by gravity,
- FIF – Friction force at interface between upper and lower blocks,
- FIM – Moment by friction force,
- VRF – Vertical impact force at the center of the block,
- VRM – Moment by vertical impact force,
- DWF – Dowel force,
- DWM – Moment by dowel force,
- BKF – Boundary impact force at the center of the block,
- BKM – Moment by boundary impact force.

(3) Output summary

At the termination of a run, an output summary is printed to give all of the maximum displacements, rotations, velocities, accelerations, forces, and moments. The following is a description of the output summary data.

Maximum displacement, θ, u, w,

Maximum velocity, $\dot{\theta}, \dot{u}, \dot{w}$,

Maximum acceleration, $\ddot{\theta}, \ddot{u}, \ddot{w}$,

Maximum friction force,

Maximum friction force moment,

Maximum vertical impact force,

Maximum vertical impact moment,

Maximum vertical impact moment,

Maximum dowel force,

Maximum dowel moment,

Maximum boundary impact force,

Maximum boundary impact moment.

4.4 Post-processor

The computer program has two post-processors that are SONPL-2V and SONWV-2V as shown in **Fig. 10**. The SONPL-2V povides the users with graphical display output of the core behavior at determined time step. The SONWV-2V provides the users with graphical display output of the time history response curve of the each block.

The input data for SONPL-2V and SONWV-2V are summarized in **Tables 2** and **3**, respectively.

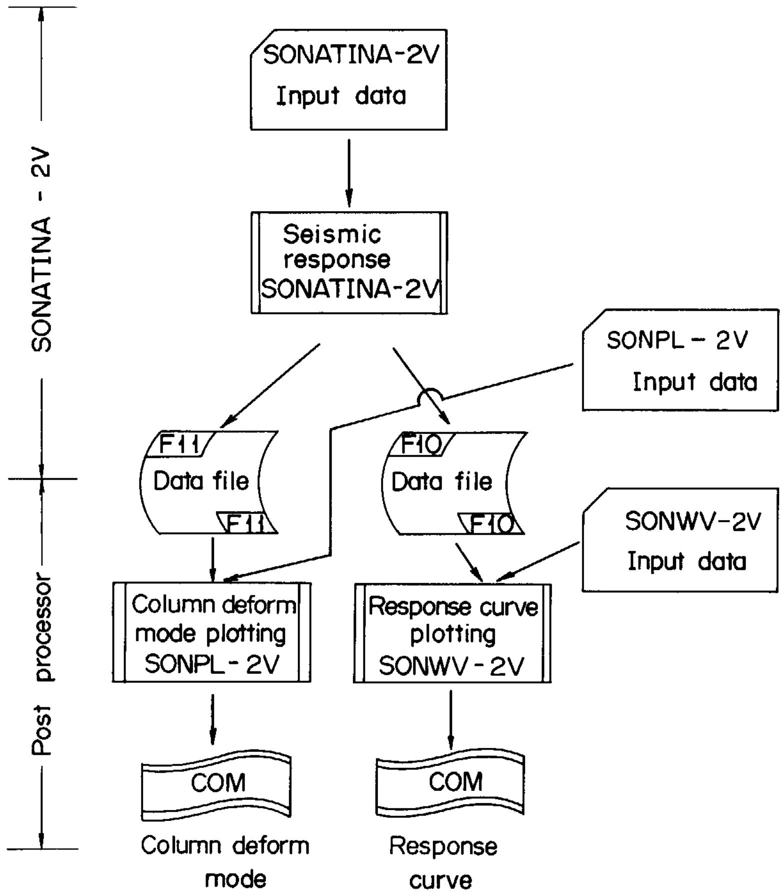


Fig. 10 Computer program SONATINA-2V and post-processors.

Table 2 Input data for post-processor SONPL-2V

Column	Format	Variable	Description
1-10	I10	JSEQ	Identification number = 200.
11-20	F10.0	SCL 1	Scaling factor of overall figure.
21-30	F10.0	SCL 2	Scaling factor for angle.
31-40	F10.0	SCL 3	Scaling factor for horizontal displacement.
41-50	F10.0	SCL 4	Scaling factor for vertical displacement.
51-60	F10.0	SCL 5	Scaling factor for gap width between blocks.

Table 3 Input data for post-processor SONWV-2V

Column	Format	Variable	Description
1-10	F10.0	XLENGT	X-axis length of plotter.
11-20	F10.0	YLENGT	Y-axis length of plotter.
21-30	I10	MMMM	Number of plotting wave in a single figure.

5. Some Examples and Discussions

The governing equations given in Chapter 3 can be solved numerically by using the Runge-Kutta-Gill and/or the Newton integration schemes. The geometry and weight of the block elements (shown in **Table 4**) are chosen in such a way that the analyzed system corresponds to an experimental VHTR core with dimension scaled by 1/2 and weight scaled by 1/4. The computation time interval is 2×10^{-4} seconds. The numerical results are compared with experimental results.[3] Calculation input data are described in Appendix B.

Table 4 Calculation data

Symbol	Unit	Column		Side reflector column
		Block Nos. 1~12	Top block	
a	cm	5.0		–
b	cm	7.25		–
C^B	kg·s/cm		7.85	
C^C	kg·s/cm	0.0		–
C^D	kg·s/cm	5.10		–
C^M	kg·s/cm	–		1.96×10^{-2}
C^V	kg·s/cm	9.81		–
d	cm	5.2		–
h	cm	14.25		
I	kg·s²/cm	0.924 (0.302)	1.75 (0.62)	–
K^B	kg/cm		1.24×10^4	
K^D	kg/cm	1.23×10^4		–
K^M	kg/cm	–	–	8300 (Hard)
K^{OP}	kg/cm	98.1		–
K^V	kg/cm	2.45×10^4		–
m	kg·s²/cm	0.0195 (0.0146)	0.0157 (0.0104)	
m_s	kg·s²/cm	–	–	0.054 (0.04)
n	–		13	–
δ	cm	0.2	0.05	
δ_L, δ_R	cm	0.05		
μ_k	–		0.2	
μ_s	–		0.2	

( ) shows short length block.

5.1 Effect of Input Acceleration Level

Figure 11 shows the relative displacement as a function of input acceleration level for harmonic excitation. In the figure, it can be seen that the calculated values are in good agreement with the experimental results at input accelerations of 100 and 500 Gal. At the 250 Gal level excitation, analytical results are lower than experimental values especially at excitation frequency 3 to 6 Hz. This frequency region is considered to be unstable. Concerning the unstable frequency, **Fig. 12** shows the resonance curve comparing the sweep-up with the sweep-down.

The sweep-down response is also presented in the figure to verify the nonlinear behavior of the multi-column vibration. As illustrated, the limit frequency for lumping in the sweep-down was slightly lower than in the sweep-up, defining an unstable region.

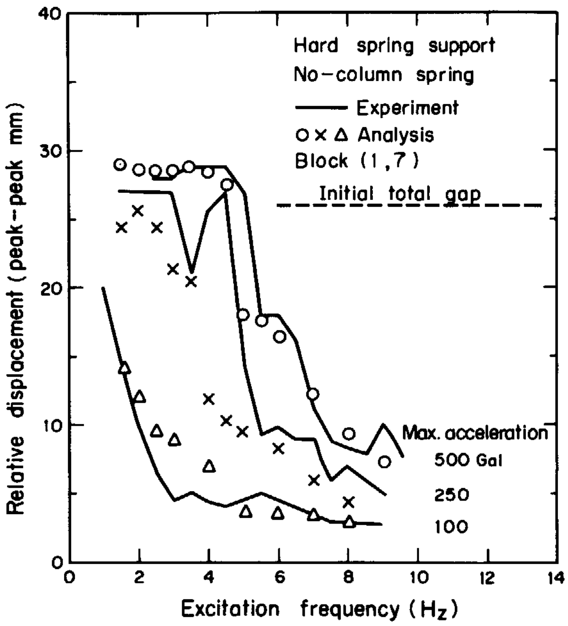


Fig. 11 Effect of input acceleration on relative displacement.

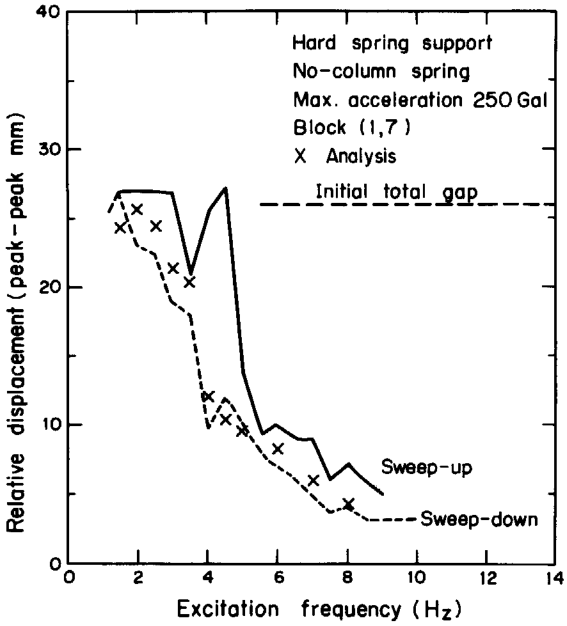


Fig. 12 Comparison between sweep-up and sweep-down responses.

The fact that the frequency of sudden decrease of displacement at the sweep-up is higher than at the sweep-down indicates that the system exhibits a nonlinear spring effect. The response curve shows hysteresis characteristics. In the unstable region, analytical values of response displacements are slightly apart from experimental ones.

Figure 13 shows the comparison between experiment and analysis of the boundary reaction force as a function of input accleration level for harmonic excitation. The agreement is good for the lower reaction force, but less satisfactory for strong reaction force.

It is seen that resonance frequency is strongly amplitude-dependent and increases with an increase in excitation level. The system exhibits a spring hardening effect, which means that the jump frequency will increase with an increase in excitation acceleration level.

5.2 Impact Reaction Forces along Column

Figure 14 shows the distribution of impact reaction forces along the column and compares the analytical results with the experimental values. Analytical results show a favorable correlation with the results of the experiments.

5.3 Effect of Side Reflector Support Stiffness

Displacement response characteristic is shown in **Fig. 15** comparing with three kinds of lateral support stiffness, hard, intermediate and soft spring support. These spring constants are shown in **Table 5**. In the low excitation frequency, the maximum column displacement decreases with increasing lateral support stiffness, while the opposite is observed in the high excitation frequency. In the figure, it can be seen that the analytical results are in good agreement with the experimental results. It is thus indicated that the harder lateral support stiffness is, the smaller the column displacement becomes.

Figure 16 shows the impact reaction force characteristic comparing analysis and experiment as a parameter of the lateral support stiffness. Hard support stiffness is found to give a large impact force in comparison with soft or intermediate stiffness. In the low excitation frequency, a lateral support with intermediate stiffness affords a smaller impact force than that with soft support. In the figure, it can be seen that analytical results are fairly in agreement with the experimental results.

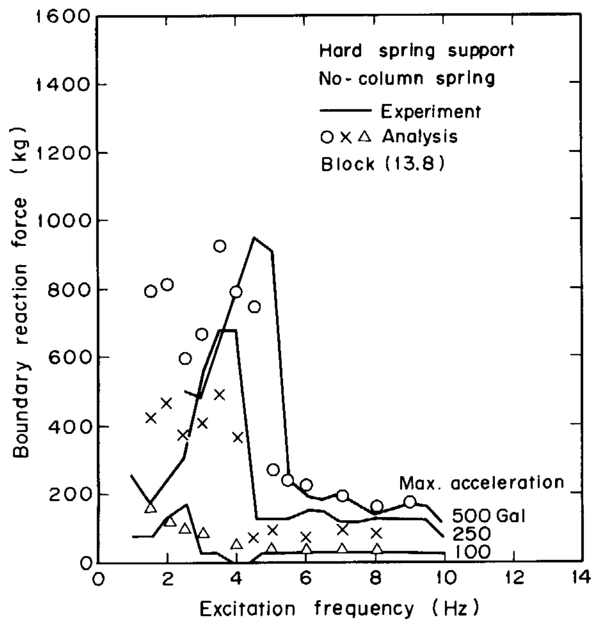


Fig. 13 Effect of input acceleration on boundary reaction force.

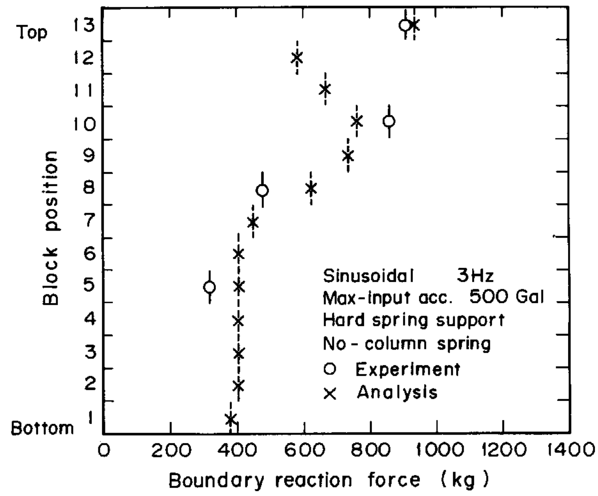


Fig. 14 Boundary reaction force distribution along column.

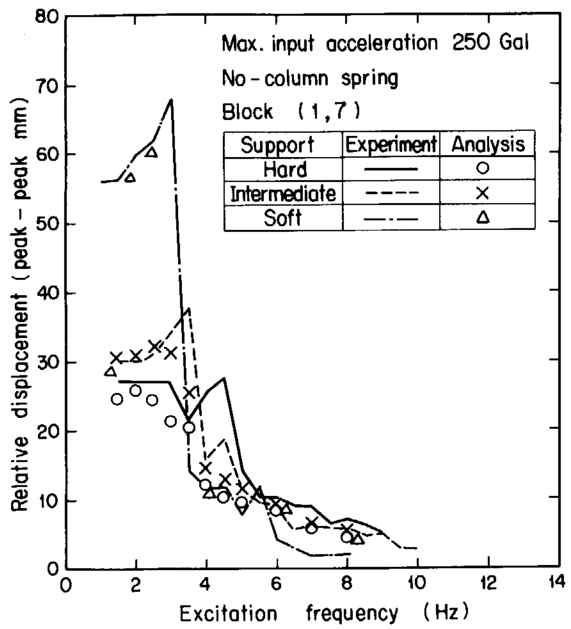


Fig. 15 Effect of support stiffness on relative displacement.

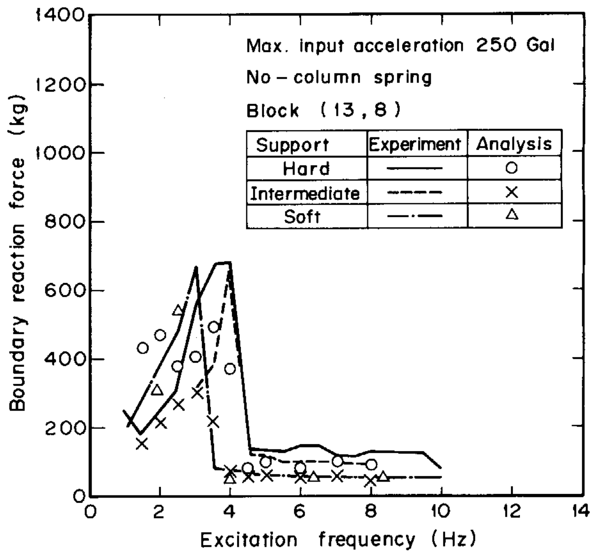


Fig. 16 Effect of support stiffness on boundary reaction force.

Table 5 Spring constant of side support structure

Support spring			Spring constant (kg/cm)	
			Referector block (per one spring)	Support plate
Hard			8300	6000
Intermediate			600	740
Soft	Displacement (cm)	0<δ<1.1	40	40
		1.1<δ<5.5	800	800
		δ > 5.5	8300	6000

5.4 Dowel Force

It is important to evaluate the stresses of dowel pins and its holes since the structural design of dowel pin and hole is often the most weak portion of a fuel block for seismic load. In the experiment, measurement of dowel force is made.

The curves in **Fig. 17** illustrate that the block dowel force frequency response is compared between analysis and experiment values. Analytical values show a favorable correlation with experimental ones.

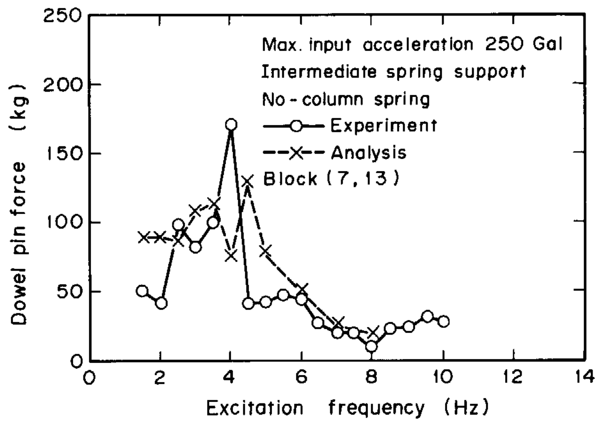


Fig. 17 Dowel pin shear force.

6. Conclusions

The author has developed a computer program SONATINA-2V for dynamic analysis of a two-dimensional vertical slice core model of HTGR core.

The calculation equations have been presented and the numerical results were compared with the results of the experiments. The following conclusions have been drawn:

(1) The analytical results agree well with experimental data for horizontal forced vibration of a series of many interacting stacked columns.

(2) The present method can be used to compute forces and moments of dowel pins and around holes. Analytical values of dowel pin forces are in good agreement with the experimental ones.

Acknowledgements

The author is indebted Mr. T. Nakazawa in Century Research Center, Ltd., Co. for help of making the computer program.

References

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(4) Ikushima T.: "Seismic Response Analysis for Prismatic Fuel HTGR Core", JAERI-M 8273 (1979).
(5) Ikushima T. and Honma T.: "Simplified Analytical Model for HTGR Core Seismic Response", J. Nucl. Sci. Technol. (Tokyo), **16**, 605 (1979).

Nomenclature

a : block rocking spring half width
b : block geometric half width
C : damping coefficient
C^B : damping coefficient associated with ε
C^C : damping coefficient of displacement detector
C^D : damping coefficient associated with β
C^M : damping coefficient of reflector restraint structure
C^V : damping coefficient associated with γ
d : distance of dowel from block center line
F^{BL} : horizontal collision force acting at bottom of left side
F^{BR} : horizontal collision force acting at bottom of right side
F^{DL} : dowel force acting at left dowel
F^{DR} : dowel force acting at right dowel
F^F : friction force acting at horizontal interface between blocks
F^M : reflector restraint force
F^{ML} : horizontal collision force acting at upper-middle of left side
F^{MR} : horizontal collision force acting at upper-middle of right side
F^{NL} : horizontal collision force acting at lower-middle of left side
F^{NR} : horizontal collision force acting at lower-middle of right side
F^{OP} : restraint force between top orifice blocks
F^{RF} : friction force acting at horizontal interface between reflectors
F^P : vertical gas pressure force acting at block center
F^{TL} : horizontal collision force at top of left side
F^{TR} : horizontal collision force at top of right side
F^{VL} : vertical collision force acting at left corner
F^{VR} : vertical collision force acting at right corner
$f(v)$: prescribed function for friction characteristics
g : gravity constant
h : block half height
I : block mass moment of intertia
K^B : spring constant associated with ε
K^D : spring constant associated with β
K^M : spring constant of side reflector restraint structure
K^V : spring constant associated with γ
m : block mass
m_s : mass of core support plate
n : total number of blocks in column
u : horizontal block displacement at center gravity
u_o : boundary displacement
u_S : core support plate displacement
v : velocity
w : vertical block displacement at center gravity
w_O : boundary vertical displacement
W^L : vertical forces due to block weight and pressure difference acting at lower part of block
W^U : vertical forces due to block weight and pressure difference acting at upper part of block

β : dowel spring deformation

γ : spring deformation of a spring-dashpot unit at interface between blocks

δ : initial gap between blocks

δ_L : gap on left side of dowel

δ_R : gap on right side of dowel

ε : spring deformation of a spring-dashpot unit at between block and boundary impact plate

θ : block rotation

μ_k : dynamic coefficient of friction

μ_s : static coefficient of friction

ω : relative velocity between dowel pin and hole.

Appendix A Impact Models[4]

A.1 Models

In the block-type fuel core, this group of blocks extends in so-called three dimensions. In the present study, the following simplified models as shown in **Fig. A.1** through **A.3** will be considered for calculations.

(1) The blocks at the top are restrained by the orifice block with some stiffness and damping.

(2) The blocks at the bottom are restrained by the core support plate with some stiffness and damping.

(3) The blocks are restrained by three dowels and dowel pins with some stiffness and damping.

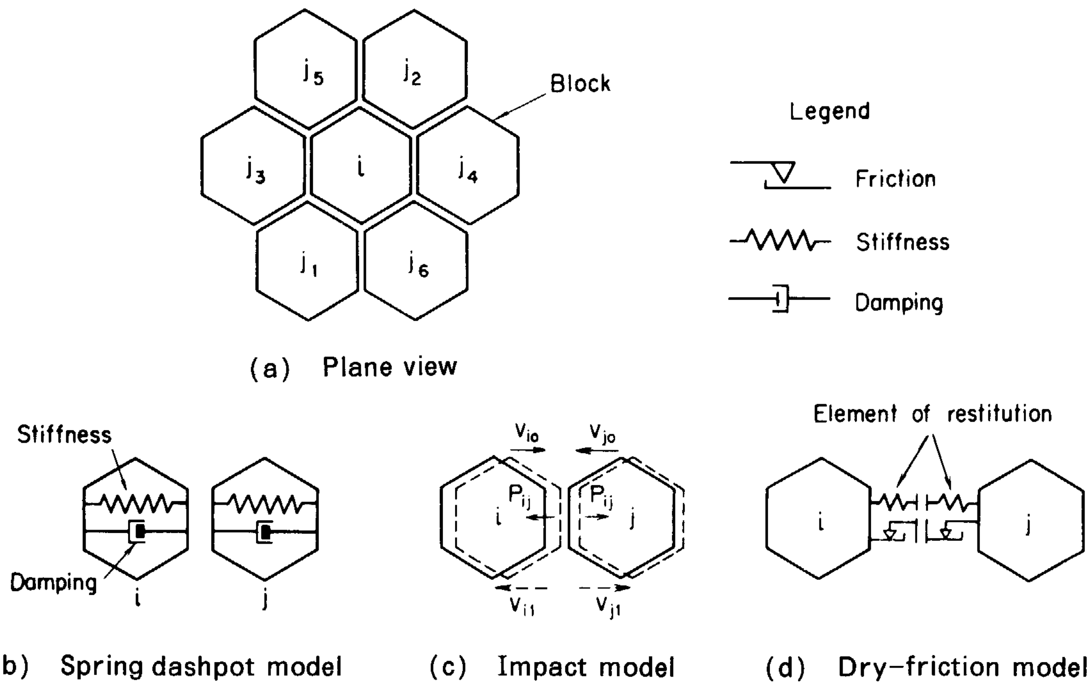

Fig. A.1 Fuel element arrangement and impact calculation models.

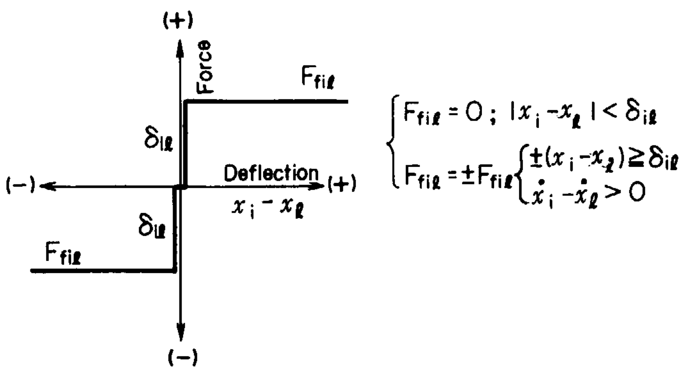

Fig. A.2 Calculation model for friction.

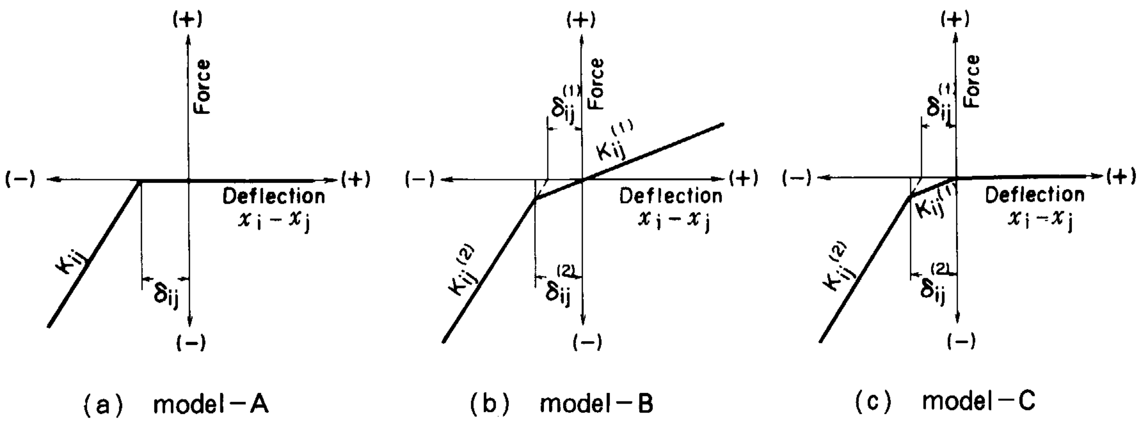

Fig. A.3 Calculation model for discontinuous mass system.

(4) The blocks in the core periphery are restrained with the restrained structure with some stiffness and damping.

(5) Frictions exist between blocks as shown in **Fig. A.2**.

(6) It can be conceivable two models for the mass of blocks:

(i) each blocks are lumped mass (L-mass type),

(ii) each blocks are consistent mass (C-mass type).

(7) It can be conceivable three models for the impact phenomena as shown in **Fig. A.1**:

(i) spring dashpot model (S-impact type),

(ii) impact model (I-impact type),

(iii) dry-friction model (D-impact type).

(8) Six calculation models can be conceivable according to the above (6) and (7) combination:

(a) L-S model (Lumped mass-Spring dashpot type model),

(b) L-I model (Lumped mass-Impact type model),

(c) L-D model (Lumped mass-Dry-friction type model),

(d) C-S model (Consistent mass-Spring dashpot type model),

(e) C-I model (Consistent mass-Impact type model),

(f) C-D model (Consistent mass-Dry-friction type model).

A.2 Formulae

A.2.1 General Formulae

In **Fig. A.1** through **A.3** the equation of motion for block i at the core center, with its position in absolute coordinate of X, is then given as

$$C_{il}(\dot{X}_i - \dot{X}_l) + K_{il}(X_i - X_l) - C_{ki}(\dot{X}_k - \dot{X}_i) - K_{ki}(X_k - X_i) \pm F_{fil} \pm - F_{fki} = -m_i \ddot{X}_i + F_p \,, \tag{A.1}$$

where F_p is the force form surrounding mass points. With x as the local coordinate from the core barrel instead of X, and $x_i = X_i - X_o$, Eq. (A.1) takes the following form:

$$m_i \ddot{x}_i + C_{il}(\dot{x}_i - \dot{x}_l) + K_{il}(x_i - x_l) - C_{ki}(\dot{x}_k - \dot{x}_i) - K_{ki}(x_k - x_i) \pm F_{fil} \pm F_{fki} = -m_i \ddot{x}_o + F_p \,. \tag{A.2}$$

In Eqs. (A.1) and (A.2), suffix zero mean the core barrel, and hence evidently $x_o = X_o$. The equation of motion for a block l adjoining the core barrel, with stiffness coefficient and damping coefficient of the restraint structure of K_{Bi} and C_{Bi} , respectively, is similarly given as

$$m_i\ddot{x}_i+C_{Bi}\dot{x}_i+K_{Bi}x_i+C_{il}(\dot{x}_i-\dot{x}_l)+K_{il}(x_i-x_l)-C_{ki}(\dot{x}_k-\dot{x}_i)-K_{ki}(x_k-x_i)$$
$$\pm F_{fij}+F_{fki}=-m_i\ddot{x}_0+F_p\,. \qquad (A.3)$$

A.2.2 Spring Dashpot Model

In Eqs. (A.2) and (A.3), if the mass i is in coupled state with its surrounding masses, F_p is given as

$$F_p=-\{\sum_j C_{ij}(\dot{x}_i-\dot{x}_j)+\sum_j K_{ij}(x_i-x_j+\delta_{ij})\}\,. \qquad (A.4)$$

Concerning the effect of gap between blocks, as shown in **Fig. A.3**, the three different models can be conceivable.

(1) Model-A: no restraint in the gap

In **Fig. A.3 (a)**, when the two adjoining masses i and j contact, there exist stiffness coefficient K_{ij} and damping coefficient C_{ij} in Eqs. (A.4) and (A.5). And if they do not, both the values are zero.

$$\left.\begin{array}{ll} K_{ij}=C_{ij}=0\,, & |x_i-x_j|\geqq-\delta_{ij}\,, \\ \left.\begin{array}{l} K_{ij}=k_{ij} \\ C_{ij}=C_{ij} \\ \delta_{ij}=\delta_{ij} \end{array}\right\}, & |x_i-x_j|<-\delta_{ij}\,. \end{array}\right\} \qquad (A.5)$$

(2) Model-B: some restraint in the gap

In **Fig. A.3 (b)**, depending on the fact whether the masses i and j contact or not, the K_{ij} and C_{ij} in Eq. (A.4) take the different values:

$$\left.\begin{array}{ll} \left.\begin{array}{l} K_{ij}=K_{ij}^{(1)},\, C_{ij}=C_{ij}^{(1)} \\ \delta_{ij}=0 \end{array}\right\}, & |x_i-x_j|\geqq-\delta_{ij}\,, \\ \left.\begin{array}{l} K_{ij}=K_{ij}^{(2)},\, C_{ij}=C_{ij}^{(2)} \\ \delta_{ij}=\delta_{ij}^{(2)} \end{array}\right\}, & |x_i-x_j|<-\delta_{ij}\,. \end{array}\right\} \qquad (A.6)$$

(3) Model-C: some restraint in the gap with limitation

In **Fig. A.3 (c)**, depending on the condition if the two masses contact or not, the K_{ij} and C_{ij} in Eq. (A.4) are different. When the masses i and j are separated beyond a certain distance, however, both the values become zero.

$$\left.\begin{array}{ll} K_{ij}=C_{ij}=0, & |x_i-x_j|\geqq0\,, \\ \left.\begin{array}{l} K_{ij}=K_{ij}^{(1)},\, C_{ij}=C_{ij}^{(1)} \\ \delta_{ij}=0 \end{array}\right\}, & 0>|x_i-x_j|\geqq-\delta_{ij}^{(2)}\,, \\ \left.\begin{array}{l} K_{ij}=K_{ij}^{(2)},\, C_{ij}=C_{ij}^{(2)} \\ \delta_{ij}=\delta_{ij}^{(1)} \end{array}\right\}, & |x_i-x_j|>\delta_{ij}^{(2)}\,. \end{array}\right\} \qquad (A.7)$$

As seen, above equations are nonlinear, and of these three models, Model-A can be applied to the motion of blocks when there exists some gap between them in horizontal direction. And Model-B and C are applicable to the case when the adjoining blocks are joined together with key and keyway.

(4) Compressive force in block

With the stiffness coefficient K_{ij} between blocks and restraint in the gap, the force acting on the mass points i and j with gap δ is given as

$$\left.\begin{array}{ll} P_{ij}=0\,, & \text{If } |x_i-x_j|\geqq\delta_{ij} \\ P_{ij}=K_{ij}(x_i-x_j+\delta_{ij}), & \text{If } |x_i-x_j|<\delta_{ij} \end{array}\right\} \qquad (A.8)$$

where the compressive force at one side of a block is P_{ij}. When it is compressed on both sides, however, the total compressive force in the block is $P_{ij}+P_{ki}$, where P_{ki} is due to block k on the other side.

A.2.3 Impact Model

In the impact model, the impulse and momentum technique for the collision is used. The velocity and the collision force after collision are calculated from the impulse-momentum equation.

$$\left.\begin{aligned} v_{i1} &= \frac{(m_i v_{io}+m_j v_{jo})-em_j(v_{io}-v_{jo})}{m_i+m_j}, \\ v_{i1} &= \frac{(m_i v_{io}+m_j v_{jo})+em_i(v_{io}-v_{jo})}{m_i+m_j}, \\ F &= \frac{(v_{jo}-v_{io})(1+e)}{t_c}\cdot\frac{m_i m_j}{m_i+m_j}\ . \end{aligned}\right\} \qquad \text{(A.9)}$$

A.2.4 Dry-friction Model

This model is a combination of impact and spring dashpot model. In Eqs. (A.2) and (A.3), F_p are given as

$$F_p = \begin{cases} K_{ij}(x_i-x_j)+\dfrac{K_{ij}(1-e)}{1+e}(x_i-x_j), & \dot{x}\geqq 0 \\ K_{ij}(x_i-x_j)-\dfrac{K_{ij}(1-e)}{1+e}(x_i-x_j), & \dot{x}\leqq 0 \end{cases} \qquad \text{(A.10)}$$

A.2.5 Relation between Coefficient of Restitution and Damping Coefficient

The relation between the coefficient of restitution and the damping coefficient will be given on the assumption (see Appendix B).

A.2.6 Comparison of Impact Model

The calculation has been performed with the above three models, and the results are shown in **Fig. A.4**.

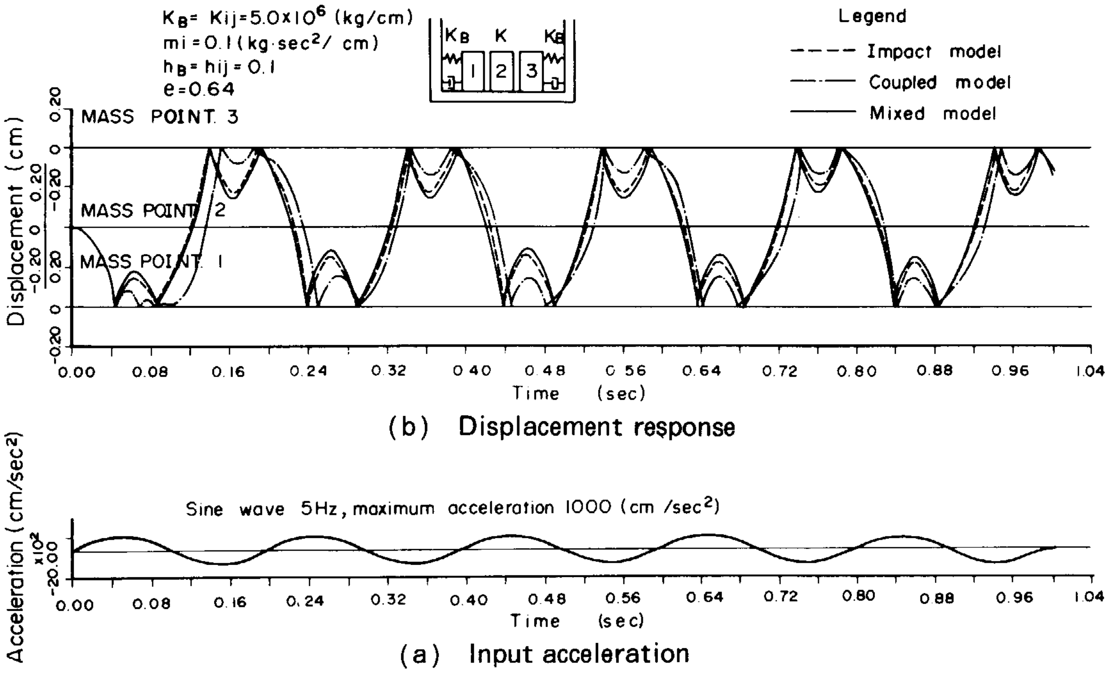

Fig. A.4 Comparison of three impact models on response.

Appendix B Input Data[5]

This section describes calculation input data. The important dynamic properties of the core are considered to be fuel block collision contact time and the coefficient of restitution, both measured in the fuel block collision tests. These properties were used to determine the spring constant and damping coefficient of the impact mechanisms for the blocks in the calculation program.

B.1 Spring Constant

The static stiffness of the elements is not used as the impact mechanism stiffness because it did not yield and adequate inter-element collision model. The static spring constant, however, is appropriately applied to the restraint structure of the side reflector block because this structure approximated simple massless structure relative to the fuel blocks with which they interact. The spring constants for two-body impact are obtained by Hertz's theorem for local deformation spring or element impact tests.

B.2 Damping Coefficient in Viscoelastic Impact Model

Let us consider a damping coefficient in the viscoelastic impact model. In the study, impact behavior is confined to elastic bodies impacting one another, and it is represented by the viscoelastic element shown in **Fig. 5**. The kinematic energy of impact bodies, the potential energy of elastic spring and the dissipation energy of dashpot are written as follows:

$$T=\frac{1}{2}m\dot{x}_1+\frac{1}{2}m\dot{x}_2^2\ ,\quad U=\frac{1}{2}K(x_1-x_2-\delta_{12})^2\ ,\quad F=\frac{1}{2}C(\dot{x}_1^2-\dot{x}_2^2)^2 .$$

The Lagrange equations of motion are written as

$$\frac{d}{dt}\cdot\frac{\partial T}{\partial \dot{x}}+\frac{\partial U}{\partial x}+\frac{\partial F}{\partial \dot{x}}=0\ , \tag{B.1}$$

$$m\ddot{x}_1+C(\dot{x}_1-\dot{x}_2)+K(x_1-x_2-\delta_{12})=0\ , \tag{B.2}$$

$$m\ddot{x}_2+C(\dot{x}_2-\dot{x}_1)+K(x_2-x_1+\delta_{12})=0\ . \tag{B.3}$$

Assume the following particular solutions of Eqs. (B. 2) and (B. 3),

$$x_1=a_0+a_1t+a_2e^{\lambda t}\ ,\qquad x_2=b_0+b_1t+b_2e^{\lambda t}\ , \tag{B.4}$$

where $a_0, a_1, a_2, b_0, b_1, b_2$ and λ are constants. And the initial conditions are given as follows:

$$x_1=0\ ,\ x_2=-\delta_{12},\ v_1=\dot{x}_1=0\ ,\ v_2=\dot{x}_2=0\ ,\ t=0. \tag{B.5}$$

We have the following equations from Eqs. (B.4) and (B.5),

$$a_0=0\ ,\ a_1=a_2\lambda=0\ ,\ b_0=-\delta_{12}\ ,\ b_0+b_2\lambda=v_2\ . \tag{B.6}$$

Substituting Eq. (B.6) into Eq. (B.4), it gives

$$x_1=a_1t+a_2e^{\lambda t}\ ,\quad x_2=-\delta_{12}+b_1t+b_2e^{\lambda t}\ . \tag{B.7}$$

Substitution of Eq. (B.7) into Eqs. (B.2) and (B.3) yields

$$\left.\begin{aligned}(C+Kt)(a_1-b_1)+e^{\lambda t}\{ma_2\lambda^2+C(a_2+b_2)\lambda+K(a_2-b_2)\}=0\ ,\\ (C+Kt)(b_1-a_1)+e^{\lambda t}\{ma_2\lambda^2+C(b_2-a_2)\lambda+K(b_2-a_2)\}=0\ .\end{aligned}\right\} \tag{B.8}$$

Since Eqs. (B.8) are satisfied generally at any times, equations below are derived:

$$a_1=b_1,\quad a_2+b_2=0\,,\quad a_2-b_2=-\frac{v_2}{\lambda}\,. \tag{B.9}$$

From Eqs. (B.6) and (B.9),

$$a_1=b_1=\frac{v_2}{2}\,. \tag{B.10}$$

Hence we obtain the so-called characteristic equation from Eqs. (B.8),

$$(m\lambda^2+2C\lambda+2K)a_2e^{\lambda t}=0 \text{ or } \lambda^2+2\omega_n h+\omega_n^2=0\,, \tag{B.11}$$

where $$\omega_n\equiv\sqrt{2K/m}\,,\quad C_c\equiv\sqrt{2mK}\,,\quad C/C_c\equiv h\,, \tag{B.12}$$

$$\lambda=\omega_n(-h\pm\sqrt{h^2-1}\,)\,. \tag{B.13}$$

Since the impact takes place as an internal damping, the damping factor is smaller than 1. Equation (B.13) becomes

$$\lambda=\omega_n(-h\pm\sqrt{1-h^2}\,)\,, \tag{B.14}$$

or $$\lambda=\omega_n(-h+\sqrt{1-h^2}\,)\,. \tag{B.15}$$

Substituting Eqs. (B.10) and (B.15) into (B.7), we get

$$\left.\begin{aligned} x_1&=\frac{v_2}{2}t+a_2\exp(-h\omega_n t+i\omega_n\sqrt{1-h^2}t\,)\,,\\ x_2&=-\delta_{12}+\frac{v_2}{2}t+b_2\exp(-h\omega_n t+i\omega_n\sqrt{1-h^2}t\,)\,, \end{aligned}\right\} \tag{B.16}$$

$$\left.\begin{aligned} x_1&=\frac{v_2}{2}t+a_2\exp(-h\omega_n t)\sin\omega_n\sqrt{1-h^2}t\,,\\ x_2&=-\delta_{12}+\frac{v_2}{2}t+b_2\exp(-h\omega_n t)\sin\omega_n\sqrt{1-h^2}t\,. \end{aligned}\right\} \tag{B.17}$$

Applying the initial conditions, we obtain the relations:

$$\frac{v_2}{2}+a_2\omega_n\sqrt{1-h^2}=0\,,\quad (t=0\,;\,\dot{x}=0)$$

$$\frac{v_2}{2}+b_2\omega_n\sqrt{1-h^2}=v_2\,,\quad (t=0\,;\,\dot{x}=v_2)\,,$$

which are solved for a_2 and b_2 to give

$$a_2=-\frac{1}{\omega_2\sqrt{1-h^2}}\cdot\frac{v_2}{2}\,,\qquad b_2=\frac{1}{\omega_n\sqrt{1-h^2}}\cdot\frac{v_2}{2}\,.$$

Therefore after the impact, Eq. (B.17) becomes, with the initial conditions,

$$\left.\begin{aligned} x_1&=\frac{v_2}{2}t-\frac{1}{\omega_n\sqrt{1-h_2}}\cdot\frac{v_2}{2}\exp(-h\omega_n t)\sin\omega_n\sqrt{1-h^2}t\,,\\ x_2&=-\delta_{12}+\frac{v_2}{2}t+\frac{1}{\omega_n\sqrt{1-h^2}}\cdot\frac{v_2}{2}\exp(-h\omega_n t)\sin\omega_n\sqrt{1-h^2}t\,. \end{aligned}\right\} \tag{B.18}$$

Since $x_1-x_2=\delta_{12}$ when two bodies leave each other after impact, from Eq. (B.18) the contact time is derived as

$$-\frac{1}{\omega_n\sqrt{1-h^2}}v_2\exp(-h\omega_n t)\sin\omega_n\sqrt{1-h^2}t=0\,,$$

or $$\omega_n\sqrt{1-h^2}\,t_c=\pi\,,\qquad t_c=\frac{\pi}{\omega_n\sqrt{1-h^2}}\,,$$

where t_c is the contact time. Velocities of the two impacting bodies after impact are given as:

$$(\dot{x}_1)_{t=t_c}=\frac{v_2}{2}+\frac{v_2}{2}\exp(-h\omega_n t_c)=\frac{v_2}{2}(1+\exp(-h\omega_n t_c)),$$

$$(\dot{x}_2)_{t=t_c}=\frac{v_2}{2}-\frac{v_2}{2}\exp(-h\omega_n t_c)=\frac{v_2}{2}(1-\exp(-h\omega_n t_c)).$$

The coefficient of restitution η is given by

$$\eta=\frac{(\dot{x}_2)_{t=t_c}-(\dot{x}_1)_{t=t_c}}{v_2}, \quad \text{(B.19)}$$

or

$$\eta=\exp(-h\omega_n t_c)=\exp\left(-\frac{\pi h}{\sqrt{1-h^2}}\right). \quad \text{(B.20)}$$

In the model, the relation between the damping factor h and the coefficient of restitution η is thus obtained, and from Eq. (B.12) the relation between the damping factor h and the damping coefficient C is also obtained:

$$C=\sqrt{2\pi K}h, \quad \text{(B.21)}$$

or

$$C=2m\omega_n h=2mh(2\pi f_n). \quad \text{(B.22)}$$

Since the coefficient of restitution η, the contact time t_c and the natural frequency ω_n are obtained from the experimental data, the damping factor h is calculated using the Eq. (B.20). Finally the damping coefficient can be calculated from Eq. (B.22).

Appendix C Sample Problem Input

```
                                                                                 PAGE-0001
          ********************
          *                  *
          * INPUT DATA LIST  *
          *                  *
          ********************

....*....1....*....2....*....3....*....4....*....5....*....6....*....7....*....8
    SONATINA-2V SAMPLE PROBLEM SINUSOIDAL INPUT 4.0 HZ 250 GAL
     100      12.0      13.0
     200       1.0       1.0                          19.1      0.0195    0.924
     200       2.0       1.0                          14.3      0.0146    0.302
     200       5.0       1.0                          14.3      0.0146    0.302
     200       8.0       1.0                          14.3      0.0146    0.302
     200      11.0       1.0                          14.3      0.0146    0.302
     200      12.0       1.0                          19.1      0.0195    0.924
     200       1.0      13.0                          10.2      0.0104    0.62
     200       2.0      13.0                          15.4      0.0157    1.75
     200       5.0      13.0                          15.4      0.0157    1.75
     200      11.0      13.0                          15.4      0.0157    1.75
     200       8.0      13.0                          15.4      0.0157    1.75
     200      12.0      13.0                          10.2      0.0104    0.62
     210       3.0       4.0       1.0       1.0      19.1      0.0195    0.924
     210       6.0       7.0       1.0       1.0      19.1      0.0195    0.924
     210       9.0      10.0       1.0       1.0      19.1      0.0195    0.924
     210       3.0       4.0      13.0      13.0      10.2      0.0104    0.62
     210       6.0       7.0      13.0      13.0      10.2      0.0104    0.62
     210       9.0      10.0      13.0      13.0      10.2      0.0104    0.62
     210       1.0      12.0       2.0      12.0      19.5      0.0195    0.924
     210      13.0      14.0       1.0       1.0      39.0      0.04      1.6
     210      13.0      14.0       2.0      13.0      52.8      0.054     2.05
     250       1.0       1.0                          14.25     7.23
     250       2.0       1.0                          10.7      7.23
     250       5.0       1.0                          10.7      7.23
     250       8.0       1.0                          10.7      7.23
     250      11.0       1.0                          10.7      7.23
     250      12.0       1.0                          14.25     7.23
     250       1.0      13.0                          10.7      7.23
     250       2.0      13.0                          14.25     7.23
     250       5.0      13.0                          14.25     7.23
     250       8.0      13.0                          14.25     7.23
     250      11.0      13.0                          14.25     7.23
     250      12.0      13.0                          10.7      7.23
     260       3.0       4.0       1.0       1.0      14.25     7.23
     260       6.0       7.0       1.0       1.0      14.25     7.23
     260       9.0      10.0       1.0       1.0      14.25     7.23
     260       3.0       4.0      13.0      13.0      10.7      7.23
     260       6.0       7.0      13.0      13.0      10.7      7.23
     260       9.0      10.0      13.0      13.0      10.7      7.23
     260       1.0      12.0       2.0      12.0      14.25     7.23
     260      13.0      14.0       1.0       1.0      10.7      7.23
     260      13.0      14.0       2.0      13.0      14.25     7.23
     310       1.0      12.0       1.0      13.0      -5.2      5.2
     360       1.0      12.0       1.0      13.0      -2.5      2.5
     410       1.0      13.0       1.0      12.0       0.2
     410       1.0      13.0      13.0      13.0       0.05
     460       1.0      12.0       1.0      13.0       0.05      0.05
     510       1.0      12.0       1.0      13.0       0.05      0.05
....*....1....*....2....*....3....*....4....*....5....*....6....*....7....*....8

*** CONTINUE ***

                                                                                 PAGE-0002
          ********************
          *                  *
          * INPUT DATA LIST  *
          *                  *
          ********************

....*....1....*....2....*....3....*....4....*....5....*....6....*....7....*....8
     560       1.0      12.0       1.0      13.0      25000.0
     610       1.0      12.0       1.0      13.0      10.0
     660       1.0      12.0       1.0      13.0      12500.0
     710       1.0      12.0       1.0      13.0       5.2
     760       1.0      14.0       1.0      13.0      12600.0
     810       1.0      14.0       1.0      13.0       8.0
     860       1.0       2.0       1.0      13.0       8300.0    0.02
     870         1         3                                   1
     870         4         6                                   2
     870         7         9                                   3
     870        10        12                                   4
     880         1         4                           100.0
     900                                              0.365     0.01      3300.0
     910                                              6000.0    0.02
     960       1.0      14.0       1.0      13.0
    1010       1.0      14.0       1.0      13.0
    1060       1.0      12.0       1.0      13.0       0.0
    1110       1.0      14.0       1.0      13.0       0.2
    1130    0.2
    1200    0.0        1.0    7160.0       0.0
    1250    0.0        1.6       0.0002     20.0
    1300 50000.0   50000.0    50000.0     1.0        1.0
    1310 10000.0   10000.0    10000.0      100.0       20.0
    3000   0.3958   25.132                0.3958    25.132
       0
       1        20
       1         3         3
       1         7         3
       1         8         3
       1        11         3
       1        13         3
       6         3         3
       6         7         3
       6         8         3
       6        11         3
       6        13         3
      12         6        16
      12         8        16
      12         9        16
      12        10        16
      12        13        16
       1         6        16
       1         8        16
       1         9        16
       1        10        16
       1        13        16
....*....1....*....2....*....3....*....4....*....5....*....6....*....7....*....8

*** INPUT DATA END ***
```

Appendix D Sample Problem Output

```
                    SONATINA-2V SAMPLE PROBLEM SINUSOIDAL INPUT 4.0 HZ 250 GAL            SONATINA-2V


**                                 **
*    INFORMATION OF RESTART         *
**                                 **

TIMS ( RESTART TIME ) =          1.600066D+00

THE STATE  AT  RESTART TIME
WAS  WRITTEN
AS  THE INITIAL STATE
TO  RESTART TAPE(51)



**                                 **
*   DIMENSION                       *
**                                 **

... SECURE WORDS ...
   26000
... USED   WORDS ...
   25772



**                                 **
*    CALUCULATION SYSTEM            *
**                                 **

NO. OF MASS                              ( M=   12 ,   N=   13    )

TIMS     ( START TIME          )  =            0.0
TIMEND   (    END TIME         )  =            1.600000D+00
TIMSP    (        TIME STEP    )  =            2.000000D-04
TIMOP1   (        TIME OPTION
                     NO.1      )  =            2.000000D+01

JCPRBG   ( BEGIN OF CYCLE OF DISPLACEMENT , VELOCITY , ACCELERATION  PRINT       )  =          50000
JCPRSP   ( STEP  OF CYCLE OF DISPLACEMENT , VELOCITY , ACCELERATION  PRINT       )  =          10000
JCFMBG   ( BEGIN OF CYCLE OF FORCE , MOMENT                          PRINT       )  =          50000
JCFMSP   ( STEP  OF CYCLE OF FORCE , MOMENT                          PRINT       )  =          10000
JCMXBG   ( BEGIN OF CYCLE OF MAX VALUE                               PRINT       )  =          50000
JCMXSP   ( STEP  OF CYCLE OF MAX VALUE                               PRINT       )  =          10000
JCPLBG   ( BEGIN OF CYCLE OF PICKING UP OF DISPLACEMENT DATA FOR PLOTTING        )  =              1
JCPLSP   ( STEP  OF CYCLE OF PICKING UP OF DISPLACEMENT DATA FOR PLOTTING        )  =            100
JCP2BG   ( BEGIN OF CYCLE OF PICKING UP OF TIME HISTORY DATA FOR PLOTTING        ) =               1
JCP2SP   ( STEP  OF CYCLE OF PICKING UP OF TIME HISTORY DATA FOR PLOTTING        ) =              20

JPLOT    ( TIME HISTORY DATA -- 0/1 -- NO PLOTTING / PLOTTING                     )  =             1
MAXPLT   ( NUMBER OF PLOTTING KIND                                               )  =             20

   *THA...... 1 *U........ 3 *W........ 5 *THADF2... 7 *FIF......10 *VRF......12 *DWF......14 *BKF......16 *WGF......18
   *THADF1... 2 *UDF1..... 4 *WDF1..... 6 *UDF2..... 8 *FIM......11 *VRM......13 *DWM......15 *BKM......17 *WGM......19
                                          *WDF2..... 9

   *BLOCK(  1 ,  3 )---PLOTTING OPTION =    3
   *BLOCK(  1 ,  7 )---PLOTTING OPTION =    3
   *BLOCK(  1 ,  8 )---PLOTTING OPTION =    3
   *BLOCK(  1 , 11 )---PLOTTING OPTION =    3
   *BLOCK(  1 , 13 )---PLOTTING OPTION =    3
   *BLOCK(  6 ,  3 )---PLOTTING OPTION =    3
   *BLOCK(  6 ,  7 )---PLOTTING OPTION =    3
   *BLOCK(  6 ,  8 )---PLOTTING OPTION =    3
   *BLOCK(  6 , 11 )---PLOTTING OPTION =    3
   *BLOCK(  6 , 13 )---PLOTTING OPTION =    3
   *BLOCK( 12 ,  6 )---PLOTTING OPTION =   16
   *BLOCK( 12 ,  8 )---PLOTTING OPTION =   16
   *BLOCK( 12 ,  9 )---PLOTTING OPTION =   16
   *BLOCK( 12 , 10 )---PLOTTING OPTION =   16
   *BLOCK( 12 , 13 )---PLOTTING OPTION =   16
   *BLOCK(  1 ,  6 )---PLOTTING OPTION =   16
   *BLOCK(  1 ,  8 )---PLOTTING OPTION =   16
   *BLOCK(  1 ,  9 )---PLOTTING OPTION =   16
   *BLOCK(  1 , 10 )---PLOTTING OPTION =   16
   *BLOCK(  1 , 13 )---PLOTTING OPTION =   16
```

SONATINA-2V SAMPLE PROBLEM SINUSOIDAL INPUT 4.0 HZ 250 GAL SONATINA-2V

```
***                                          ***
*   RESULT                    MAX VALUE        *
*                   FROM PREVIOUS STATE        *
*                     TO    NOW      STATE     *
***                                          ***
*         TIME  =  1.600066D+00                *
*                                              *
*         CYCLE OF MAX VALUE PRINT             *
*                 = 13324                      *    DISPLACEMENT OF BASE PLATE (MAX)  0.0
***                                          ***
```

.....COLUMN 1.....

ROW	MAX OF THA	MAX OF U	MAX OF W	MAX OF THADF1	MAX OF UDF1	MAX OF WDF1	MAX OF THADF2	MAX OF UDF2	MAX OF WDF2
1	3.08424D-03	1.03263D-01	1.64826D-02	4.13191D+00	1.77599D+01	2.21126D+00	1.41073D+04	3.32345D+04	5.06404D+03
2	3.97019D-03	2.39474D-01	3.19132D-02	3.50973D+00	2.08878D+01	2.82412D+00	8.74238D+03	2.34871D+04	6.96186D+03
3	4.99717D-03	3.77618D-01	4.60683D-02	3.50153D+00	2.27201D+01	3.17721D+00	9.98138D+03	3.24829D+04	4.74178D+03
4	6.06510D-03	5.42771D-01	5.94938D-02	3.15287D+00	2.18774D+01	4.54001D+00	1.27254D+04	3.04832D+04	7.56379D+03
5	6.24977D-03	7.32318D-01	7.21466D-02	2.82579D+00	2.09614D+01	4.82321D+00	8.04002D+03	3.43262D+04	6.48969D+03
6	6.45505D-03	9.02892D-01	8.36778D-02	2.49477D+00	1.81460D+01	5.64401D+00	6.52216D+03	2.54797D+04	6.22934D+03
7	6.09648D-03	1.05030D+00	9.41451D-02	2.09527D+00	1.81334D+01	6.79280D+00	6.58404D+03	2.00108D+04	5.95694D+03
8	5.75952D-03	1.21126D+00	1.03213D-01	1.84748D+00	1.73980D+01	7.54911D+00	6.71498D+03	2.56337D+04	4.91960D+03
9	5.64816D-03	1.34245D+00	1.10595D-01	1.61085D+00	1.92315D+01	8.77305D+00	5.59480D+03	3.07848D+04	3.82344D+03
10	7.52168D-03	1.37637D+00	1.16216D-01	1.44720D+00	2.24591D+01	9.32535D+00	5.48078D+03	2.61607D+04	4.15590D+03
11	1.11739D-02	1.27970D+00	1.19891D-01	2.02211D+00	2.25207D+01	9.69442D+00	6.61174D+03	2.76782D+04	4.17129D+03
12	1.99163D-02	9.21347D-01	1.22045D-01	1.64230D+00	2.01889D+01	1.05617D+01	5.70028D+03	1.96695D+04	4.99693D+03
13	2.03386D-02	6.40349D-01	1.17713D-01	2.33963D+00	1.98439D+01	1.19852D+01	1.01288D+04	3.45258D+04	9.35791D+03

.....COLUMN 2.....

ROW	MAX OF THA	MAX OF U	MAX OF W	MAX OF THADF1	MAX OF UDF1	MAX OF WDF1	MAX OF THADF2	MAX OF UDF2	MAX OF WDF2
1	3.78377D-03	9.55605D-02	1.71562D-02	8.92627D+00	2.95969D+01	2.85353D+00	6.32093D+04	5.19153D+04	1.28728D+04
2	4.46001D-03	2.09474D-01	3.36957D-02	3.86166D+00	2.05268D+01	4.20870D+00	1.46475D+04	3.97356D+04	1.08299D+04
3	5.54205D-03	3.52754D-01	4.91771D-02	3.38784D+00	2.25765D+01	3.68941D+00	9.66366D+03	3.35973D+04	7.36733D+03
4	6.22002D-03	5.16165D-01	6.33993D-02	3.05741D+00	2.19877D+01	4.36467D+00	1.04089D+04	2.32750D+04	7.04588D+03
5	7.02820D-03	6.88215D-01	7.63072D-02	2.85952D+00	2.16630D+01	4.91743D+00	7.75108D+03	2.24745D+04	6.23492D+03
6	6.33083D-03	8.54792D-01	8.78733D-02	2.47076D+00	1.98280D+01	6.31355D+00	7.82046D+03	2.45008D+04	5.83118D+03
7	6.13288D-03	1.02380D+00	9.80632D-02	2.33589D+00	1.71313D+01	6.58510D+00	8.22723D+03	2.25012D+04	4.89351D+03
8	6.11627D-03	1.17828D+00	1.06839D-01	1.90863D+00	1.80015D+01	7.17633D+00	1.15042D+04	3.83481D+04	4.22477D+03
9	5.91778D-03	1.30359D+00	1.14192D-01	1.66521D+00	1.80145D+01	7.57332D+00	5.68261D+03	3.11060D+04	3.78310D+03
10	7.11589D-03	1.37189D+00	1.20095D-01	1.80298D+00	1.97540D+01	8.20847D+00	7.76738D+03	3.03393D+04	4.00754D+03
11	9.87213D-03	1.25745D+00	1.24506D-01	1.81709D+00	2.03212D+01	8.75721D+00	1.10753D+04	5.21680D+04	4.15094D+03
12	1.73327D-02	9.26146D-01	1.27375D-01	1.38611D+00	1.69427D+01	9.69743D+00	6.09041D+03	2.03951D+04	3.86941D+03
13	2.03884D-02	6.20569D-01	1.28668D-01	1.75905D+00	1.62639D+01	1.01907D+01	6.19904D+03	4.88128D+04	4.09961D+03

.....COLUMN 3.....

ROW	MAX OF THA	MAX OF U	MAX OF W	MAX OF THADF1	MAX OF UDF1	MAX OF WDF1	MAX OF THADF2	MAX OF UDF2	MAX OF WDF2
1	2.61664D-03	1.01556D-01	1.73572D-02	4.05033D+00	1.77714D+01	3.58115D+00	1.30016D+04	2.87838D+04	6.81297D+03
2	3.56856D-03	2.00288D-01	3.38176D-02	3.92452D+00	1.88797D+01	4.04140D+00	1.00026D+04	2.97048D+04	8.47665D+03
3	4.51235D-03	3.42589D-01	4.91339D-02	3.75914D+00	2.00399D+01	4.75627D+00	8.79272D+03	2.53361D+04	7.82459D+03
4	5.19654D-03	4.84224D-01	6.30691D-02	3.28237D+00	2.14429D+01	5.75062D+00	9.10461D+03	2.48200D+04	7.39399D+03
5	5.42563D-03	6.42442D-01	7.55733D-02	2.95913D+00	1.81903D+01	5.11575D+00	9.91319D+03	2.40024D+04	7.69567D+03
6	5.46233D-03	8.22295D-01	8.65996D-02	2.46531D+00	1.81367D+01	5.88579D+00	9.08529D+03	2.93037D+04	5.89066D+03
7	5.26380D-03	1.00383D+00	9.61241D-02	2.09657D+00	1.58402D+01	6.55370D+00	7.95757D+03	3.38243D+04	4.64812D+03
8	5.22582D-03	1.16274D+00	1.04156D-01	1.84176D+00	1.62214D+01	7.52666D+00	7.43358D+03	2.06619D+04	4.56351D+03
9	5.60464D-03	1.28663D+00	1.10712D-01	1.54539D+00	1.62892D+01	8.06983D+00	6.84689D+03	3.03723D+04	4.33152D+03
10	8.83029D-03	1.28767D+00	1.15761D-01	2.72108D+00	2.12309D+01	8.35029D+00	1.10852D+04	4.02006D+04	4.01284D+03
11	1.29037D-02	1.17110D+00	1.19326D-01	1.73377D+00	1.94259D+01	8.77709D+00	1.13716D+04	3.92075D+04	4.92394D+03
12	1.64924D-02	8.04568D-01	1.21522D-01	2.14150D+00	2.48635D+01	9.79785D+00	9.19934D+03	4.40342D+04	7.95912D+03
13	1.84544D-02	5.44222D-01	1.22340D-01	1.97554D+00	2.03471D+01	9.67477D+00	1.32048D+04	7.52379D+04	1.39738D+04

.....COLUMN 4.....

ROW	MAX OF THA	MAX OF U	MAX OF W	MAX OF THADF1	MAX OF UDF1	MAX OF WDF1	MAX OF THADF2	MAX OF UDF2	MAX OF WDF2
1	2.52166D-03	1.01556D-01	1.73771D-02	4.05033D+00	1.63730D+01	3.17454D+00	1.41174D+04	2.71452D+04	5.76587D+03
2	3.55805D-03	2.12056D-01	3.38045D-02	3.41442D+00	1.82392D+01	4.39506D+00	9.93044D+03	2.70378D+04	8.03234D+03
3	4.68709D-03	3.43675D-01	4.90875D-02	3.48876D+00	1.71628D+01	4.25190D+00	1.00256D+04	2.31535D+04	7.53116D+03
4	5.58366D-03	5.03696D-01	6.30349D-02	3.15879D+00	1.58988D+01	5.45659D+00	9.68494D+03	2.24220D+04	7.01748D+03
5	6.28457D-03	6.79645D-01	7.55333D-02	2.80252D+00	1.59908D+01	5.99500D+00	7.78588D+03	1.98244D+04	8.38521D+03
6	5.85505D-03	8.57978D-01	8.65657D-02	2.46531D+00	1.75646D+01	5.64405D+00	7.76403D+03	2.01009D+04	6.34648D+03
7	5.99414D-03	1.04260D+00	9.60963D-02	2.02201D+00	1.57035D+01	6.84217D+00	8.62320D+03	2.06711D+04	5.90768D+03
8	5.66278D-03	1.21155D+00	1.04142D-01	1.81713D+00	1.88438D+01	7.12849D+00	5.81816D+03	1.85821D+04	4.67134D+03
9	5.46843D-03	1.24113D+00	1.10724D-01	1.78246D+00	1.93563D+01	7.80709D+00	8.54276D+03	2.41039D+04	4.03404D+03
10	8.38115D-03	1.24243D+00	1.15867D-01	1.90857D+00	2.12302D+01	8.35029D+00	9.94807D+03	3.34414D+04	3.37468D+03
11	1.28829D-02	1.10587D+00	1.19611D-01	1.40787D+00	2.03215D+01	8.77709D+00	9.27182D+03	3.14835D+04	5.37249D+03
12	1.71330D-02	7.43447D-01	1.21924D-01	2.09289D+00	1.50449D+01	9.79785D+00	1.13087D+04	3.90778D+04	4.03590D+03
13	1.71675D-02	4.93846D-01	1.21473D-01	1.94762D+00	2.06683D+01	1.00824D+01	3.92331D+03	2.37837D+04	7.62818D+03

.....COLUMN 5.....

ROW	MAX OF THA	MAX OF U	MAX OF W	MAX OF THADF1	MAX OF UDF1	MAX OF WDF1	MAX OF THADF2	MAX OF UDF2	MAX OF WDF2
1	4.45183D-03	9.39450D-02	1.71792D-02	9.14407D+00	2.01884D+01	3.14875D+00	3.79085D+04	4.84627D+04	1.23323D+04
2	4.04340D-03	1.86483D-01	3.37067D-02	3.50204D+00	1.69698D+01	4.20870D+00	1.42416D+04	3.67939D+04	8.79831D+03
3	4.81676D-03	3.31030D-01	4.91455D-02	3.43829D+00	1.65534D+01	5.11820D+00	9.76392D+03	2.80541D+04	9.00507D+03
4	5.83316D-03	4.71434D-01	6.33696D-02	3.38490D+00	1.62526D+01	5.87891D+00	1.13699D+04	2.88373D+04	8.76633D+03
5	6.26338D-03	6.25767D-01	7.63014D-02	3.04529D+00	1.53709D+01	4.91714D+00	8.72509D+03	2.11088D+04	7.36618D+03
6	5.79375D-03	7.84825D-01	8.78795D-02	2.37959D+00	1.53400D+01	6.96774D+00	7.64794D+03	1.88877D+04	8.43568D+03
7	6.23248D-03	9.29819D-01	9.80824D-02	2.12620D+00	1.49891D+01	7.04971D+00	6.19444D+03	1.75731D+04	7.04480D+03
8	6.09892D-03	1.07344D+00	1.06865D-01	1.88438D+00	1.69033D+01	7.17633D+00	5.52866D+03	2.28869D+04	5.69265D+03
9	5.47923D-03	1.26200D+00	1.14221D-01	1.68082D+00	1.59905D+01	7.58462D+00	5.73906D+03	2.34539D+04	4.87525D+03
10	6.53497D-03	1.23030D+00	1.20110D-01	1.21591D+00	1.92794D+01	8.21768D+00	4.00281D+03	2.54303D+04	3.52539D+03
11	1.10239D-02	1.07227D+00	1.24487D-01	1.03561D+00	2.07706D+01	8.68019D+00	4.42036D+03	1.54469D+04	3.48288D+03
12	1.76499D-02	7.46730D-01	1.27315D-01	1.35288D+00	1.40830D+01	9.41005D+00	5.17109D+03	1.75376D+04	4.55935D+03
13	1.79908D-02	4.61579D-01	1.28571D-01	1.62218D+00	2.02196D+01	1.07175D+01	3.87054D+03	4.33796D+04	5.12254D+03

.....COLUMN 6.....

ROW	MAX OF THA	MAX OF U	MAX OF W	MAX OF THADF1	MAX OF UDF1	MAX OF WDF1	MAX OF THADF2	MAX OF UDF2	MAX OF WDF2

1	2.52166D-03	1.01556D-01	1.73725D-02	4.05033D+00	1.57497D+01	4.78082D+00	1.28145D+04	2.78117D+04	7.97991D+03
2	3.72973D-03	1.71439D-01	3.38051D-02	3.64147D+00	1.60712D+01	5.75518D+00	8.18131D+03	2.53693D+04	9.22458D+03
3	5.02510D-03	2.94197D-01	4.909250D-02	3.48876D+00	1.43051D+01	6.135800D+00	8.32787D+03	2.45274D+04	6.86755D+03
4	5.68241D-03	4.46991D-01	6.30336D-02	3.15879D+00	1.36610D+01	4.51407D+00	8.28436D+03	2.02174D+04	5.73800D+03
5	5.58804D-03	6.03209D-01	7.553130D-02	2.80252D+00	1.65274D+01	4.91885D+00	6.94374D+03	1.86655D+04	8.30267D+03
6	5.77108D-03	7.64142D-01	8.65634D-02	2.46531D+00	1.73798D+01	6.29524D+00	7.91629D+03	2.42020D+04	6.61927D+03
7	6.04862D-03	9.37193D-01	9.60914D-02	2.10346D+00	1.53424D+01	7.14038D+00	7.42655D+03	2.47238D+04	5.40796D+03
8	6.08007D-03	1.11291D+00	1.04130D-01	2.11581D+00	1.71783D+01	7.84981D+00	8.14791D+03	2.05584D+04	5.78402D+03
9	6.06537D-03	1.19804D+00	1.10690D-01	1.45929D+00	1.79410D+01	8.46533D+00	4.81193D+03	2.01499D+04	5.38968D+03
10	6.67126D-03	1.18650D+00	1.15772D-01	1.73148D+00	2.23371D+01	8.35029D+00	9.87588D+03	3.33342D+04	4.372550D+03
11	1.33952D-02	9.90440D-01	1.19400D-01	1.38278D+00	1.83168D+01	8.77709D+00	4.66978D+03	1.79852D+04	3.58933D+03
12	1.86405D-02	6.23390D-01	1.21575D-01	2.62257D+00	1.23928D+01	9.79785D+00	8.89070D+03	2.74888D+04	6.54429D+03
13	1.90027D-02	3.98633D-01	1.22190D-01	1.62957D+00	2.43574D+01	1.07054D+01	1.01358D+04	7.85594D+04	1.24377D+04

.....COLUMN 7.....

ROW	MAX OF THA	MAX OF U	MAX OF W	MAX OF THADF1	MAX OF UDF1	MAX OF WDF1	MAX OF THADF2	MAX OF UDF2	MAX OF WDF2
1	2.88138D-03	1.01556D-01	1.73725D-02	4.05033D+00	1.65306D+01	4.16671D+00	1.29344D+04	2.71452D+04	6.36768D+03
2	3.55761D-03	1.78542D-01	3.38051D-02	3.50259D+00	1.60712D+01	5.21491D+00	8.67182D+03	2.22741D+04	8.53522D+03
3	4.45423D-03	2.94902D-01	4.90925D-02	3.48876D+00	1.42980D+01	6.27229D+00	8.62493D+03	1.93354D+04	7.96122D+03
4	5.21179D-03	4.20276D-01	6.30336D-02	3.28616D+00	1.28237D+01	4.92608D+00	8.668030D+03	2.08488D+04	7.23958D+03
5	5.66728D-03	5.72603D-01	7.55313D-02	2.98753D+00	1.22164D+01	4.67435D+00	8.94686D+03	2.207390D+04	7.39789D+03
6	5.54352D-03	7.51808D-01	8.65634D-02	2.46531D+00	1.44190D+01	7.37974D+00	9.01377D+03	2.26757D+04	6.79008D+03
7	6.07098D-03	9.27798D-01	9.60914D-02	2.00313D+00	1.58897D+01	9.05549D+00	6.92102D+03	2.06384D+04	6.87406D+03
8	6.13792D-03	1.13368D+00	1.04130D-01	1.81414D+00	1.80836D+01	8.49689D+00	6.44338D+03	2.04393D+04	4.75374D+03
9	5.39009D-03	1.32718D+00	1.10690D-01	1.58700D+00	2.04740D+01	7.80709D+00	1.00595D+04	3.43031D+04	3.51357D+03
10	6.86436D-03	1.34287D+00	1.15772D-01	1.22696D+00	1.98412D+01	8.35029D+00	3.49971D+03	1.30772D+04	3.19437D+03
11	1.57152D-02	1.09879D+00	1.19400D-01	1.22525D+00	2.15190D+01	8.77709D+00	7.70927D+03	2.57232D+04	2.67454D+03
12	1.99775D-02	6.04466D-01	1.21575D-01	2.50579D+00	1.21754D+01	9.79785D+00	1.08580D+04	3.56232D+04	5.37709D+03
13	2.10117D-02	3.64857D-01	1.22190D-01	2.11118D+00	2.50799D+01	9.67477D+00	4.55899D+03	2.67353D+04	1.01198D+04

.....COLUMN 8.....

ROW	MAX OF THA	MAX OF U	MAX OF W	MAX OF THADF1	MAX OF UDF1	MAX OF WDF1	MAX OF THADF2	MAX OF UDF2	MAX OF WDF2
1	3.67453D-03	9.39450D-02	1.71792D-02	9.14407D+00	2.00340D+01	5.01590D+00	4.21693D+04	7.49373D+04	1.34771D+04
2	3.30004D-03	1.69346D-01	3.37067D-02	3.16069D+00	1.64938D+01	4.20870D+00	1.69739D+04	5.70394D+04	8.27253D+03
3	4.53436D-03	2.93282D-01	4.91455D-02	3.57478D+00	1.64394D+01	6.12867D+00	1.09020D+04	2.36169D+04	8.36342D+03
4	5.64555D-03	4.32572D-01	6.33696D-02	3.23274D+00	1.51074D+01	4.36406D+00	1.04721D+04	3.54724D+04	6.31267D+03
5	6.05019D-03	5.87467D-01	7.63014D-02	3.24559D+00	1.52513D+01	5.24225D+00	1.06647D+04	3.47692D+04	9.23611D+03
6	6.04476D-03	7.44253D-01	8.78795D-02	2.67806D+00	1.50519D+01	7.67744D+00	9.42927D+03	2.06239D+04	8.71265D+03
7	5.95417D-03	9.21119D-01	9.80824D-02	2.31206D+00	1.63526D+01	7.86606D+00	6.65740D+03	3.03756D+04	6.71265D+03
8	6.09882D-03	1.10516D+00	1.06865D-01	2.13698D+00	1.83657D+01	9.05589D+00	8.02830D+03	3.37720D+04	4.46481D+03
9	5.95801D-03	1.28692D+00	1.14221D-01	1.94240D+00	1.74009D+01	7.58462D+00	6.25818D+03	2.282900D+04	5.89527D+03
10	5.45243D-03	1.38572D+00	1.20110D-01	1.65658D+00	1.97249D+01	8.21768D+00	6.41276D+03	1.80227D+04	4.42957D+03
11	1.20496D-02	1.27349D+00	1.24487D-01	1.12044D+00	2.03140D+01	1.04667D+01	3.89409D+03	1.21092D+04	4.70943D+03
12	1.97365D-02	8.37554D-01	1.27315D-01	1.47718D+00	1.66225D+01	1.01087D+01	2.54201D+03	8.34115D+03	4.33567D+03
13	2.15356D-02	4.29599D-01	1.28571D-01	1.62596D+00	2.03688D+01	9.31080D+00	2.85205D+03	3.63905D+04	3.46231D+03

.....COLUMN 9.....

ROW	MAX OF THA	MAX OF U	MAX OF W	MAX OF THADF1	MAX OF UDF1	MAX OF WDF1	MAX OF THADF2	MAX OF UDF2	MAX OF WDF2
1	2.62590D-03	1.01556D-01	1.73725D-02	4.05033D+00	1.53724D+01	4.49673D+00	1.43210D+04	2.71452D+04	6.72429D+03
2	3.77982D-03	1.91017D-01	3.38051D-02	3.41442D+00	1.82558D+01	5.22195D+00	1.08575D+04	2.41170D+04	8.79180D+03
3	4.59773D-03	3.06374D-01	4.90925D-02	3.48876D+00	1.54218D+01	5.43592D+00	8.84151D+03	2.06268D+04	7.51315D+03
4	4.920960D-03	4.48175D-01	6.30336D-02	3.15879D+00	1.74184D+01	4.30131D+00	9.63322D+03	2.20890D+04	6.72749D+03
5	5.65487D-03	6.11537D-01	7.55313D-02	2.87670D+00	1.80361D+01	4.67435D+00	7.68774D+03	2.18883D+04	6.58176D+03
6	6.15354D-03	7.94698D-01	8.656340D-02	2.63458D+00	1.96287D+01	6.37092D+00	8.56868D+03	2.32547D+04	6.82803D+03
7	6.35464D-03	9.84500D-01	9.60914D-02	2.17648D+00	1.73700D+01	7.70286D+00	1.16725D+04	2.68477D+04	6.19208D+03
8	6.02857D-03	1.17558D+00	1.04130D-01	1.87287D+00	1.89628D+01	7.84636D+00	1.05725D+04	2.81982D+04	4.55380D+03
9	6.05732D-03	1.36402D+00	1.10690D-01	1.58634D+00	1.82127D+01	7.80709D+00	5.85461D+03	2.12289D+04	3.78512D+03
10	7.88380D-03	1.35221D+00	1.15772D-01	1.54983D+00	1.94710D+01	8.35029D+00	8.86831D+03	2.99331D+04	3.25609D+03
11	1.47619D-02	1.17957D+00	1.19400D-01	1.17996D+00	2.27820D+01	8.77709D+00	4.18934D+03	1.90218D+04	3.10850D+03
12	1.88566D-02	7.20452D-01	1.21575D-01	2.24989D+00	1.67963D+01	9.79785D+00	8.43361D+03	2.83360D+04	5.82299D+03
13	2.15466D-02	4.56504D-01	1.22190D-01	1.75768D+00	2.40735D+01	1.09270D+01	1.12073D+04	6.51695D+04	8.06235D+03

.....COLUMN 10.....

ROW	MAX OF THA	MAX OF U	MAX OF W	MAX OF THADF1	MAX OF UDF1	MAX OF WDF1	MAX OF THADF2	MAX OF UDF2	MAX OF WDF2
1	2.79427D-03	1.05263D-01	1.73725D-02	4.05033D+00	1.76363D+01	4.87992D+00	1.30897D+04	2.93433D+04	7.42521D+03
2	3.98799D-03	2.15291D-01	3.38051D-02	3.52290D+00	1.97327D+01	5.82425D+00	1.02683D+04	2.30628D+04	8.71021D+03
3	5.03872D-03	3.34900D-01	4.90925D-02	3.72448D+00	2.15193D+01	5.43566D+00	1.04199D+04	2.61831D+04	7.513150D+03
4	5.74204D-03	4.70119D-01	6.30336D-02	3.15879D+00	2.30711D+01	4.30131D+00	1.07729D+04	2.61031D+04	7.86427D+03
5	5.74831D-03	6.38048D-01	7.55313D-02	2.87502D+00	1.88430D+01	4.75991D+00	9.89957D+03	2.35192D+04	7.03821D+03
6	5.95611D-03	8.12467D-01	8.65634D-02	2.52698D+00	1.68447D+01	6.37089D+00	9.95604D+03	2.33039D+04	6.82803D+03
7	5.99710D-03	9.94358D-01	9.60914D-02	2.12527D+00	1.54535D+01	7.69629D+00	1.04439D+04	2.86400D+04	6.18400D+03
8	6.07546D-03	1.17876D+00	1.04130D-01	1.81414D+00	1.48381D+01	7.84598D+00	5.42049D+03	2.02756D+04	4.54753D+03
9	5.83364D-03	1.35850D+00	1.10690D-01	1.58634D+00	1.62329D+01	7.80709D+00	4.72906D+03	2.18245D+04	3.78512D+03
10	1.07857D-02	1.34341D+00	1.15772D-01	1.28174D+00	1.78346D+01	8.35029D+00	4.93554D+03	2.09706D+04	3.27427D+03
11	1.30560D-02	1.11663D+00	1.19400D-01	1.39239D+00	1.79934D+01	8.77709D+00	8.69678D+03	3.01823D+04	4.65754D+03
12	2.17996D-02	7.62711D-01	1.21575D-01	2.14506D+00	1.35180D+01	9.79785D+00	1.04954D+04	3.55371D+04	4.16651D+03
13	2.21402D-02	4.89124D-01	1.22190D-01	1.82066D+00	2.25728D+01	9.67477D+00	4.05555D+03	2.26893D+04	8.83570D+03

.....COLUMN 11.....

ROW	MAX OF THA	MAX OF U	MAX OF W	MAX OF THADF1	MAX OF UDF1	MAX OF WDF1	MAX OF THADF2	MAX OF UDF2	MAX OF WDF2
1	4.26153D-03	9.61166D-02	1.71792D-02	9.73437D+00	2.00340D+01	4.55144D+00	5.89930D+04	6.44621D+04	1.76078D+04
2	3.55400D-03	1.95838D-01	3.37067D-02	3.70892D+00	1.78673D+01	5.07939D+00	1.79100D+04	4.91965D+04	1.08748D+04
3	4.75034D-03	3.232150D-01	4.91455D-02	3.19382D+00	1.89431D+01	6.11718D+00	1.04040D+04	2.32811D+04	8.61450D+03
4	5.65521D-03	4.75968D-01	6.33696D-02	3.18689D+00	1.79780D+01	4.36406D+00	9.048280D+03	2.24979D+04	6.29970D+03
5	5.98843D-03	6.52389D-01	7.63014D-02	2.89392D+00	1.84104D+01	4.91714D+00	1.01672D+04	2.42071D+04	7.07786D+03
6	6.40306D-03	8.35538D-01	8.78795D-02	2.60162D+00	1.68670D+01	6.91716D+00	8.06116D+03	2.35839D+04	7.93141D+03
7	6.72921D-03	1.01813D+00	9.80824D-02	2.24730D+00	1.60388D+01	7.58521D+00	8.20734D+03	2.62486D+04	7.12299D+03
8	6.047500D-03	1.21473D+00	1.06865D-01	1.99607D+00	1.71747D+01	7.97693D+00	6.22306D+03	1.95119D+04	5.64869D+03
9	6.06897D-03	1.37131D+00	1.14221D-01	1.94790D+00	1.78245D+01	7.58462D+00	6.11713D+03	2.87969D+04	3.99198D+03
10	7.67276D-03	1.37966D+00	1.20110D-01	1.49926D+00	1.87951D+01	8.21768D+00	5.541840D+03	2.05569D+04	3.07859D+03
11	1.21677D-02	1.22062D+00	1.244870D-01	1.67398D+00	1.91203D+01	9.72742D+00	5.30306D+03	3.09682D+04	3.82212D+03
12	1.54407D-02	9.14130D-01	1.27315D-01	1.44265D+00	1.77606D+01	1.04991D+01	4.44674D+03	2.58739D+04	6.15437D+03
13	2.30448D-02	5.19854D-01	1.28571D-01	1.98488D+00	1.63773D+01	1.12482D+01	4.47017D+03	3.42913D+04	5.45097D+03

.....COLUMN 12.....

ROW	MAX OF THA	MAX OF U	MAX OF W	MAX OF THADF1	MAX OF UDF1	MAX OF WDF1	MAX OF THADF2	MAX OF UDF2	MAX OF WDF2
1	2.52166D-03	1.01556D-01	1.73725D-02	4.050330D+00	1.60496D+01	3.39855D+00	1.32917D+04	2.98162D+04	6.00643D+03
2	3.05200D-03	1.90869D-01	3.38051D-02	3.95607D+00	1.71739D+01	5.22195D+00	1.01004D+04	2.34315D+04	8.50094D+03
3	4.12068D-03	2.99996D-01	4.90925D-02	3.48876D+00	1.91157D+01	5.43566D+00	8.22778D+03	2.61753D+04	7.51315D+03

4	5.01747D-03	4.37795D-01	6.30336D-02	3.15879D+00	2.02950D+01	4.30131D+00	7.55975D+03	2.13503D+04	6.34033D+03
5	5.36065D-03	5.97817D-01	7.55313D-02	3.07818D+00	2.05062D+01	4.67435D+00	6.64817D+03	2.18665D+04	6.56743D+03
6	5.69418D-03	7.61182D-01	8.65634D-02	2.90635D+00	1.93258D+01	6.37089D+00	7.25513D+03	2.59679D+04	6.82803D+03
7	5.62065D-03	9.13793D-01	9.60914D-02	2.00680D+00	2.00591D+01	7.69629D+00	7.64459D+03	3.00428D+04	6.18400D+03
8	5.41424D-03	1.06546D+00	1.04130D-01	1.97714D+00	2.05160D+01	7.84598D+00	7.69718D+03	2.45523D+04	4.54753D+03
9	5.15638D-03	1.22944D+00	1.10690D-01	1.62076D+00	2.03530D+01	7.80709D+00	6.81027D+03	2.46824D+04	3.87739D+03
10	8.73766D-03	1.23309D+00	1.15772D-01	1.44213D+00	2.27416D+01	8.35029D+00	6.91574D+03	2.59251D+04	3.86992D+03
11	1.22248D-02	1.05687D+00	1.19400D-01	1.89138D+00	2.39285D+01	8.77709D+00	6.47399D+03	2.99256D+04	5.06072D+03
12	1.44205D-02	7.61517D-01	1.21575D-01	2.54447D+00	2.27128D+01	9.79785D+00	7.45193D+03	2.74954D+04	5.83757D+03
13	2.07827D-02	5.22924D-01	1.22190D-01	2.59440D+00	2.02139D+01	1.19444D+01	7.88105D+03	4.45677D+04	9.39821D+03

.....COLUMN 13.....

ROW	MAX OF THA	MAX OF U	MAX OF W	MAX OF THADF1	MAX OF UDF1	MAX OF WDF1	MAX OF THADF2	MAX OF UDF2	MAX OF WDF2
1	0.0	2.49933D-02	0.0	0.0	1.95608D+01	0.0	0.0	5.14244D+03	0.0
2	0.0	2.52508D-02	0.0	0.0	1.96608D+01	0.0	0.0	4.72488D+03	0.0
3	0.0	2.53472D-02	0.0	0.0	1.96533D+01	0.0	0.0	5.01143D+03	0.0
4	0.0	2.53766D-02	0.0	0.0	1.97220D+01	0.0	0.0	8.53355D+03	0.0
5	0.0	2.54993D-02	0.0	0.0	1.97903D+01	0.0	0.0	4.99391D+03	0.0
6	0.0	2.55224D-02	0.0	0.0	1.97912D+01	0.0	0.0	5.00479D+03	0.0
7	0.0	2.56718D-02	0.0	0.0	1.98034D+01	0.0	0.0	8.48094D+03	0.0
8	0.0	2.56359D-02	0.0	0.0	1.97914D+01	0.0	0.0	6.57136D+03	0.0
9	0.0	2.56488D-02	0.0	0.0	1.97617D+01	0.0	0.0	9.00656D+03	0.0
10	0.0	2.56554D-02	0.0	0.0	1.97794D+01	0.0	0.0	9.22334D+03	0.0
11	0.0	2.57417D-02	0.0	0.0	1.97831D+01	0.0	0.0	7.33836D+03	0.0
12	0.0	2.56881D-02	0.0	0.0	1.97576D+01	0.0	0.0	9.38245D+03	0.0
13	0.0	2.52897D-02	0.0	0.0	1.78504D+01	0.0	0.0	7.83129D+03	0.0

.....COLUMN 14.....

ROW	MAX OF THA	MAX OF U	MAX OF W	MAX OF THADF1	MAX OF UDF1	MAX OF WDF1	MAX OF THADF2	MAX OF UDF2	MAX OF WDF2
1	0.0	2.49933D-02	0.0	0.0	1.95608D+01	0.0	0.0	5.14244D+03	0.0
2	0.0	2.52508D-02	0.0	0.0	1.96608D+01	0.0	0.0	4.70534D+03	0.0
3	0.0	2.53472D-02	0.0	0.0	1.96533D+01	0.0	0.0	4.62005D+03	0.0
4	0.0	2.53766D-02	0.0	0.0	1.97220D+01	0.0	0.0	7.41803D+03	0.0
5	0.0	2.55195D-02	0.0	0.0	1.97903D+01	0.0	0.0	5.74514D+03	0.0
6	0.0	2.55683D-02	0.0	0.0	1.97912D+01	0.0	0.0	4.67560D+03	0.0
7	0.0	2.56914D-02	0.0	0.0	1.98034D+01	0.0	0.0	7.49519D+03	0.0
8	0.0	2.57231D-02	0.0	0.0	1.97914D+01	0.0	0.0	5.56373D+03	0.0
9	0.0	2.57345D-02	0.0	0.0	1.97617D+01	0.0	0.0	7.12035D+03	0.0
10	0.0	2.57229D-02	0.0	0.0	1.98060D+01	0.0	0.0	7.71559D+03	0.0
11	0.0	2.57805D-02	0.0	0.0	1.97645D+01	0.0	0.0	9.07914D+03	0.0
12	0.0	2.57978D-02	0.0	0.0	1.97829D+01	0.0	0.0	1.03919D+04	0.0
13	0.0	3.84243D-02	0.0	0.0	1.97792D+01	0.0	0.0	7.92189D+03	0.0

.....COLUMN 1.....

ROW	MAX OF WGM	MAX OF FIF	MAX OF FIM	MAX OF VRF	MAX OF VRM	MAX OF DWF	MAX OF DWM	MAX OF BKF	MAX OF BKM
1	3.39181D+03	1.87400D+01	2.67461D+02	1.17849D+02	1.02664D+03	6.47309D+02	9.74454D+03	0.0	0.0
2	3.12773D+03	1.71960D+01	2.45529D+02	1.55256D+02	1.21221D+03	4.40803D+02	6.55887D+03	2.90624D+02	4.14052D+03
3	2.84786D+03	1.56360D+01	2.23372D+02	1.11965D+02	1.15683D+03	4.40803D+02	6.28142D+03	5.80232D+02	6.16450D+03
4	2.56854D+03	1.40760D+01	2.01197D+02	1.31583D+02	1.22280D+03	5.95203D+02	8.48164D+03	4.16618D+02	4.70438D+03
5	2.28649D+03	1.25160D+01	1.78909D+02	1.20049D+02	1.09102D+03	5.95203D+02	8.48164D+03	4.85289D+02	5.93560D+03
6	2.00227D+03	1.09560D+01	1.56631D+02	1.12179D+02	9.34071D+02	3.65443D+02	5.20753D+03	4.85898D+02	5.02296D+03
7	1.71602D+03	9.39600D+00	1.34304D+02	1.11272D+02	7.77279D+02	3.65443D+02	5.20752D+03	3.89431D+02	4.64527D+03
8	1.43089D+03	7.83600D+00	1.11982D+02	1.04360D+02	6.84872D+02	2.79165D+02	3.97810D+03	4.91431D+02	5.70301D+03
9	1.14591D+03	6.27600D+00	8.96805D+01	9.40571D+01	5.16472D+02	3.17339D+02	4.52201D+03	5.99524D+02	4.56423D+03
10	8.59478D+02	4.71600D+00	6.74500D+01	9.41186D+01	3.59849D+02	3.17339D+02	4.52207D+03	5.09354D+02	4.20168D+03
11	5.78921D+02	3.15600D+00	4.51630D+01	1.00840D+02	4.08495D+02	3.41311D+02	4.86367D+03	5.38944D+02	5.46008D+03
12	2.93400D+02	1.59600D+00	2.29634D+01	8.11893D+01	3.58387D+02	3.41311D+02	4.86365D+03	2.67948D+02	3.80397D+03
13	7.58882D+01	4.08000D-01	4.42469D+00	1.07522D+02	2.62364D+02	2.23912D+02	2.39407D+03	3.63490D+02	6.26776D+03

.....COLUMN 2.....

ROW	MAX OF WGM	MAX OF FIF	MAX OF FIM	MAX OF VRF	MAX OF VRM	MAX OF DWF	MAX OF DWM	MAX OF BKF	MAX OF BKM
1	3.43479D+03	1.89640D+01	2.03433D+02	2.02243D+02	1.44946D+03	7.57392D+02	1.46173D+04	0.0	0.0
2	3.20115D+03	1.76120D+01	2.51526D+02	2.00114D+02	1.19729D+03	7.57231D+02	1.07905D+04	0.0	0.0
3	2.92420D+03	1.60520D+01	2.29380D+02	1.35106D+02	1.03050D+03	6.39095D+02	9.10709D+03	2.90624D+02	4.04974D+03
4	2.64706D+03	1.44920D+01	2.07153D+02	1.25748D+02	1.03621D+03	4.53083D+02	6.45643D+03	3.54623D+02	4.20931D+03
5	2.36492D+03	1.29320D+01	1.84929D+02	1.03253D+02	9.29110D+02	4.39032D+02	6.25604D+03	4.01407D+02	4.68972D+03
6	2.07880D+03	1.13720D+01	1.62563D+02	1.06902D+02	9.56461D+02	4.39032D+02	6.25618D+03	4.78545D+02	4.31203D+03
7	1.79300D+03	9.81200D+00	1.40253D+02	9.43869D+01	7.34803D+02	3.19454D+02	4.55220D+03	4.37994D+02	4.50904D+03
8	1.50653D+03	8.25200D+00	1.17953D+02	7.81431D+01	6.12231D+02	3.50340D+02	4.99235D+03	7.56039D+02	8.81084D+03
9	1.22264D+03	6.69200D+00	9.56448D+01	7.35587D+01	4.85903D+02	3.64491D+02	5.19400D+03	5.54130D+02	4.78952D+03
10	9.34514D+02	5.13200D+00	7.33578D+01	8.08977D+01	4.29029D+02	3.64491D+02	5.19400D+03	5.90837D+02	5.99016D+03
11	6.53772D+02	3.57200D+00	5.11077D+01	8.48152D+01	3.67495D+02	3.34935D+02	4.77281D+03	1.01650D+03	9.80947D+03
12	3.69413D+02	2.01200D+00	2.88997D+01	9.49536D+01	3.42441D+02	2.62612D+02	3.74184D+03	3.95148D+02	5.63542D+03
13	1.14837D+02	6.16000D-01	8.86697D+00	7.97638D+01	1.95705D+02	2.62612D+02	3.74195D+03	7.66977D+02	1.10360D+04

.....COLUMN 3.....

ROW	MAX OF WGM	MAX OF FIF	MAX OF FIM	MAX OF VRF	MAX OF VRM	MAX OF DWF	MAX OF DWM	MAX OF BKF	MAX OF BKM
1	3.39140D+03	1.87400D+01	2.67384D+02	1.51953D+02	1.05073D+03	5.62047D+02	8.86399D+03	0.0	0.0
2	3.12337D+03	1.71960D+01	2.45431D+02	1.84795D+02	1.41237D+03	5.62047D+02	9.41489D+03	2.84372D+02	2.02498D+03
3	2.84741D+03	1.56360D+01	2.23295D+02	1.53266D+02	1.14980D+03	4.78417D+02	6.69627D+03	2.63945D+02	3.74996D+03
4	2.56673D+03	1.40760D+01	2.01109D+02	1.38593D+02	1.18743D+03	4.69915D+02	6.69626D+03	3.54623D+02	5.05377D+03
5	2.28298D+03	1.25160D+01	1.78836D+02	1.34561D+02	1.07016D+03	4.55532D+02	6.49133D+03	4.02924D+02	5.74934D+03
6	1.99894D+03	1.09560D+01	1.56549D+02	1.13840D+02	8.86413D+02	4.55532D+02	6.49132D+03	4.02307D+02	5.73113D+03
7	1.71418D+03	9.39600D+00	1.34246D+02	9.51506D+01	7.33699D+02	3.56328D+02	5.07765D+03	6.68970D+02	7.58321D+03
8	1.43001D+03	7.83600D+00	1.11957D+02	8.88711D+01	7.21434D+02	2.98161D+02	4.34150D+03	4.02128D+02	4.96392D+03
9	1.14595D+03	6.27600D+00	8.96812D+01	7.46117D+01	5.63718D+02	2.98161D+02	4.24879D+03	5.91481D+02	6.32035D+03
10	8.61816D+02	4.71600D+00	6.74990D+01	9.77504D+01	4.48929D+02	2.58374D+02	3.68183D+03	7.83132D+02	1.03228D+04
11	5.80339D+02	3.15600D+00	4.51802D+01	1.15517D+02	3.05388D+02	3.16470D+02	4.50972D+03	7.29025D+02	1.06251D+04
12	2.93809D+02	1.59600D+00	2.29010D+01	1.35703D+02	3.14817D+02	4.29263D+02	3.72263D+03	8.05060D+02	8.52881D+03
13	7.55337D+01	4.08000D-01	4.41929D+00	1.55528D+02	2.38890D+02	2.42759D+02	2.59742D+03	7.77331D+02	8.26470D+03

.....COLUMN 4.....

ROW	MAX OF WGM	MAX OF FIF	MAX OF FIM	MAX OF VRF	MAX OF VRM	MAX OF DWF	MAX OF DWM	MAX OF BKF	MAX OF BKM
1	3.39118D+03	1.87400D+01	2.67384D+02	1.31534D+02	9.93621D+02	5.10591D+02	1.39558D+04	0.0	0.0
2	3.12190D+03	1.71960D+01	2.45483D+02	1.57767D+02	1.15200D+03	5.10041D+02	7.26808D+03	0.0	0.0
3	2.84607D+03	1.56360D+01	2.23341D+02	1.53565D+02	1.14980D+03	4.35856D+02	6.21095D+03	2.65485D+02	3.78325D+03
4	2.56576D+03	1.40760D+01	2.01134D+02	1.36813D+02	1.18743D+03	4.23153D+02	6.02992D+03	3.35472D+02	4.78700D+03
5	2.28437D+03	1.25160D+01	1.78918D+02	1.61475D+02	1.07040D+03	3.74060D+02	6.01596D+03	3.27882D+02	4.65414D+03
6	2.00092D+03	1.09560D+01	1.56575D+02	1.18366D+02	8.86409D+02	3.65858D+02	5.41485D+03	4.02924D+02	5.71462D+03
7	1.71610D+03	9.39600D+00	1.34291D+02	1.04256D+02	7.19018D+02	3.65858D+02	5.21347D+03	4.02307D+02	5.71800D+03

8	1.43090D+03	7.83600D+00	1.11982D+02	1.10591D+02	6.84299D+02	3.61570D+02	5.15237D+03	3.25693D+02	3.84222D+03
9	1.14399D+03	6.27600D+00	8.96755D+01	9.81639D+01	5.98605D+02	2.51668D+02	3.58624D+03	4.69245D+02	6.68050D+03
10	8.59061D+02	4.71600D+00	6.74826D+01	8.49609D+01	4.78173D+02	2.40693D+02	3.42987D+03	6.52887D+02	9.29951D+03
11	5.79855D+02	3.15600D+00	4.51808D+01	8.91527D+01	3.69690D+02	2.40693D+02	3.42977D+03	6.11745D+02	8.10168D+03
12	2.93747D+02	1.59600D+00	2.29332D+01	9.82000D+01	3.82304D+02	2.80125D+02	3.19530D+03	7.62798D+02	1.08523D+04
13	7.56048D+01	4.08000D-01	4.41560D+00	8.95331D+01	2.05205D+02	2.52179D+02	2.69824D+03	2.43723D+02	2.51231D+03

.....COLUMN 5.....

ROW	MAX OF WGM	MAX OF FIF	MAX OF FIM	MAX OF VRF	MAX OF VRM	MAX OF DWF	MAX OF DWM	MAX OF BKF	MAX OF BKM
1	3.43628D+03	1.89640D+01	2.03520D+02	1.94352D+02	1.51023D+03	7.08127D+02	8.37139D+03	0.0	0.0
2	3.19994D+03	1.76120D+01	2.51462D+02	1.52067D+02	1.22181D+03	7.08127D+02	1.00908D+04	0.0	0.0
3	2.92234D+03	1.60520D+01	2.29297D+02	1.63464D+02	1.24420D+03	5.47836D+02	7.80665D+03	0.0	0.0
4	2.64303D+03	1.44920D+01	2.07106D+02	1.51443D+02	1.13225D+03	5.47836D+02	7.80666D+03	2.65485D+02	2.57446D+03
5	2.36202D+03	1.29320D+01	1.84863D+02	1.53624D+02	9.11666D+02	4.10842D+02	5.85447D+03	3.35472D+02	3.58471D+03
6	2.07680D+03	1.13720D+01	1.62525D+02	1.44996D+02	7.93554D+02	3.56938D+02	5.13569D+03	3.09646D+02	4.41658D+03
7	1.79284D+03	9.81200D+00	1.40256D+02	1.37707D+02	6.54803D+02	3.41896D+02	4.87198D+03	2.80345D+02	4.00209D+03
8	1.50762D+03	8.25200D+00	1.17953D+02	1.05609D+02	5.29666D+02	3.31841D+02	4.72874D+03	4.45515D+02	4.78718D+03
9	1.22070D+03	6.69200D+00	9.56248D+01	9.15067D+01	4.76038D+02	2.69563D+02	3.84125D+03	4.56570D+02	4.82162D+03
10	9.33688D+02	5.13200D+00	7.33066D+01	7.55675D+01	3.95881D+02	2.31973D+02	3.30561D+03	4.96670D+02	3.87374D+03
11	6.52317D+02	3.57200D+00	5.11826D+01	7.38247D+01	2.94243D+02	2.31973D+02	3.30561D+03	3.01994D+02	4.29995D+03
12	3.71376D+02	2.01200D+00	2.89230D+01	8.00460D+01	3.46626D+02	2.85243D+02	4.06481D+03	3.28959D+02	4.70360D+03
13	1.15200D+02	6.16000D-01	8.85670D+00	9.58239D+01	2.35223D+02	2.85243D+02	4.06403D+03	6.81675D+02	6.94812D+03

.....COLUMN 6.....

ROW	MAX OF WGM	MAX OF FIF	MAX OF FIM	MAX OF VRF	MAX OF VRM	MAX OF DWF	MAX OF DWM	MAX OF BKF	MAX OF BKM
1	3.39118D+03	1.87400D+01	2.67384D+02	1.65512D+02	9.53281D+02	5.23588D+02	7.67138D+03	0.0	0.0
2	3.12299D+03	1.71960D+01	2.45503D+02	1.81466D+02	1.15200D+03	4.77505D+02	6.80445D+03	0.0	0.0
3	2.84588D+03	1.56360D+01	2.23365D+02	1.33132D+02	1.14980D+03	4.77505D+02	6.80443D+03	1.63397D+02	2.32804D+03
4	2.56548D+03	1.40760D+01	2.01158D+02	1.31391D+02	1.18743D+03	3.80163D+02	5.41727D+03	3.92883D+02	5.59882D+03
5	2.28421D+03	1.25160D+01	1.78855D+02	1.42402D+02	1.07040D+03	3.64757D+02	6.54034D+03	2.53762D+02	3.61751D+03
6	2.00003D+03	1.09560D+01	1.56567D+02	1.26243D+02	8.86409D+02	4.72719D+02	6.73623D+03	3.09646D+02	3.90691D+03
7	1.71642D+03	9.39600D+00	1.34301D+02	1.02512D+02	7.15689D+02	4.72719D+02	6.73624D+03	3.85518D+02	5.47719D+03
8	1.42856D+03	7.83600D+00	1.12005D+02	1.12802D+02	6.86345D+02	2.89031D+02	4.11869D+03	4.01668D+02	5.72722D+03
9	1.14202D+03	6.27600D+00	8.97065D+01	1.04268D+02	5.98399D+02	2.26647D+02	3.22972D+03	3.86648D+02	4.72701D+03
10	8.57085D+02	4.71600D+00	6.74008D+01	8.26557D+01	4.80841D+02	2.97029D+02	4.23266D+03	6.60168D+02	9.06464D+03
11	5.77015D+02	3.15600D+00	4.52724D+01	6.79585D+01	3.61413D+02	3.09263D+02	4.40698D+03	3.38706D+02	3.55733D+03
12	2.95488D+02	1.59600D+00	2.29531D+01	1.08114D+02	4.59642D+02	3.09263D+02	4.40700D+03	5.50270D+02	7.89733D+03
13	7.57388D+01	4.08000D-01	4.42086D+00	1.39552D+02	2.59214D+02	2.48193D+02	2.65542D+03	8.16610D+02	6.18129D+03

.....COLUMN 7.....

ROW	MAX OF WGM	MAX OF FIF	MAX OF FIM	MAX OF VRF	MAX OF VRM	MAX OF DWF	MAX OF DWM	MAX OF BKF	MAX OF BKM
1	3.39144D+03	1.87400D+01	2.67434D+02	1.43270D+02	1.06297D+03	5.10591D+02	7.89654D+03	0.0	0.0
2	3.12044D+03	1.71960D+01	2.45459D+02	1.85937D+02	1.21522D+03	4.17149D+02	5.94437D+03	0.0	0.0
3	2.84418D+03	1.56360D+01	2.23299D+02	1.44990D+02	1.19133D+03	3.61405D+02	5.14999D+03	1.20441D+02	1.64035D+03
4	2.56417D+03	1.40760D+01	2.01111D+02	1.43588D+02	1.18743D+03	3.92476D+02	5.59278D+03	2.43761D+02	2.32401D+03
5	2.28281D+03	1.25160D+01	1.78836D+02	1.42634D+02	1.07040D+03	4.31220D+02	6.14487D+03	3.92883D+02	5.58036D+03
6	2.00028D+03	1.09560D+01	1.56550D+02	1.38898D+02	8.86409D+02	4.31220D+02	6.14489D+03	2.53762D+02	3.60544D+03
7	1.71655D+03	9.39600D+00	1.34303D+02	1.53544D+02	7.15689D+02	2.83092D+02	4.04067D+03	4.01668D+02	5.70320D+03
8	1.43054D+03	7.83600D+00	1.12009D+02	1.11138D+02	6.86345D+02	2.95163D+02	4.20607D+03	3.27284D+02	4.66622D+03
9	1.14344D+03	6.27600D+00	8.96647D+01	8.62709D+01	5.98399D+02	2.95163D+02	4.20606D+03	6.49883D+02	9.25313D+03
10	8.57325D+02	4.71600D+00	6.74119D+01	6.98380D+01	4.80841D+02	2.29992D+02	3.27738D+03	2.54225D+02	3.44597D+03
11	5.77369D+02	3.15600D+00	4.52960D+01	6.20513D+01	3.29117D+02	2.29992D+02	3.27738D+03	5.06253D+02	7.18409D+03
12	2.96634D+02	1.59600D+00	2.29672D+01	8.53533D+01	3.47788D+02	2.25934D+02	4.03211D+03	6.92148D+02	9.90422D+03
13	7.58948D+01	4.08000D-01	4.42661D+00	1.15446D+02	2.21443D+02	2.16988D+02	2.32169D+03	2.77639D+02	2.77572D+03

.....COLUMN 8.....

ROW	MAX OF WGM	MAX OF FIF	MAX OF FIM	MAX OF VRF	MAX OF VRM	MAX OF DWF	MAX OF DWM	MAX OF BKF	MAX OF BKM
1	3.43628D+03	1.89640D+01	2.03429D+02	2.11066D+02	1.42722D+03	1.09466D+03	1.17128D+04	0.0	0.0
2	3.20015D+03	1.76120D+01	2.51376D+02	1.68732D+02	1.12602D+03	1.09466D+03	1.55988D+04	0.0	0.0
3	2.91833D+03	1.60520D+01	2.29263D+02	1.71948D+02	1.05410D+03	4.47298D+02	7.13477D+03	1.64840D+02	2.34850D+03
4	2.64309D+03	1.44920D+01	2.07099D+02	1.42597D+02	1.03903D+03	6.77219D+02	9.65034D+03	2.43761D+02	3.47431D+03
5	2.36068D+03	1.29320D+01	1.84843D+02	1.60604D+02	8.71198D+02	6.77219D+02	9.65028D+03	2.48126D+02	3.54106D+03
6	2.07552D+03	1.13720D+01	1.62519D+02	1.77719D+02	7.77641D+02	3.90795D+02	6.12088D+03	3.48954D+02	4.98094D+03
7	1.79222D+03	9.81200D+00	1.40240D+02	1.50397D+02	6.85535D+02	3.90795D+02	5.56882D+03	5.82511D+02	4.83258D+03
8	1.50787D+03	8.25200D+00	1.17952D+02	1.06564D+02	5.97477D+02	2.75708D+02	3.92882D+03	6.29195D+02	6.93373D+03
9	1.22264D+03	6.69200D+00	9.56436D+01	1.34458D+02	5.14097D+02	3.50663D+02	4.99690D+03	4.22989D+02	5.04594D+03
10	9.33798D+02	5.13200D+00	7.33322D+01	8.62354D+01	4.34589D+02	3.50663D+02	4.99693D+03	3.49123D+02	3.11169D+03
11	6.50057D+02	3.57200D+00	5.12047D+01	1.11334D+02	3.69306D+02	2.35350D+02	3.69458D+03	1.94948D+02	1.87725D+03
12	3.71892D+02	2.01200D+00	2.89466D+01	1.04046D+02	2.83230D+02	1.63432D+02	2.32893D+03	1.49953D+02	2.13759D+03
13	1.15563D+02	6.16000D-01	8.87187D+00	6.97583D+01	1.59301D+02	1.63432D+02	2.32882D+03	5.66791D+02	5.16912D+03

.....COLUMN 9.....

ROW	MAX OF WGM	MAX OF FIF	MAX OF FIM	MAX OF VRF	MAX OF VRM	MAX OF DWF	MAX OF DWM	MAX OF BKF	MAX OF BKM
1	3.39152D+03	1.87400D+01	2.67398D+02	1.50224D+02	1.02394D+03	5.10591D+02	8.95607D+03	0.0	0.0
2	3.12228D+03	1.71960D+01	2.45497D+02	1.80021D+02	1.16455D+03	4.69501D+02	6.69039D+03	0.0	0.0
3	2.84475D+03	1.56360D+01	2.23330D+02	1.56277D+02	1.14980D+03	3.86588D+02	6.38489D+03	1.71415D+02	1.98799D+03
4	2.56465D+03	1.40760D+01	2.01071D+02	1.27006D+02	1.18743D+03	4.16660D+02	6.29910D+03	2.94507D+02	4.20041D+03
5	2.28427D+03	1.25160D+01	1.78862D+02	1.33902D+02	1.07040D+03	3.38659D+02	4.98180D+03	4.27602D+02	6.08212D+03
6	2.00138D+03	1.09560D+01	1.56607D+02	1.25592D+02	8.86409D+02	3.27484D+02	5.75818D+03	4.52686D+02	6.46211D+03
7	1.71750D+03	9.39600D+00	1.34316D+02	1.13647D+02	7.15689D+02	3.36347D+02	5.41698D+03	5.24310D+02	6.48886D+03
8	1.43182D+03	7.83600D+00	1.12003D+02	1.08299D+02	6.86345D+02	3.43442D+02	4.89404D+03	5.57700D+02	7.95260D+03
9	1.14593D+03	6.27600D+00	8.97046D+01	7.23734D+01	5.98399D+02	3.43442D+02	4.89404D+03	4.07688D+02	5.27687D+03
10	8.59384D+02	4.71600D+00	6.74696D+01	8.29937D+01	4.80841D+02	2.53462D+02	3.61182D+03	5.78980D+02	8.24634D+03
11	5.79263D+02	3.15600D+00	4.52616D+01	8.01157D+01	3.29117D+02	3.01226D+02	4.29247D+03	3.70146D+02	4.07970D+03
12	2.95505D+02	1.59600D+00	2.29527D+01	9.40484D+01	3.01307D+02	4.76647D+02	5.86837D+03	5.54147D+02	7.89344D+03
13	7.57717D+01	4.08000D-01	4.42814D+00	9.40484D+01	1.75806D+02	4.15185D+02	4.44220D+03	6.78171D+02	7.04466D+03

.....COLUMN 10.....

ROW	MAX OF WGM	MAX OF FIF	MAX OF FIM	MAX OF VRF	MAX OF VRM	MAX OF DWF	MAX OF DWM	MAX OF BKF	MAX OF BKM
1	3.39137D+03	1.87400D+01	2.67421D+02	1.63892D+02	1.05206D+03	5.53454D+02	7.88672D+03	0.0	0.0
2	3.12450D+03	1.71960D+01	2.45537D+02	1.85268D+02	1.21571D+03	4.50505D+02	7.61881D+03	7.34132D+01	1.04321D+03
3	2.84886D+03	1.563600+01	2.23369D+02	1.53736D+02	1.14995D+03	4.94935D+02	7.05279D+03	2.94507D+02	4.18075D+03
4	2.56754D+03	1.40760D+01	2.01118D+02	1.38699D+02	1.18743D+03	4.94935D+02	7.05282D+03	3.12919D+02	4.46212D+03
5	2.28414D+03	1.25160D+01	1.78870D+02	1.33913D+02	1.07040D+03	4.57845D+02	6.52429D+03	4.48321D+02	6.36264D+03
6	2.00052D+03	1.09560D+01	1.56552D+02	1.25592D+02	8.86409D+02	4.11847D+02	5.86876D+03	4.55206D+02	6.45823D+03
7	1.71583D+03	9.39600D+00	1.34298D+02	1.13647D+02	7.15689D+02	4.11847D+02	5.86878D+03	5.57700D+02	7.89328D+03
8	1.43240D+03	7.83600D+00	1.12005D+02	1.08177D+02	6.86345D+02	2.95076D+02	4.20481D+03	3.87538D+02	5.22318D+03
9	1.14374D+03	6.27600D+00	8.96946D+01	7.04483D+01	5.98399D+02	2.95076D+02	4.20482D+03	4.19302D+02	3.75097D+03
10	8.59313D+02	4.71600D+00	6.75017D+01	7.65233D+01	4.80841D+02	2.43683D+02	3.47248D+03	3.57626D+02	4.75341D+03
11	5.81352D+02	3.15600D+00	4.52670D+01	7.13221D+01	3.29117D+02	2.43683D+02	3.47247D+03	5.85400D+02	8.30338D+03

12	2.95845D+02	1.59600D+00	2.29840D+01	9.74891D+01	3.26734D+02	2.47369D+02	3.52491D+03	6.72245D+02	9.63643D+03
13	7.60815D+01	4.08000D-01	4.42983D+00	1.02091D+02	1.90583D+02	2.47369D+02	2.64686D+03	2.35561D+02	2.59169D+03

.....COLUMN 11.....

ROW	MAX OF WGM	MAX OF FIF	MAX OF FIM	MAX OF VRF	MAX OF VRM	MAX OF DWF	MAX OF DWM	MAX OF BKF	MAX OF BKM
1	3.43628D+03	1.89640D+01	2.03505D+02	2.71374D+02	1.51491D+03	9.41719D+02	1.32238D+04	0.0	0.0
2	3.19864D+03	1.76120D+01	2.51386D+02	2.00818D+02	1.20487D+03	9.41719D+02	1.34195D+04	0.0	0.0
3	2.92208D+03	1.60520D+01	2.29290D+02	1.63828D+02	1.05291D+03	4.37930D+02	6.24050D+03	2.03405D+02	1.97095D+03
4	2.64297D+03	1.44920D+01	2.07087D+02	1.42344D+02	9.58762D+02	4.37930D+02	6.24046D+03	3.12919D+02	4.43339D+03
5	2.36070D+03	1.29320D+01	1.84837D+02	1.57518D+02	8.76666D+02	4.59106D+02	6.54227D+03	3.61569D+02	5.15377D+03
6	2.07819D+03	1.13720D+01	1.62573D+02	1.47192D+02	7.32865D+02	4.59106D+02	6.54225D+03	3.78072D+02	4.57093D+03
7	1.79486D+03	9.81200D+00	1.40295D+02	1.35162D+02	6.99547D+02	3.87252D+02	5.51834D+03	5.11067D+02	7.28740D+03
8	1.50838D+03	8.25200D+00	1.17946D+02	1.19398D+02	5.52422D+02	2.95462D+02	4.21031D+03	3.79703D+02	4.20994D+03
9	1.22134D+03	6.69200D+00	9.56457D+01	9.12775D+01	4.76038D+02	3.48563D+02	4.96696D+03	5.54847D+02	4.10454D+03
10	9.36380D+02	5.13200D+00	7.33291D+01	7.24444D+01	3.95881D+02	3.48563D+02	4.96699D+03	3.91208D+02	4.59474D+03
11	6.51272D+02	3.57200D+00	5.12095D+01	9.40313D+01	3.36482D+02	2.68875D+02	3.83147D+03	6.03100D+02	4.04031D+03
12	3.72264D+02	2.01200D+00	2.88608D+01	1.06879D+02	3.83608D+02	2.70490D+02	3.85447D+03	4.50477D+02	4.30888D+03
13	1.14235D+02	6.16000D-01	8.87829D+00	1.00980D+02	2.26025D+02	2.70490D+02	3.85449D+03	5.37757D+02	7.65317D+03

.....COLUMN 12.....

ROW	MAX OF WGM	MAX OF FIF	MAX OF FIM	MAX OF VRF	MAX OF VRM	MAX OF DWF	MAX OF DWM	MAX OF BKF	MAX OF BKM
1	3.39112D+03	1.87400D+01	2.67384D+02	1.36225D+02	1.07538D+03	5.62675D+02	8.18277D+03	0.0	0.0
2	3.12284D+03	1.71960D+01	2.45420D+02	1.85268D+02	1.25440D+03	4.39717D+02	6.26597D+03	0.0	0.0
3	2.84320D+03	1.56360D+01	2.23269D+02	1.53736D+02	1.14980D+03	3.64782D+02	5.86327D+03	4.83655D+02	5.26734D+03
4	2.56425D+03	1.40760D+01	2.01066D+02	1.27006D+02	1.18743D+03	3.51062D+02	5.00263D+03	4.02255D+02	3.88541D+03
5	2.28285D+03	1.25160D+01	1.78831D+02	1.33913D+02	1.07040D+03	3.48530D+02	4.96654D+03	4.31842D+02	4.39977D+03
6	1.99963D+03	1.09560D+01	1.56572D+02	1.25592D+02	8.86409D+02	3.55296D+02	5.06296D+03	5.11067D+02	4.55236D+03
7	1.71540D+03	9.39600D+00	1.34271D+02	1.13647D+02	7.15689D+02	3.55296D+02	5.06297D+03	5.76439D+02	4.54083D+03
8	1.43048D+03	7.83600D+00	1.11968D+02	1.08177D+02	6.86345D+02	3.26452D+02	4.65193D+03	4.79551D+02	5.51313D+03
9	1.14415D+03	6.27600D+00	8.96599D+01	7.44414D+01	5.98399D+02	3.26452D+02	4.65193D+03	4.80526D+02	4.91973D+03
10	8.59937D+02	4.71600D+00	6.74875D+01	8.85847D+01	4.80841D+02	2.74490D+02	5.77637D+03	5.04760D+02	5.29093D+03
11	5.79913D+02	3.15600D+00	4.52482D+01	1.18184D+02	4.14115D+02	3.77064D+02	5.37316D+03	5.82769D+02	5.93591D+03
12	2.95422D+02	1.59600D+00	2.29032D+01	9.73295D+01	3.23658D+02	4.63096D+02	6.59919D+03	5.37757D+02	6.71052D+03
13	7.52056D+01	4.08000D-01	4.42596D+00	1.07941D+02	2.58140D+02	4.63096D+02	4.95394D+03	3.79923D+02	4.62558D+03

.....COLUMN 13 (REFLECTOR BLOCK).....

ROW	MAX OF FIA	MAX OF BKA	MAX OF SRF
1	5.22480D+01	0.0	2.07441D+02
2	4.85760D+01	0.0	2.09578D+02
3	4.43520D+01	2.35488D+02	2.10380D+02
4	4.01280D+01	5.09329D+02	2.10624D+02
5	3.59040D+01	3.63794D+02	2.11643D+02
6	3.16800D+01	3.25379D+02	2.11835D+02
7	2.74560D+01	5.83388D+02	2.13077D+02
8	2.32320D+01	3.51476D+02	2.12779D+02
9	1.90080D+01	5.31945D+02	2.12886D+02
10	1.47840D+01	3.87155D+02	2.12942D+02
11	1.05600D+01	3.99389D+02	2.13664D+02
12	6.33600D+00	5.05279D+02	2.13207D+02
13	2.11200D+00	5.00929D+02	2.09905D+02

.....COLUMN 14 (REFLECTOR BLOCK).....

ROW	MAX OF FIA	MAX OF BKA	MAX OF SRF
1	5.22480D+01	0.0	2.07441D+02
2	4.85760D+01	0.0	2.09578D+02
3	4.43520D+01	1.26880D+02	2.10380D+02
4	4.01280D+01	4.52001D+02	2.10624D+02
5	3.59040D+01	3.08853D+02	2.11811D+02
6	3.16800D+01	2.67400D+02	2.12217D+02
7	2.74560D+01	4.22017D+02	2.13239D+02
8	2.32320D+01	3.22795D+02	2.13503D+02
9	1.90080D+01	3.56587D+02	2.13598D+02
10	1.47840D+01	4.33483D+02	2.13502D+02
11	1.05600D+01	4.92518D+02	2.13980D+02
12	6.33600D+00	5.61061D+02	2.14124D+02
13	2.11200D+00	4.25598D+02	3.18934D+02

SONATINA-2V SAMPLE PROBLEM SINUSOIDAL INPUT 4.0 HZ 250 GAL SONATINA-2V

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***                                          ***
*   RESULT                  MAX VALUE          *
*                      AT   NOW       STATE    *
***                                          ***
*        TIME  =  1.600066D+00                 *
*                                              *
*        CYCLE OF MAX VALUE PRINT              *
*              = 13324                         *
***                                          ***
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MAX OF THA	MAX OF U	MAX OF W	MAX OF THADF1	MAX OF UDF1	MAX OF WDF1	MAX OF THADF2	MAX OF UDF2	MAX OF WDF2
2.30448D-02	1.38572D+00	1.28668D-01	9.73437D+00	2.95969D+01	1.19852D+01	6.32093D+04	7.85594D+04	1.76078D+04

MAX OF WGM	MAX OF FIF	MAX OF FIM	MAX OF VRF	MAX OF VRM	MAX OF DWF	MAX OF DWM	MAX OF BKF	MAX OF BKM
3.43628D+03	1.89640D+01	2.67461D+02	2.71374D+02	1.51491D+03	1.09466D+03	1.55988D+04	1.01650D+03	1.10360D+04

SONATINA-2V SAMPLE PROBLEM SINUSOIDAL INPUT 4.0 HZ 250 GAL SONATINA-2V

COLUMN NO. 1

	L.BOT	R.BOT	L.CENT	R.CENT	L.TOP	R.TOP	L.DOWEL	R.DOWEL
1	0.0	0.0	0.0	0.0	0.0	0.0	3.23660D+02	3.23649D+02
2	0.0	0.0	0.0	0.0	0.0	2.90624D+02	2.15848D+02	2.15885D+02
3	2.35488D+02	0.0	2.98929D+02	0.0	4.33019D+02	2.06420D+02	2.20457D+02	2.20346D+02
4	2.64652D+02	0.0	2.22628D+02	2.83035D+02	2.40932D+02	2.92160D+02	1.83164D+02	1.83163D+02
5	3.20568D+02	2.95261D+02	2.37559D+02	3.14856D+02	2.55688D+02	3.47696D+02	2.97589D+02	2.97814D+02
6	2.13646D+02	2.73641D+02	2.79915D+02	2.98391D+02	2.18699D+02	3.21231D+02	1.47751D+02	1.48424D+02
7	2.20164D+02	2.22138D+02	2.27957D+02	2.66983D+02	2.08599D+02	3.26036D+02	1.82901D+02	1.82543D+02
8	2.89967D+02	3.51937D+02	2.63656D+02	3.58378D+02	2.94407D+02	2.65774D+02	1.39568D+02	1.39597D+02
9	2.64640D+02	2.42595D+02	2.87206D+02	3.35316D+02	1.92874D+02	2.15477D+02	1.20745D+02	1.19681D+02
10	2.37622D+02	2.68634D+02	2.30671D+02	2.86936D+02	2.04774D+02	1.20824D+02	1.58304D+02	1.59035D+02
11	2.44370D+02	2.25139D+02	2.39067D+02	3.19710D+02	2.66212D+02	3.88705D+01	1.24660D+02	1.24735D+02
12	2.67948D+02	2.25665D+02	2.04737D+02	1.53799D+02	0.0	0.0	1.70856D+02	1.70455D+02
13	2.05191D+02	2.86137D+02	3.63490D+02	1.27110D+02	2.68651D+02	1.30720D+02	1.19909D+02	1.06928D+02

COLUMN NO. 2

	L.BOT	R.BOT	L.CENT	R.CENT	L.TOP	R.TOP	L.DOWEL	R.DOWEL
1	0.0	0.0	0.0	0.0	0.0	0.0	3.79036D+02	3.78356D+02
2	0.0	0.0	0.0	0.0	0.0	0.0	3.78425D+02	3.78806D+02
3	0.0	2.84372D+02	2.90624D+02	1.59812D+02	0.0	2.26043D+02	3.19571D+02	3.19525D+02
4	0.0	1.86761D+02	2.06420D+02	3.54623D+02	9.45575D+01	2.95329D+02	2.26579D+02	2.26504D+02
5	2.83035D+02	0.0	3.21598D+02	3.70340D+02	3.14856D+02	3.28995D+02	1.74223D+02	1.74268D+02
6	1.15705D+02	0.0	3.47696D+02	2.70895D+02	2.98391D+02	3.02560D+02	2.18874D+02	2.20158D+02
7	2.52979D+02	2.03192D+02	3.21231D+02	3.08781D+02	2.66983D+02	3.16285D+02	1.59803D+02	1.59650D+02
8	2.42745D+02	6.18594D+02	3.51937D+02	5.17238D+02	3.24862D+02	2.43009D+02	1.29138D+02	1.29023D+02
9	2.63347D+02	3.36369D+02	2.97733D+02	3.54951D+02	2.57746D+02	2.51342D+02	1.75171D+02	1.75170D+02
10	3.35316D+02	4.20426D+02	2.68634D+02	4.61114D+02	2.86936D+02	1.50142D+02	1.82241D+02	1.82251D+02
11	1.19795D+02	6.88295D+02	2.25139D+02	8.20969D+02	3.19710D+02	2.73908D+02	1.67544D+02	1.67391D+02
12	2.58056D+02	3.95148D+02	2.25665D+02	2.45821D+02	1.53799D+02	0.0	1.09203D+02	1.09369D+02
13	6.54106D+01	7.76703D+02	2.86137D+02	4.23224D+02	1.27110D+02	1.86876D+02	1.32131D+02	1.31599D+02

COLUMN NO. 3

	L.BOT	R.BOT	L.CENT	R.CENT	L.TOP	R.TOP	L.DOWEL	R.DOWEL
1	0.0	0.0	0.0	0.0	0.0	0.0	2.62551D+02	2.62676D+02
2	0.0	0.0	2.84372D+02	0.0	0.0	0.0	2.81071D+02	2.80976D+02
3	1.59812D+02	0.0	2.26043D+02	2.63945D+02	0.0	1.43230D+02	1.79550D+02	1.79713D+02
4	3.54623D+02	0.0	2.95329D+02	1.79816D+02	0.0	3.27882D+02	2.34883D+02	2.35032D+02
5	3.70340D+02	0.0	3.28995D+02	2.56617D+02	0.0	4.02924D+02	1.99556D+02	1.99601D+02
6	2.70895D+02	0.0	3.02560D+02	1.91698D+02	2.66737D+02	4.02307D+02	2.27745D+02	2.27787D+02
7	2.79115D+02	3.54303D+02	6.18594D+02	2.34612D+02	4.75809D+02	2.23316D+02	1.78043D+02	1.78284D+02
8	1.74467D+02	2.11808D+02	3.36369D+02	2.28924D+02	2.42973D+02	3.48167D+02	1.25729D+02	1.25830D+02
9	1.91396D+02	3.17045D+02	5.40742D+02	2.15578D+02	4.43519D+02	1.22798D+02	1.49027D+02	1.49134D+02
10	2.67536D+02	3.52476D+02	7.35116D+02	4.72570D+02	7.24671D+02	2.44200D+02	1.29193D+02	1.29181D+02
11	2.24473D+02	2.23047D+02	4.80614D+02	6.52887D+02	0.0	4.10214D+02	1.00608D+02	1.00836D+02
12	2.45821D+02	5.97083D+02	7.76703D+02	3.51536D+02	4.23224D+02	0.0	1.59829D+02	1.56641D+02
13	3.05026D+02	7.62798D+02	1.86876D+02	6.56838D+02	2.04259D+02	1.98432D+02	1.24399D+02	1.18360D+02

COLUMN NO. 4

	L.BOT	R.BOT	L.CENT	R.CENT	L.TOP	R.TOP	L.DOWEL	R.DOWEL
1	0.0	0.0	0.0	0.0	0.0	0.0	2.55229D+02	2.55362D+02
2	0.0	0.0	0.0	0.0	0.0	0.0	2.55109D+02	2.54932D+02
3	0.0	0.0	0.0	0.0	0.0	2.65485D+02	2.17902D+02	2.17954D+02
4	2.63945D+02	0.0	1.43230D+02	2.51239D+02	0.0	3.35472D+02	2.11561D+02	2.11591D+02
5	1.79816D+02	0.0	3.27882D+02	2.08820D+02	0.0	3.09622D+02	1.87203D+02	1.86858D+02
6	2.56617D+02	0.0	4.02924D+02	2.42304D+02	1.84812D+02	1.95341D+02	1.74331D+02	1.74156D+02
7	1.83828D+02	0.0	4.02307D+02	2.25691D+02	2.34612D+02	2.16393D+02	1.82776D+02	1.83082D+02
8	2.20564D+02	2.29002D+02	2.23316D+02	3.05389D+02	1.80859D+02	1.89749D+02	1.80678D+02	1.80893D+02
9	2.28924D+02	1.86349D+02	3.48167D+02	2.15434D+02	4.69245D+02	1.34507D+02	1.25970D+02	1.25698D+02
10	4.07423D+02	3.02524D+02	3.52476D+02	2.71808D+02	6.52887D+02	1.06533D+02	1.17033D+02	1.17079D+02
11	4.00622D+02	1.56196D+02	5.97083D+02	1.77535D+02	2.06226D+02	7.59448D+01	1.21321D+02	1.19372D+02
12	3.51536D+02	1.24752D+02	7.62798D+02	0.0	6.56838D+02	0.0	1.04898D+02	1.04570D+02
13	3.22520D+02	1.69394D+02	1.98432D+02	2.36345D+02	2.00677D+02	2.00950D+02	1.26499D+02	1.25680D+02

COLUMN NO. 5

	L.BOT	R.BOT	L.CENT	R.CENT	L.TOP	R.TOP	L.DOWEL	R.DOWEL
1	0.0	0.0	0.0	0.0	0.0	0.0	3.27192D+02	3.27622D+02
2	0.0	0.0	0.0	0.0	0.0	0.0	3.54220D+02	3.53907D+02
3	0.0	0.0	0.0	0.0	0.0	0.0	2.03027D+02	2.03089D+02
4	0.0	0.0	2.65485D+02	0.0	0.0	1.80612D+02	2.73895D+02	2.73941D+02
5	2.51239D+02	0.0	3.35472D+02	1.38038D+02	4.61244D+01	1.98314D+02	2.05478D+02	2.05364D+02
6	2.08820D+02	0.0	3.09622D+02	1.55278D+02	1.48005D+02	3.09646D+02	1.78940D+02	1.77998D+02
7	2.42304D+02	0.0	1.95341D+02	2.47805D+02	1.08706D+02	2.80345D+02	1.71021D+02	1.70875D+02
8	2.25691D+02	1.80787D+02	2.29002D+02	2.61220D+02	2.43490D+02	2.08963D+02	1.65973D+02	1.65868D+02
9	2.57539D+02	1.35803D+02	1.89749D+02	2.84957D+02	2.15434D+02	1.76317D+02	1.34696D+02	1.34866D+02
10	1.45623D+02	1.27368D+02	3.02524D+02	3.31285D+02	2.71808D+02	1.65385D+02	9.66497D+01	9.66368D+01
11	1.71863D+02	3.01994D+02	1.56196D+02	2.50893D+02	1.77535D+02	1.02816D+02	1.15989D+02	1.15984D+02
12	1.07387D+02	3.28959D+02	1.24752D+02	5.66493D+01	0.0	0.0	9.81039D+01	9.79347D+01
13	0.0	5.10519D+02	2.19873D+02	6.17222D+02	2.36345D+02	2.19573D+02	1.45314D+02	1.39930D+02

COLUMN NO. 6

	L.BOT	R.BOT	L.CENT	R.CENT	L.TOP	R.TOP	L.DOWEL	R.DOWEL
1	0.0	0.0	0.0	0.0	0.0	0.0	2.65438D+02	2.65527D+02
2	0.0	0.0	0.0	0.0	0.0	0.0	2.08531D+02	2.08618D+02
3	0.0	0.0	0.0	0.0	0.0	1.63397D+02	2.38709D+02	2.38796D+02
4	0.0	1.15510D+02	1.80612D+02	0.0	0.0	3.92883D+02	1.90207D+02	1.89957D+02
5	1.38038D+02	0.0	1.98314D+02	1.93183D+02	0.0	2.53762D+02	1.70067D+02	1.69588D+02
6	1.55278D+02	2.73989D+02	3.09646D+02	1.33217D+02	0.0	2.57033D+02	1.82356D+02	1.82401D+02
7	2.47805D+02	1.95748D+02	2.80345D+02	3.85518D+02	0.0	2.81822D+02	2.36367D+02	2.36351D+02
8	2.61220D+02	4.01668D+02	2.08963D+02	1.44867D+02	2.84957D+02	2.93527D+02	1.44387D+02	1.44644D+02
9	1.70997D+02	1.30083D+02	1.76317D+02	3.27284D+02	3.31285D+02	2.17231D+02	1.13291D+02	1.13356D+02
10	1.94942D+02	2.32188D+02	3.01994D+02	6.49857D+02	0.0	5.06253D+02	1.04364D+02	1.04289D+02
11	2.50893D+02	2.43569D+02	3.28959D+02	1.55187D+02	0.0	2.10504D+02	1.48537D+02	1.48492D+02
12	5.66493D+01	3.64896D+02	5.10519D+02	7.80118D+01	5.50270D+02	0.0	1.54790D+02	1.54473D+02
13	2.16193D+02	5.92961D+02	2.19573D+02	7.17322D+02	2.40989D+02	2.60965D+02	1.24887D+02	1.23305D+02

COLUMN NO. 7

	L.BOT	R.BOT	L.CENT	R.CENT	L.TOP	R.TOP	L.DOWEL	R.DOWEL
1	0.0	0.0	0.0	0.0	0.0	0.0	2.60834D+02	2.60911D+02
2	0.0	0.0	0.0	0.0	0.0	0.0	2.08531D+02	2.08618D+02
3	0.0	0.0	1.15510D+02	1.20441D+02	0.0	0.0	1.80826D+02	1.80579D+02
4	0.0	1.53116D+02	1.63397D+02	2.43761D+02	0.0	0.0	1.80470D+02	1.79426D+02
5	2.24521D+01	1.42287D+02	3.92883D+02	2.00669D+02	7.47029D+01	0.0	1.96212D+02	1.96264D+02
6	1.93183D+02	1.99602D+02	2.53762D+02	1.88655D+02	4.91676D+01	0.0	2.15561D+02	2.15659D+02
7	1.47151D+02	2.29640D+02	4.01668D+02	2.43757D+02	3.85518D+02	1.79689D+02	1.41451D+02	1.41641D+02
8	1.44867D+02	1.77637D+02	2.81822D+02	1.95015D+02	3.27284D+02	1.89529D+02	1.26508D+02	1.26310D+02
9	1.23398D+02	1.45799D+02	3.18637D+02	1.20483D+02	6.44890D+02	1.72765D+02	1.47491D+02	1.47672D+02
10	1.83897D+02	1.70803D+02	2.43569D+02	1.33941D+02	1.45597D+02	1.94948D+02	7.97146D+01	8.02785D+01
11	1.53748D+02	1.49629D+02	5.06253D+02	1.49953D+02	5.67798D+01	1.41638D+02	1.15066D+02	1.14926D+02
12	1.55187D+02	6.71485D+01	5.92961D+02	0.0	6.92148D+02	0.0	1.15068D+02	1.10867D+02
13	2.35589D+02	2.02622D+02	2.60965D+02	2.00979D+02	2.52116D+02	2.09456D+02	1.09208D+02	1.07779D+02

COLUMN NO. 8

	L.BOT	R.BOT	L.CENT	R.CENT	L.TOP	R.TOP	L.DOWEL	R.DOWEL
1	0.0	0.0	0.0	0.0	0.0	0.0	3.69352D+02	3.69270D+02
2	0.0	0.0	0.0	0.0	0.0	0.0	5.47220D+02	5.47436D+02
3	0.0	0.0	0.0	1.39615D+02	1.20441D+02	1.64840D+02	2.23722D+02	2.23734D+02
4	0.0	1.71415D+02	1.53116D+02	0.0	2.43761D+02	0.0	2.22251D+02	2.22226D+02
5	0.0	2.48126D+02	1.42287D+02	0.0	2.00669D+02	0.0	3.38807D+02	3.38412D+02
6	0.0	3.48954D+02	1.99602D+02	0.0	1.88655D+02	0.0	1.64321D+02	1.64406D+02
7	0.0	2.46140D+02	2.29640D+02	4.52686D+02	2.43757D+02	1.29825D+02	1.95355D+02	1.95439D+02
8	0.0	2.90959D+02	1.79689D+02	4.22194D+02	1.95015D+02	2.07001D+02	1.37823D+02	1.37885D+02
9	0.0	3.53716D+02	1.89529D+02	2.29610D+02	1.20483D+02	2.00027D+02	1.05435D+02	1.05619D+02
10	8.38508D+00	2.04577D+02	1.72765D+02	1.46450D+02	1.33941D+02	2.00275D+02	1.75530D+02	1.75133D+02
11	1.14108D+02	1.32192D+02	1.94948D+02	9.13949D+01	7.53673D+01	9.57160D+01	1.17687D+02	1.17665D+02
12	1.49953D+02	0.0	1.47071D+02	1.15180D+02	0.0	0.0	7.47035D+01	7.46918D+01
13	0.0	3.61145D+02	2.84443D+02	5.54147D+02	2.00979D+02	2.32091D+02	8.25907D+01	8.35217D+01

COLUMN NO. 9

	L.BOT	R.BOT	L.CENT	R.CENT	L.TOP	R.TOP	L.DOWEL	R.DOWEL
1	0.0	0.0	0.0	0.0	0.0	0.0	2.60431D+02	2.60626D+02
2	0.0	0.0	0.0	0.0	0.0	0.0	2.34722D+02	2.34779D+02
3	1.39615D+02	7.34132D+01	1.71415D+02	7.08551D+01	0.0	0.0	1.67959D+02	1.67942D+02
4	0.0	2.94507D+02	2.48126D+02	8.23305D+01	0.0	2.03645D+02	2.08141D+02	2.08519D+02
5	0.0	2.32237D+02	3.48954D+02	3.97807D+02	0.0	4.27602D+02	1.71221D+02	1.69148D+02
6	0.0	4.48321D+02	2.46140D+02	0.0	4.52686D+02	3.70278D+02	1.63413D+02	1.64071D+02
7	0.0	4.55206D+02	2.90959D+02	2.39260D+02	4.22194D+02	2.85049D+02	1.68397D+02	1.67950D+02
8	9.00404D+01	5.57700D+02	3.53716D+02	3.25206D+02	2.29610D+02	2.53745D+02	1.57108D+02	1.57214D+02
9	7.83679D+01	3.67852D+02	2.04577D+02	1.99921D+02	6.92496D+01	3.25936D+02	1.71735D+02	1.71707D+02
10	1.46450D+02	2.31220D+02	2.00275D+02	2.44220D+02	0.0	5.75947D+02	1.26691D+02	1.26771D+02
11	9.13949D+01	2.56210D+02	9.57160D+01	2.71090D+02	0.0	3.05878D+02	9.50034D+01	9.49928D+01
12	1.15180D+02	8.70031D+01	3.61145D+02	1.45852D+02	5.54147D+02	0.0	1.50579D+02	1.50647D+02
13	3.00905D+02	6.54222D+02	2.32091D+02	7.01841D+02	1.41360D+02	2.15624D+02	2.07276D+02	2.07909D+02

COLUMN NO. 10

	L.BOT	R.BOT	L.CENT	R.CENT	L.TOP	R.TOP	L.DOWEL	R.DOWEL
1	0.0	0.0	0.0	0.0	0.0	0.0	2.76622D+02	2.76832D+02
2	0.0	0.0	7.34132D+01	0.0	0.0	0.0	2.08531D+02	2.08618D+02
3	7.08551D+01	2.03405D+02	2.94507D+02	1.38284D+02	0.0	1.94629D+02	2.25215D+02	2.25289D+02
4	2.61311D+01	3.12919D+02	2.32237D+02	3.10990D+02	1.21208D+02	2.65065D+02	2.47357D+02	2.47577D+02
5	8.23305D+01	1.66402D+02	4.48321D+02	3.23924D+02	0.0	2.41143D+02	2.28952D+02	2.28893D+02
6	3.97807D+02	1.55114D+02	4.55206D+02	3.03609D+02	2.39260D+02	1.64902D+02	1.66094D+02	1.66017D+02
7	2.33623D+02	1.74697D+02	5.57700D+02	2.63714D+02	3.25206D+02	2.61915D+02	2.06098D+02	2.05749D+02
8	3.23151D+02	1.72768D+02	3.67852D+02	2.08963D+02	2.14227D+02	2.06779D+02	1.23331D+02	1.23132D+02
9	2.63303D+02	1.87212D+02	2.19096D+02	2.99949D+02	1.99921D+02	1.76213D+02	1.47573D+02	1.47502D+02
10	1.91094D+02	2.10169D+02	3.36607D+02	2.83587D+02	2.32296D+02	1.86372D+02	9.88122D+01	9.86004D+01
11	2.71090D+02	1.03734D+02	5.85400D+02	2.40637D+02	9.19349D+01	1.28004D+02	1.21960D+02	1.21723D+02
12	1.66115D+02	8.18937D+01	6.54222D+02	0.0	6.72245D+02	0.0	1.10676D+02	1.10889D+02
13	2.04971D+02	2.83925D+02	2.60805D+02	2.44612D+02	1.70343D+02	2.17443D+02	1.24407D+02	1.22963D+02

COLUMN NO. 11

	L.BOT	R.BOT	L.CENT	R.CENT	L.TOP	R.TOP	L.DOWEL	R.DOWEL
1	0.0	0.0	0.0	0.0	0.0	0.0	4.14536D+02	4.16694D+02
2	0.0	0.0	0.0	0.0	0.0	0.0	4.70897D+02	4.70822D+02
3	0.0	0.0	2.03405D+02	0.0	1.38284D+02	0.0	2.15163D+02	2.15205D+02
4	0.0	0.0	3.12919D+02	0.0	3.10990D+02	0.0	2.18799D+02	2.19130D+02
5	3.84230D+01	3.61569D+02	2.65065D+02	2.05035D+02	3.23924D+02	2.84745D+02	1.77233D+02	1.77339D+02
6	2.82837D+02	3.20866D+02	2.41143D+02	3.19418D+02	3.03609D+02	2.51659D+02	2.29622D+02	2.29484D+02
7	1.34712D+02	5.11067D+02	2.23373D+02	2.33985D+02	2.27468D+02	2.88274D+02	1.93683D+02	1.93569D+02
8	2.01613D+02	2.77474D+02	2.61915D+02	2.67748D+02	2.08963D+02	2.77767D+02	1.37454D+02	1.37995D+02
9	1.17181D+02	3.26414D+02	2.06779D+02	4.58896D+02	2.99949D+02	3.05080D+02	1.47714D+02	1.47748D+02
10	2.79644D+02	1.89998D+02	3.02137D+02	2.64788D+02	1.40571D+02	3.48870D+02	1.74433D+02	1.74130D+02
11	2.83587D+02	1.83527D+02	1.86372D+02	2.79755D+02	1.34288D+01	2.93267D+02	1.06463D+02	1.06575D+02
12	2.40637D+02	1.82076D+02	1.28004D+02	3.01186D+02	0.0	0.0	1.34080D+02	1.34795D+02
13	0.0	5.37757D+02	2.83925D+02	4.92051D+02	2.44612D+02	2.10070D+02	1.35373D+02	1.35117D+02

COLUMN NO. 12

	L.BOT	R.BOT	L.CENT	R.CENT	L.TOP	R.TOP	L.DOWEL	R.DOWEL
1	0.0	0.0	0.0	0.0	0.0	0.0	2.84274D+02	2.84179D+02
2	0.0	0.0	0.0	0.0	0.0	0.0	2.19866D+02	2.19851D+02
3	0.0	0.0	0.0	2.30551D+02	0.0	2.96014D+02	1.85665D+02	1.85835D+02
4	0.0	2.72686D+02	3.61569D+02	2.45465D+02	2.04641D+02	1.58531D+02	1.75524D+02	1.75538D+02
5	1.00618D+02	3.08853D+02	3.20866D+02	2.16965D+02	1.74544D+02	2.52230D+02	1.74427D+02	1.74103D+02
6	3.19418D+02	2.44739D+02	5.11067D+02	1.57172D+02	2.33985D+02	2.54326D+02	1.69866D+02	1.69890D+02
7	2.22784D+02	2.11767D+02	4.71155D+02	2.89491D+02	1.61326D+02	1.93681D+02	1.77715D+02	1.77581D+02
8	2.41790D+02	2.20750D+02	4.20574D+02	1.96726D+02	4.11560D+02	2.42209D+02	1.37868D+02	1.37963D+02
9	2.57526D+02	2.16300D+02	3.05080D+02	2.20902D+02	1.04501D+02	2.47207D+02	1.63175D+02	1.63277D+02
10	2.64788D+02	2.09198D+02	3.48870D+02	2.33227D+02	6.68921D+01	2.59291D+02	1.37283D+02	1.37207D+02
11	2.79755D+02	2.21766D+02	2.93267D+02	2.65991D+02	0.0	2.97628D+02	1.23155D+02	1.23603D+02
12	3.01186D+02	3.08297D+02	5.37757D+02	2.25085D+02	4.69128D+02	0.0	1.88607D+02	1.88458D+02
13	2.21943D+02	1.46243D+02	2.10070D+02	2.67733D+02	3.41727D+02	1.52273D+02	2.27500D+02	2.35596D+02

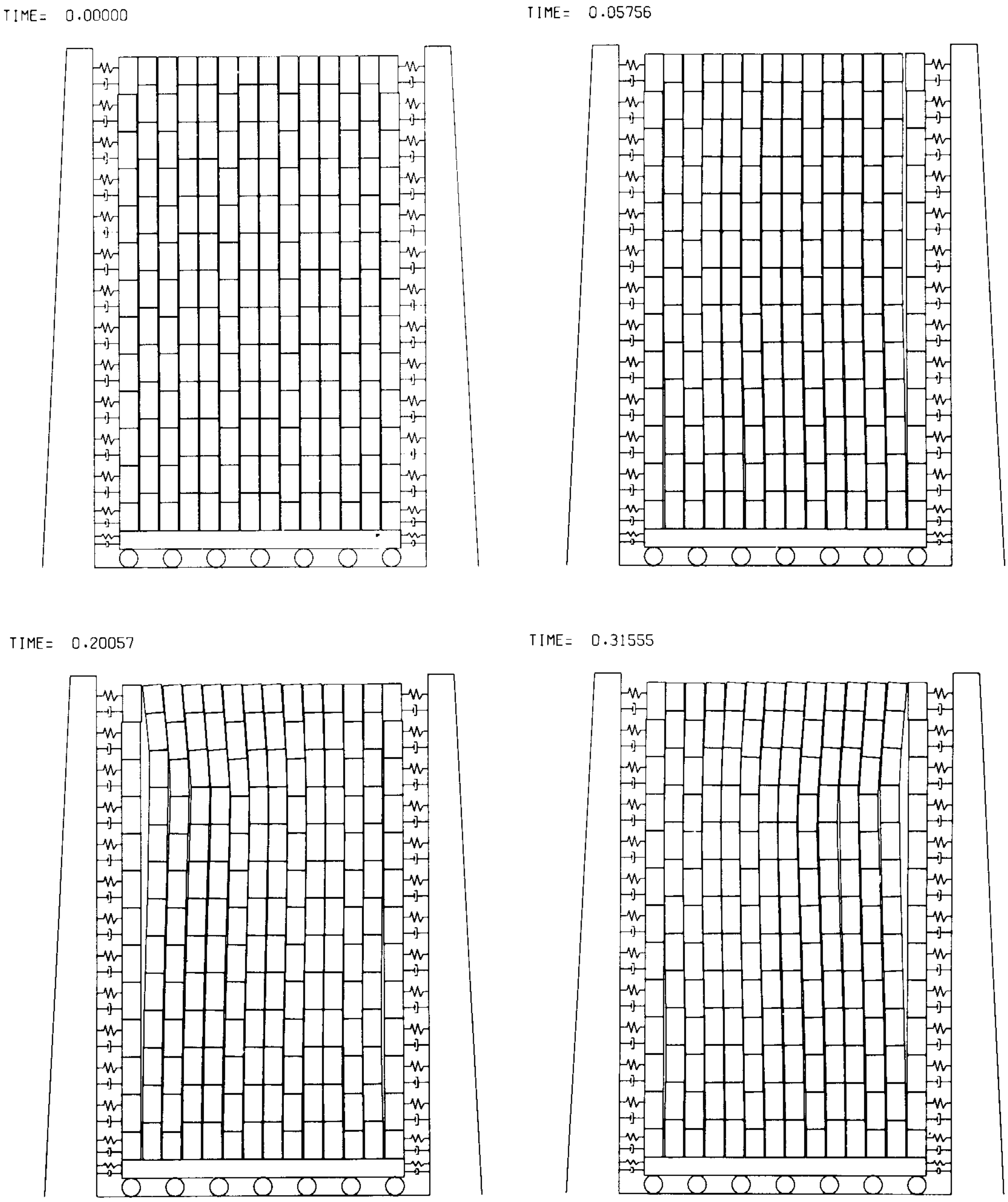


Fig. D.1 Output of SONPL-2V

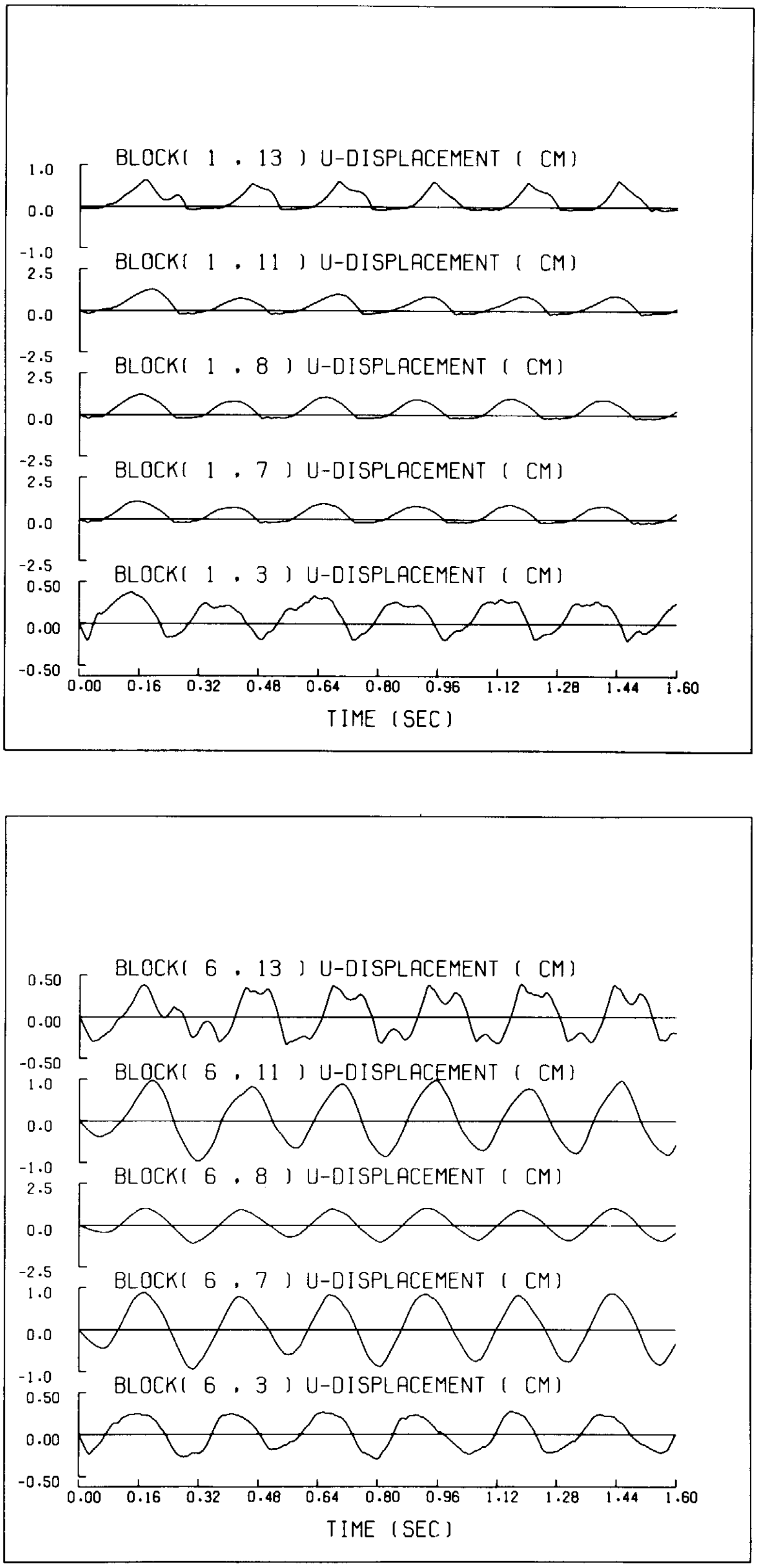
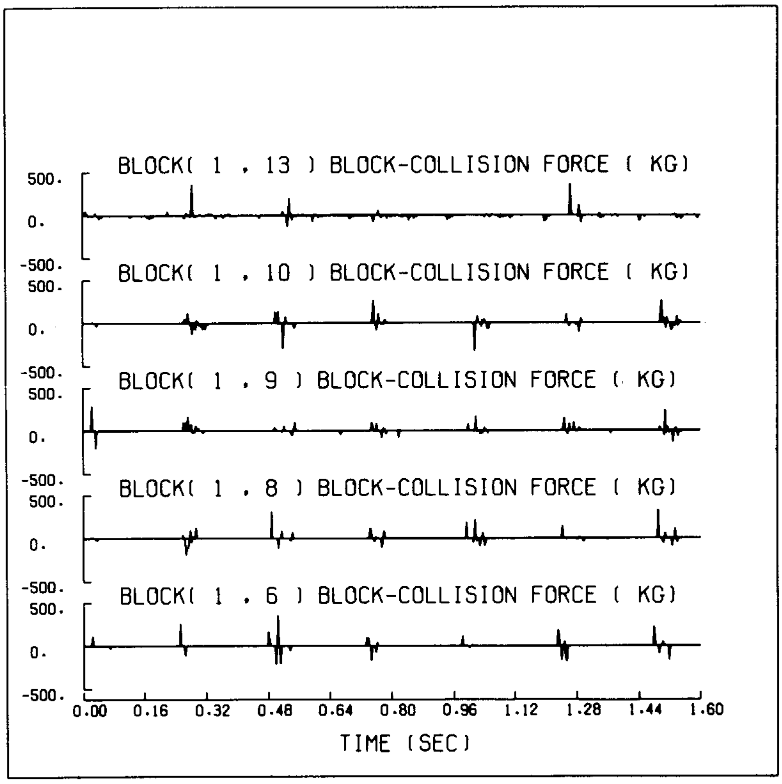


Fig. D.2a Output of SONWV-2V



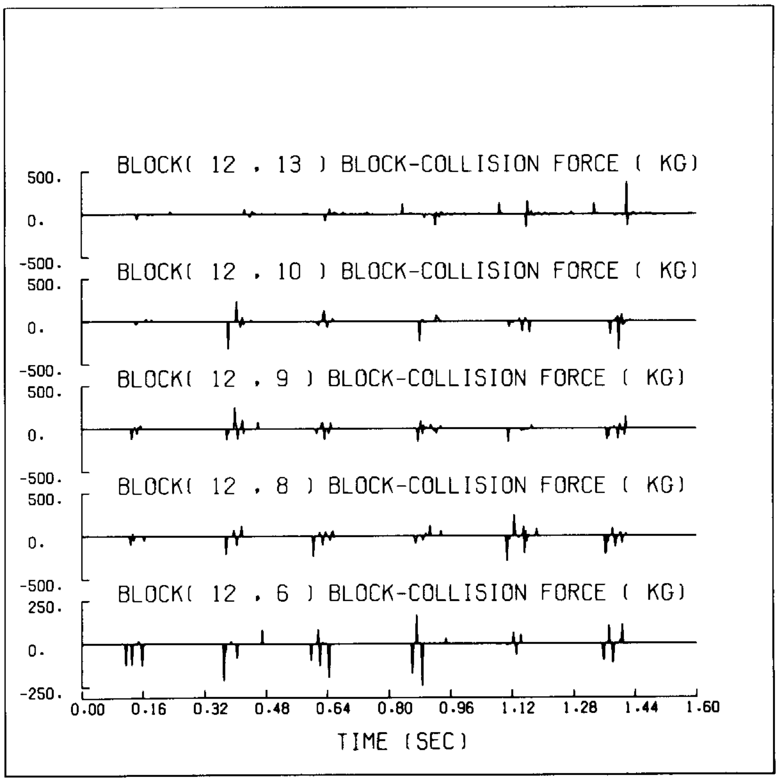


Fig. D.2b Output of SONWV-2V