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User's Manual of SECOM2-DQFM: A Computer Code for Seismic System Reliability Analysis

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This is the English translation of the Japanese version of the user's manual of SECOM2-DQFM, which is developed for seismic reliability analysis of complex engineering systems, such as nuclear power plants.

Given that the seismic hazard curve of the location site of a plant and the fault tree / event tree (FT/ET) models of this plant were known, if the capacities and responses of components were available, the conditional occurrence probability (or frequency) of the top event of the FT models could be estimated with SECOM2-DQFM. In addition, the importance of each basic event as well as the occurrence frequency of each accident sequence could also be obtained.In order to evaluate the concurrent failure probability of multiple components due to earthquake, the method of Direct Quantification of Fault Tree using Monte Carlo simulation (DQFM) is adopted in SECOM2-DQFM. In this method, the capacity and response of each component are generated from their probability distributions. Then the capacities (as well as responses) of several components are made correlated following a given set of correlation rules.

As a user manual of SECOM2-DQFM, this report is organized as follows. Chapter 1 gives a short summary of SEOM2-DQFM. Then how to combine and execute SECOM2-DQFM is described in Chapter 2. Further, how to prepare the original SECOM2 format input data is written in Chapter 3. Finally, how to prepare the NAMELIST format input data is given in Chapter 4.

Keywords: Seismic Probabilistic Safety Assessment, Seismic System Reliability Analysis, Fault Tree, Event Tree, Monte Carlo Simulation, Correlations of Component Failures

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地震時システム信頼性解析コード SECOM2-DQFM のユーザーズマニュアル

日本原子力研究開発機構　安全研究センター
原子力エネルギー関連施設安全評価研究ユニット
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(2008 年 1 月 30 日　受理)

本報告書は、原子力発電所をはじめとするプラントシステムの地震時のシステム信頼性解析を目的として開発してきた SECOM2-DQFM コードの日本語で記述されたユーザーズマニュアルの英訳版である。

SECOM2-DQFM コードは、対象プラントの地震ハザード曲線、システム故障や損傷を発生させる起因事象及び緩和設備の失敗の条件を表現するフォールトツリー及びイベントツリーのモデル、それらの FT/ET を構成する設備の地震応答と耐力に関するデータなどを入力条件として、ある地震動に対する FT モデル頂上事象の条件付き発生確率や発生頻度を計算するほか、基事象の重要度指標や ET で定義した事故シーケンスの発生頻度を計算する機能がある。

また、SECOM2-DQFM コードは、地震による複数の設備の同時損傷確率を正しく評価するために、応答又は耐力の確率分布間の相関によって生じる機器損傷の相関性を適切に表現できるようモンテカルロ法を用いてフォールトツリーを定量化する DQFM(Direct Quantification of Fault Tree by Monte Carlo Simulation)手法を採用している。また FT モデルにおいて AND 結合された機器間のみでなく OR 結合された多数の機器間の相関性の影響も考慮できる。

本報告書は SECOM2-DQFM コードの使用手引きとして、以下の内容に構成される。

第 1 章：SECOM2-DQFM コードの概要
第 2 章：SECOM2-DQFM コード取扱方法
第 3 章：SECOM2 初版形式入力マニュアル
第 4 章: NAMELIST 形式入力マニュアル

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Contents

目　次

Figures

Tables

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1. Summary of the Code

Name of Computer Code

SECOM2-DQFM

Object for Analysis

SECOM2-DQFM is a seismic system reliability analysis code for complex engineering systems such as nuclear power plants. It can perform (1) Calculation of conditional occurrence probability and frequency of a top event in a Fault Tree(FT) for each seismic motion level; (2) Analysis of accident sequences defined in an Event Tree(ET);(3) Importance analysis of basic events.

Calculations in this code are based on Direct Quantification of Fault Tree using Monte Carlo Simulation (DQFM) method.

Development of the Code

SECOM2 is the mother code system of SECOM2-DQFM, which was developed on the mainframe computer FACOM M-380, and then transplanted to a calculation server system SR8000, the operating system of which is UNIX: HI-UX/MPP for SR8000. SECOM2 is a code system which consists of 14 codes and written in ANSI standard Fortran 90.

SECOM2-DQFM is developed by combining three subroutine programs (monte.f, mntseq.f, mntimp.f) based on DQFM method in the SECOM2 code system for improvement of programming. In addition, new subroutines are added into it for extention of importance analysis capabilities.

Computer Systems on Which Code Can Be Executed

SECOM2-DQFM is transplanted to an IBM PC/AT compatible machine on which a Microsoft Windows operating system is installed. The source code can be compiled with a Fortran 90 compiler and math library IMSL. It can be run if the computer has 256MB real memory.

Features of the Code

SECOM2-DQFM has the following features:

- Calculation of conditional occurrence probability and frequency of a top event in a Fault Tree for each seismic motion level
- Calculation of conditional occurrence probability for basic events and intermediate events in a Fault Tree(FT) for each seismic motion level
- Accident sequence analysis

- Accident sequence group analysis
- Importance analysis for basic events
- Importance analysis weighted with source term release quantities
- All above analyses with the consideration of correlations of component failures

It should be noted that the following functions, which were implemented in the original SECOM2 code system, is not implemented in SECOM2-DQFM code system.

- The quantification of a fault tree based on Minimal Cut Set (MCS) method [1]
- The quantification of a fault tree based on Boolean Arithmetic Model method [2]
- Uncertainty Analysis (This function was implemented in MCS method)

2. Instructions for Use

2.1 Introduction

SECOM2-DQFM is a seismic level 1 PSA (Probabilistic Safety Analysis) code designed for analyzing seismic reliability of plant systems such as nuclear power plants.

The standard feature in SECOM2-DQFM is the calculation of occurrence frequency of top event in a FT model given information about basic events and the seismic hazard curve. In addition, SECOM2-DQFM can calculate occurrence frequencies of accident sequences defined in ET and importance measures of all basic events. The strongest point of the code is that correlation of component failures can be considered by giving correlation coefficients between responses of components and between capacities of components.

In general, a computer code has three different types of manual: calculation method manual, programmer's manual, and user's manual. The documents about calculation methods of this code are included in Ref. 1)-3).There are no available programmer's manuals for SECOM2-DQFM, but variable definitions and subroutine notations are described in the comment lines of the source codes.

The tree structure of all subroutines and how to compile and run SECOM2-DQFM are shown in this user's manual to provide the user with additional information for programming. In addition, how to prepare the data input files are also included in this manual. The main contents included are listed as follows:

- Directories and files included in the code package (Section 2.2)
- Compiling SECOM2-DQFM (Section 2.3)
- Running SECOM2-DQFM (Section 2.4)
- Structure of subroutines (Section 2.5)
- SECOM2 (original version) format data input (Chapter 3)
- NAMELIST format input (Chapter 4)

SECOM2-DQFM has two data input interfaces: one is for data input which has the same format as in original version of the SECOM2 code system, and the other is for NAMELIST format input supported by Fortran 90. The two interfaces can be switched from one to the other by compiling the code switching a flag in the source code. The SECOM2 format input document is shown in Chapter 3, and the NAMELIST format input document is shown in Chapter 4.

2.2 Directories and Files Included in the Code Package

The code package has four directories : “src”, “inc”, “run”, and “man”. Table 2.1 shows file contents in each directory.

Table 2. 1 Contents in the SECOM2-DQFM code package

Directory	Description	Contents in Each Directory
“src”	Set of Source Codes (Except Include files)	Source Code Files of All Subroutines (*.for) Object Files of All Subroutines (*.obj) Makefile (MakeSECOM2DQFM) Batch File Used in Compiling (m.bat) Message File Generated in Compiling (f77a.msg) Executable File (secom2dqfm.exe)
“inc”	Set of Include Files	All Include files(*INC)
“run”	Set of Input and Output Files (Run the code in this directory)	Input and Output Files for Sample Problem (Table I-2 shows all kinds of files)
“man”	Directory for Manual	This Manual(man_e.pdf)

Subroutines in “src” directory and include files in “inc” directory are shown in Section 2.5. The “run” directory includes input and output files for sample problem, and the contents are shown in Table 2.2.

Table 2. 2 Files in the “run” directory

Directory	File Name	Description
Run/	SAMPLE	Calculation Control Data for Sample Problem
Run/	SAMPLEOUT	Output List for Sample Problem
Run/	go.bat	Batch File to Run the Code
Run/COMPONEN/	COMPONEN	COMPONEN Data for Sample Problem
Run/FT/	FT	FT Data for Sample Problem
Run/HAZARD/	HAZARD	HAZARD Data for Sample Problem
Run/SETCOR/	SETCOR	SETCOR Data for Sample Problem
Run/MONSET/	MONSET	MONSET Data for Sample Problem
Run/SEQDATA/	SEQDATA	SEQDATA Data for Sample Problem
Run/CMPSLCT/	CMPSLCT	CMPSLCT Data for Sample Problem
Run/	INPUT	NAMELIST format input file for Sample Problem

NAMELIST format data input method is explained in Chapter 4. The other data inputs

that have a SECOM2 format are explained in Chapter 3. The way to run a calculation is described Section 2.4.

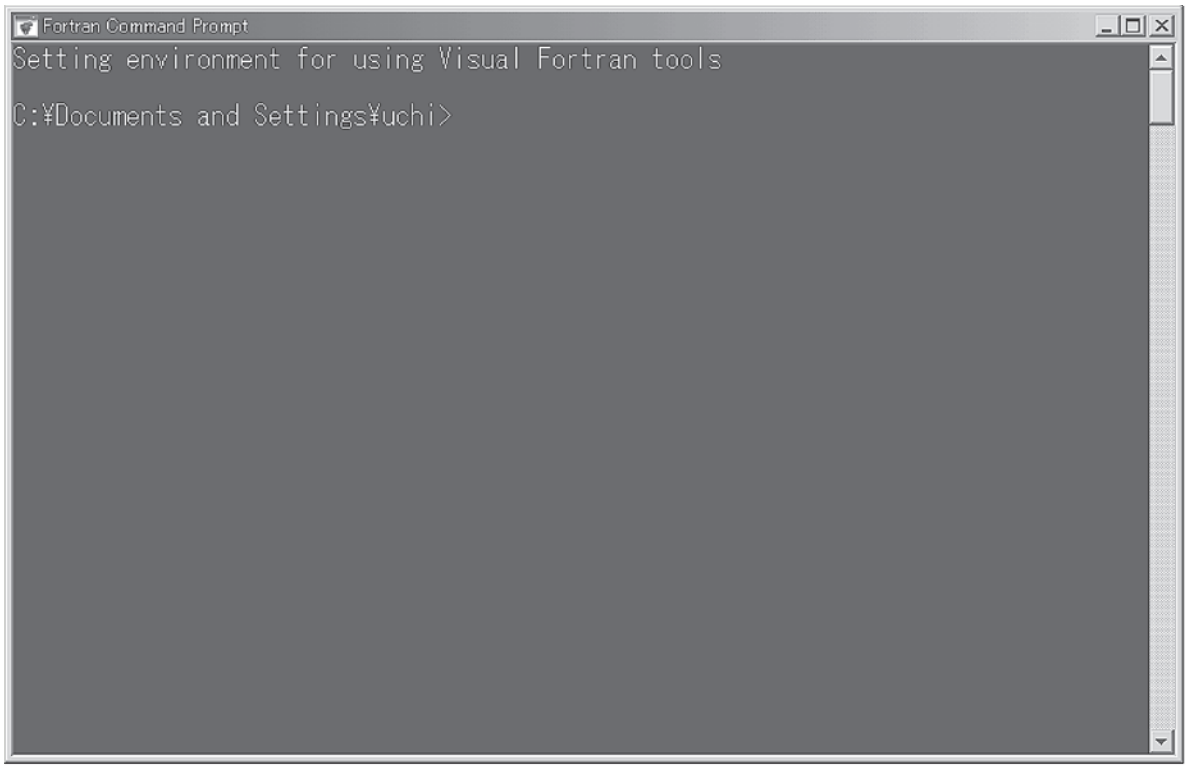
2.3 Compiling SECOM2-DQFM Codes

Compaq Visual Fortran Professional Edition Version 6.6A, which was used in developing SECOM2-DQFM code, is a recommended compiler.

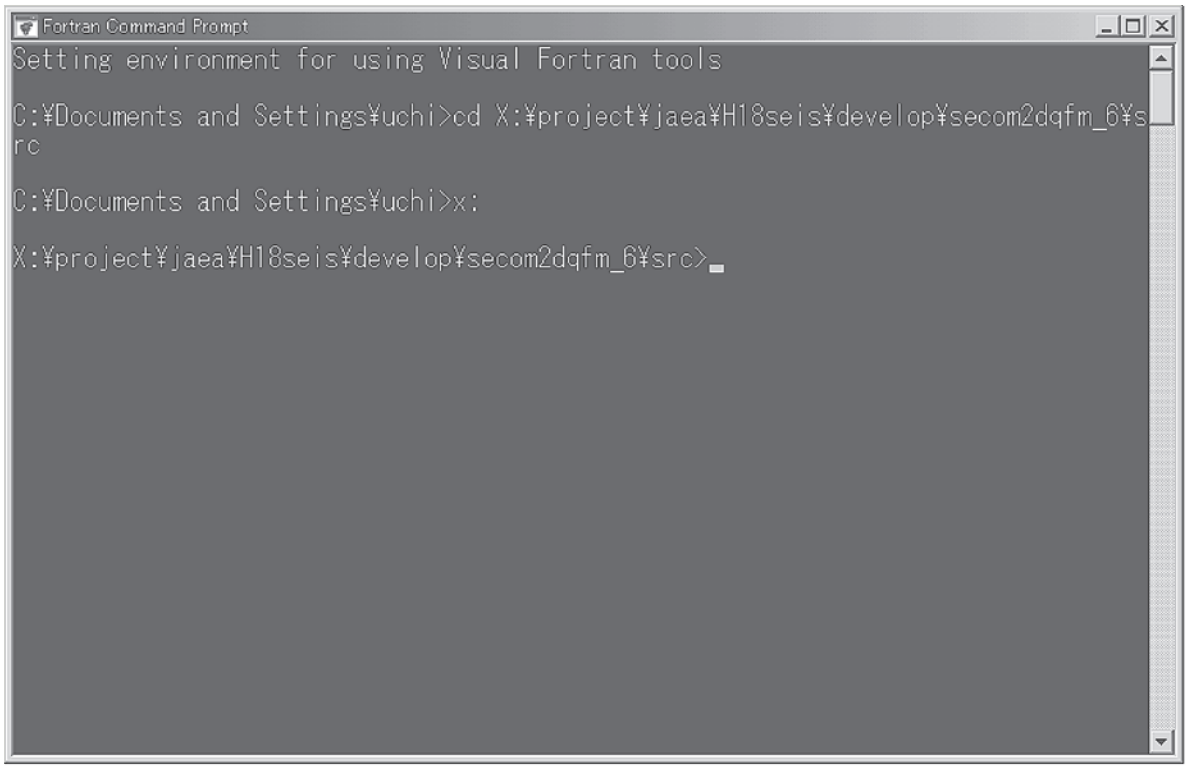
The user can change input formats from one to the other in compiling the source code. If the parameter “INAMELST” in the subroutine “initdat.for” is set to 0, the executable file generated by compiler may read SECOM2 format input files. If “INAMELST” is set to 1, NAMELIST format input becomes available.

To compile SECOM2-DQFM, It is necessary to execute the batch file “m.bat” on “Fortran Command Prompt” attached to “Compaq Visual Fortran.” Compiling conditions are written on the Makefile “makeSECOM2DQFM” which is called from “m.bat” The procedure to compile the code is as follows.

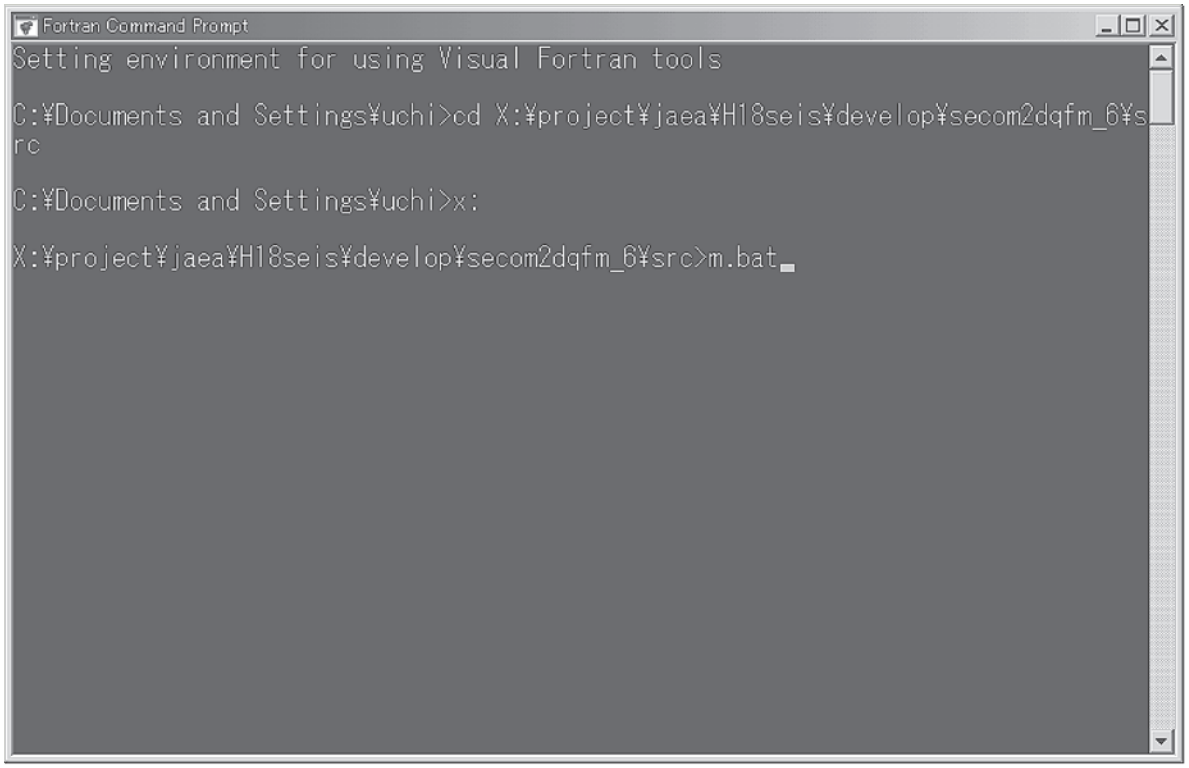
(1) Start “Fortran Command Prompt”



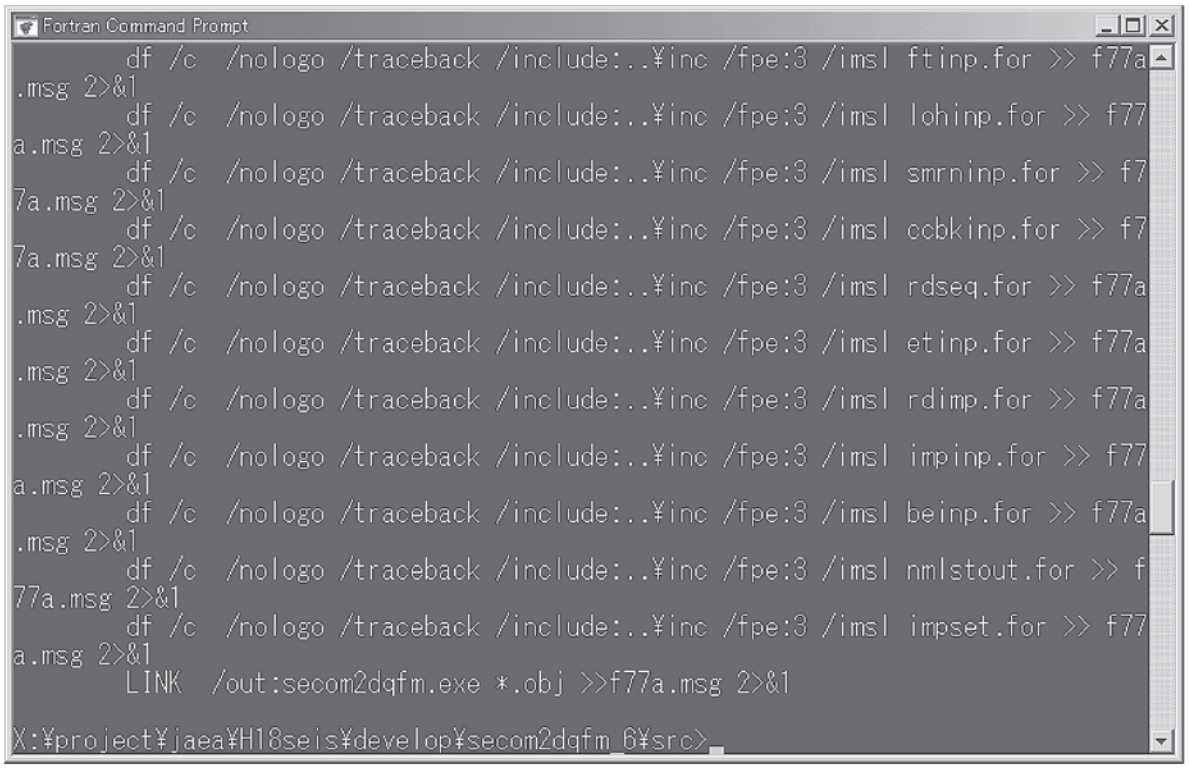
(2) Change current directory to “src”



(3) Run the batch file “m.bat”



(4) Compiling completed



2.4 Executing SECOM2-DQFM Codes

SECOM2-DQFM has Cursor User Interface (CUI). Graphical User Interface (GUI) is not available. The user can run a calculation on the command prompt of MS-DOS.

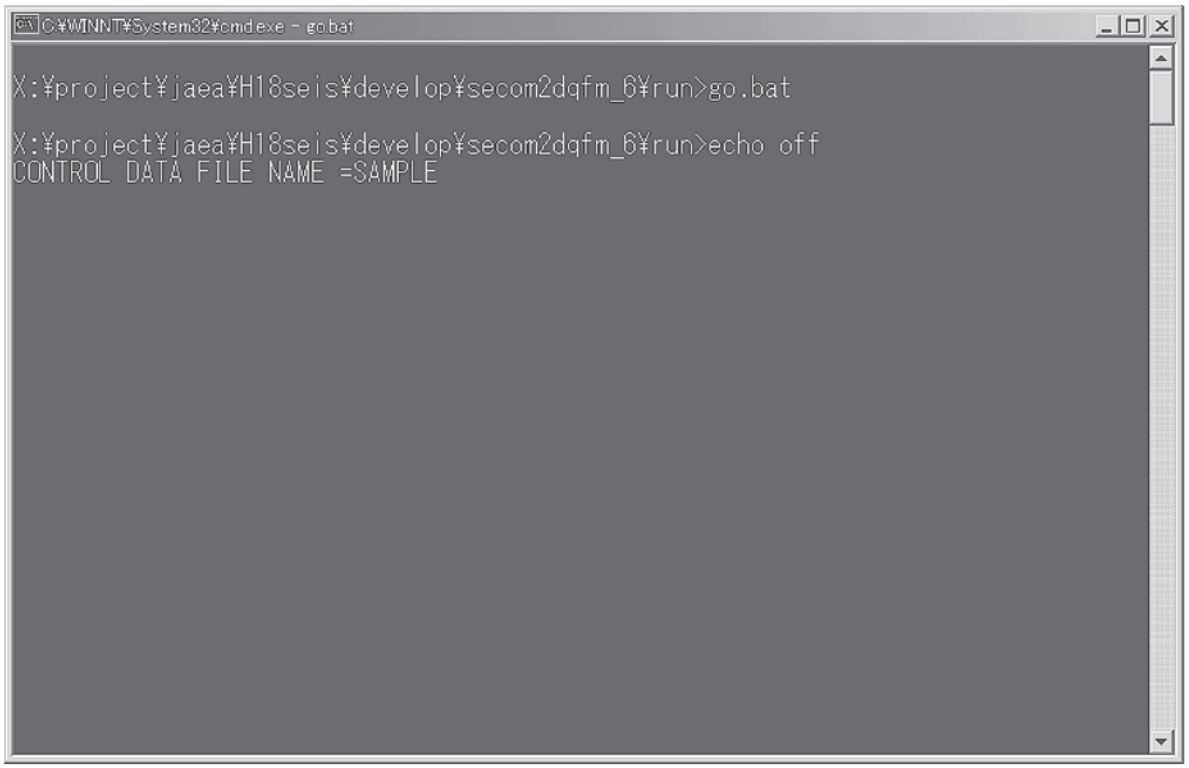
2.4.1 Starting a Calculation with SECOM2 Format Input

If the source code is compiled by setting 0 to “INAMELST,” the executable file can be run by the following procedure with prepared SECOM2 format input files.

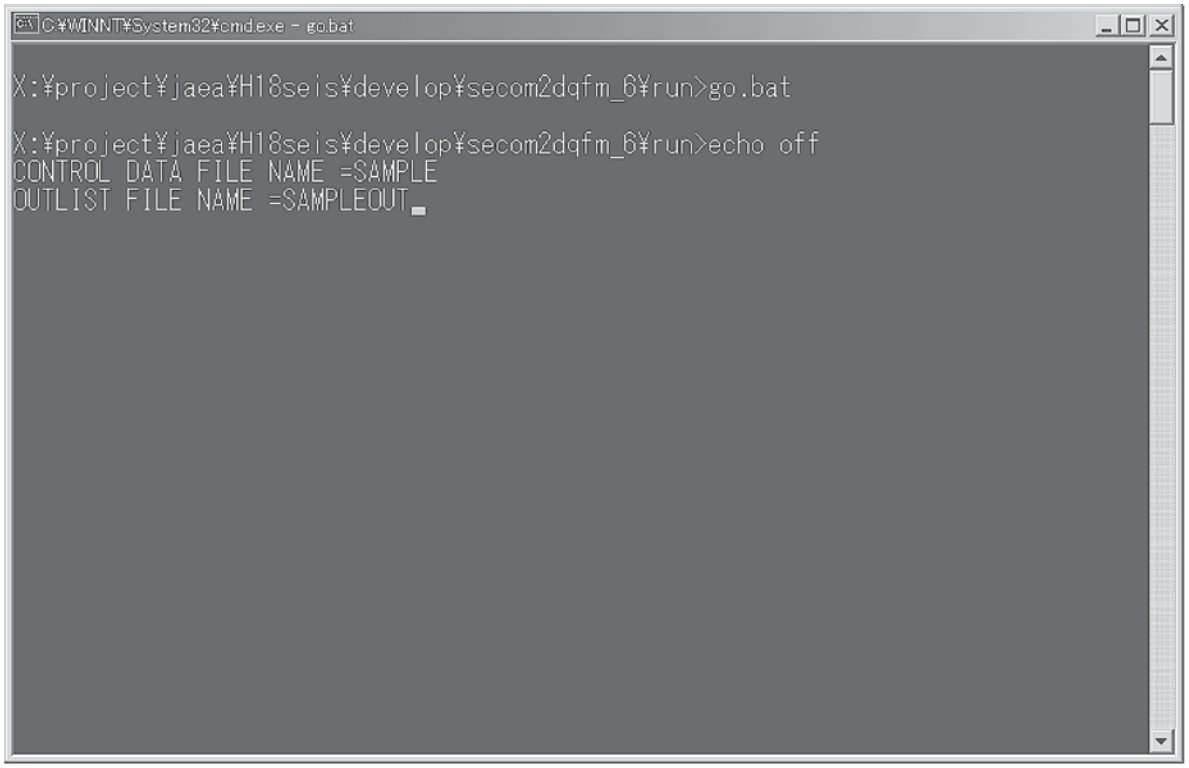
(1) Start up a command prompt of MS-DOS in “run” directory

(2) Run the batch file “go.bat”

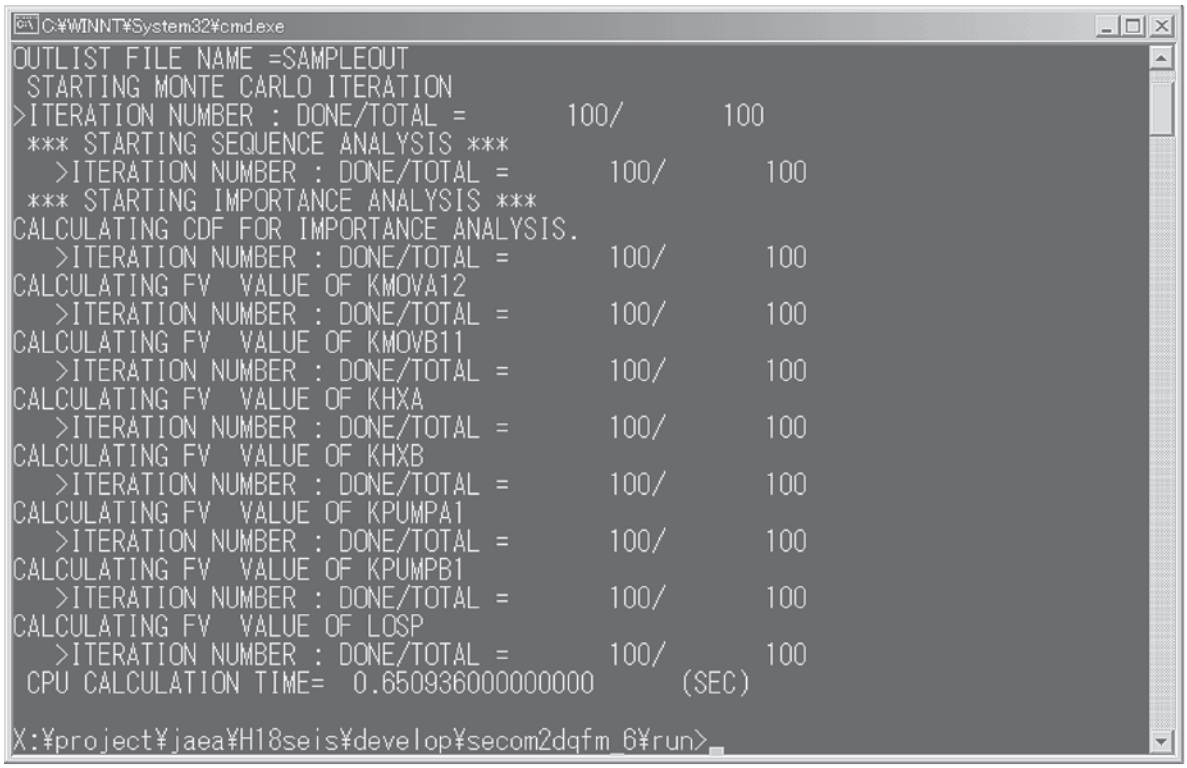
(3) Specify the file name of calculation control data and push “Enter” key



(4) Specify a file name of output list and push “Enter” key



(5) Calculation completed



2.4.2 Starting a Calculation with NAMELIST Format Input

If the source code is compiled by setting 1 to “INAMELST,” the executable can be run with given NAMELIST format input file. The input file name must be “INPUT”, and the output file name is fixed to “OUTPUT.”

Calculation can be started with a procedure written in (1) and (2) of section 2.4.1 after preparing “INPUT” in “run” directory.

2.5 Subroutine Structure of SECOM2-DQFM

Figure 2.1 shows a tree structure of subroutines used in the SECOM2-DQFM code package. The list of the subroutines is shown in Table 2.3. Each file includes only one subroutine or one function, and the file name is the same as the subroutine name or the function name included in the file. The calculation flow in SECOM2-DQFM is summarized as follows.

(1) Set initial conditions for variables
(2) Read NAMELIST format input (if 1 is set to INAMELST at (1))
(3) Read SECOM2 format input (if 0 is set to INAMELST at (1))
(4) Write input data on the output file for check

(5) Execute Cholesky decomposition of correlation coefficients
(6) Write correlation information on the output file for check
(7) Store probability values given by table, step function, or ramp function into arrays
(8) Link events in FT
(9) Generate random variables used as capacities and responses
(10) Judge occurrence of basic events
(11) Judge occurrence of top event
(12) Calculate conditional occurrence probabilities and frequencies of top event
(13) Execute inverse calculation of correlation coefficients
(14) Accident sequence analysis
(15) Importance analysis

The corresponding include files used in each subroutine are shown in Table 2.4. Description for each include file is listed in Table 2.5. One of the include files, NUNITINC is controlling unit numbers of input and output files. The unit numbers are listed in Table 2.6.

Table 2. 3 List of the subroutines used in SECOM2-DQFM (1/3)

Name	Description
beinp	Subroutine to read in basic event data in NAMELIST format input
ccbkinp	Subroutine to read in setting of inverse calculation of correlation coefficients
cdfcal	Subroutine to calculate occurrence probabilities and occurrence frequencies of events
cgpdat	Subroutine to search for basic events and intermediate events, the conditional occurrence probabilities of which is t to be calculated, and set flags to them
chekword	Subroutine to identify program name in calculation control data
chkout	Subroutine to write input data on output list file for check
cntlinp	Subroutine to read in calculation control data in NAMELIST format input
compar	Subroutine to store basic event parameters except basic event name using combination of abbreviated names and response factor, and link FT data and COMPONEN data
compfl	Subroutine to judge occurrence of basic events
compot	Subroutine to write basic event parameters on output for check
corcal	Subroutine for inverse calculation of correlation coefficients and output for check
cormul0	Subroutine to set variables for Cholesky decomposition
cormul1	Subroutine to generate correlated random variables
corrin	Subroutine to read in MONSET data
corrmk	Subroutine to set flags for correlation analysis using MONSET data
corrot	Subroutine to write output for check about correlation
corset	Subroutine to store variables for inverse calculation of correlation coefficients and write output for check
dindf	Subroutine to calculate inverse function of cumulative standard normal distribution
dsldl	Subroutine to replace DSLDL in SSL2 library using DLCHRG in IMSL math library
eq	Subroutine to read in basic event data whose type is RESP.FAC.EQ
etinp	Subroutine to read ET data in NAMELIST format input
evfreq	Subroutine to calculate occurrence frequency of top event and output results
exslout	Subroutine to write caution message if seismic motion level for analysis exceeds maximum of seismic motion level in seismic hazard data
facdire	Subroutine to read in basic event data whose type is RESP.FAC.DIRE or RESP.FAC.EQ
flopen2	Subroutine to read in calculation control data (common part to SECOM2)
frs0	Subroutine to read in response spectrum from $RESPONSESPECTRUM data blocks and calculate design response by interpolation
ft99ft06	Subroutine to open calculation control data file and output list file
ftcalmk	Subroutine to organize FT array with bottom up order
ftinp	Subroutine to read in FT data in NAMELIST format input
ftseq	Subroutine to rearrange FT and copy it to arguments for subroutine MNTSEQ
ftstra	Subroutine to link events in FT with bottom up order and top down order
gatcmp	Subroutine to abstract basic events from intermediate events and sort them
hranu2	Subroutine to generate random variable subjected to uniform distribution within a range from 0 to 1
hzdexd	Subroutine to calculate Spline interpolation of excessive occurrence frequencies
hzdinp	Subroutine to read in seismic hazard data in NAMELIST format input
hzdspl	Subroutine to calculate Spline interpolation of seismic hazard data
hzdyrg	Subroutine to calculate Spline interpolation of occurrence frequencies per Gal
imares	Subroutine to generate artificial response by substituting occurrence probability for parameters of inverse function of cumulative normal distribution

Table 2.3 List of the subroutines used in SECOM2-DQFM (2/3)

Name	Description
impinp	Subroutine to read in importance analysis data from NAMELIST format input
impset	Subroutine to fix occurrence of basic event for importance analysis
infmk	Subroutine to read in COMPONEN data
initdat	Subroutine to set initial condition
intern	Subroutine to read in basic event data whose type is INTERNAL
lentrm	Subroutine to count length of abbreviated names
lohinp	Subroutine to read in correlation coefficients in NAMELIST format input
makbar	Subroutine to generate analysis result table
maketbl	Subroutine to calculate variable Z used in Spline interpolation
mcntl	Subroutine to read in calculation control data
mknf6	Subroutine to read in FT data
mknfot	Subroutine to write FT data on the output file for check
mntimp	Subroutine for importance analysis
mntseq	Subroutine for accident sequence analysis
moncal	Subroutine to generate random variables of capacities and responses
moncalb	Subroutine to generate random variable of response subfactor
moncalc	Subroutine to generate random variable of capacity
monun	Subroutine for uncertainty analysis
monunb	Subroutine to generate random variable for uncertainty analysis
monuno	Subroutine to write output for uncertainty analysis check
nmlstinp	Subroutine to read in NAMELIST format input
nmlstout	Subroutine to write NAMELIST format input
openio	Subroutine to open NAMELIST format input file and output list file
pre_cormtrx	Subroutine to make matrix of correlation coefficients based on SETCOR data
probex	Subroutine to store probability data using ramp and step function
probmk	Subroutine to get probabilities from random failure(constant) or table data
ranu2x	Function to generate 100 random variables subjected to uniform distribution, and return the random variable in turn
rdarr	Subroutine to read $ARRANGEMENT data blocks in COMPONEN data
rdbld	Subroutine to search for $RESPONSESPECTRUM data blocks for damping coefficient, building, and floor
rdcap	Subroutine to read in $CAPACITY data blocks in COMPONEN data
rdcrd	Subroutine to read in SETCOR data
rddire	Subroutine to read in basic event data whose types are PROB.DIRE
rdimp	Subroutine to read in CMPSLCT data
rdpipe	Subroutine to read in design responses given directly
rdres	Subroutine to read in abbreviated response factor names in $RESPONSEFACTOR data blocks
rdseq	Subroutine to read in SEQDATA data
resp	Subroutine to read in response factors and response subfactors
rlatn	Function for LHS iteration
scm2inp	Subroutine to read in SECOM2 format input
secom2dqfm	Main routine of SECOM2-DQFM
seisin	Subroutine to read in HAZARD data
setcgv	Subroutine to return correlated random variable to parent subroutine
skipdata	Subroutine to check program name in calculation control data
smrninp	Subroutine to read in data setting the same random variable to consider correlation in NAMELIST format input

Table 2.3 List of the subroutines in SECOM2-DQFM (3/3)

Name	Description
spline	Functions for Spline interpolation
stprmptbl	Subroutine to store probabilities from table, step function, ramp function, or random failure(constant)
syspfl	Subroutine to judge occurrence of intermediate events and top event
timeout	Subroutine to get and write CPU calculation time
usersr	Subroutine to read in basic event data whose type is FUNCTION
vranu	Subroutine to generate capacity subjected to logarithmic normal distribution using median and standard deviation
vranul	Subroutine to generate capacity subjected to logarithmic normal distribution using median and standard deviation by LHS
vranuls	Subroutine to generate response subjected to logarithmic normal distribution using median and standard deviation by LHS
vranus	Subroutine to generate response subjected to logarithmic normal distribution using median and standard deviation
vranuv	Subroutine to generate correlated capacity subjected to logarithmic normal distribution using median and standard deviation
vranuvs	Subroutine to generate correlated response subjected to logarithmic normal distribution using median and standard deviation

Table 2. 4 Correspondences of subroutines and include files (1/2)

	DBL_INC	NUNITINC	PARAMINC	MCNTLINC	INFMKINC	COMPINC	GATEINC	HZDININC	CORRINC	MONTEINC	MNTSEQINC	MNTIMPINC	SEQIMPINC
beinp	○	○	○			○							
ccbkinp	○	○	○			○							
cdfcal	○	○	○	○		○	○			○			
cgpdat	○	○	○	○		○	○			○			
chekword	○												
chkout	○	○	○	○									
cntlinp	○	○	○	○									
compar	○		○		○	○	○						
compfl	○	○	○	○		○				○			
compot	○	○	○	○		○							
corcal	○	○	○	○		○				○			
cormul0	○		○						○				
cormul1	○		○						○				
corrin	○	○	○			○							
corrmk	○		○	○		○							
corrot	○	○	○	○		○							
corset	○	○	○	○		○				○			
dindf	○												
dsldl	○												
eq	○				○								
etinp	○	○	○								○		
evfreq	○	○	○							○			
exslout		○											
facdire	○				○								
flopen2	○	○	○										
frs0	○	○			○								
ft99ft06	○	○											
ftcalmk	○		○			○	○						
ftinp	○	○	○				○						
ftseq	○		○				○						
ftstra	○	○	○	○		○	○						
gatcmp	○	○	○				○						
hranu2	○												
hzdexd	○	○	○	○				○		○			
hzdinp	○	○	○					○					
hzdspl	○		○					○					
hzdyrg	○	○	○	○				○		○			
imares	○												
impinp	○	○	○									○	
impset	○		○									○	○
infmk	○	○	○		○	○							
initdat	○		○	○		○	○			○			
intern	○												
lentrm	○	○			○								
lohinp	○	○	○						○				
makbar	○												
maketbl	○		○										

Table 2.4 Correspondences of subroutines and include files (2/2)

	DBL_INC	NUNITINC	PARAMINC	MCNTLINC	INFMKINC	COMPINC	GATEINC	HZDININC	CORRINC	MONTEINC	MNTSEQINC	MNTIMPINC	SEQIMPINC
mcntl	○	○	○	○									
mknf6	○	○	○				○						
mknfot	○	○	○	○			○						
mntimp	○	○	○									○	○
mntseq	○	○	○								○		○
moncal	○	○	○	○		○				○			
moncalb	○	○	○	○		○							
moncalc	○	○	○	○		○							
monun	○		○	○		○				○			
monunb	○		○										
monuno	○	○	○			○							
nmlstinp	○	○	○	○									
nmlstout	○	○	○	○		○	○	○	○		○	○	
openio	○	○											
pre_cormtrx	○	○	○			○			○				
probex	○		○			○				○			
probmk	○	○	○	○		○				○			
ranu2x	○												
rdarr	○	○			○								
rdbld	○	○			○								
rdcap	○	○			○								
rdcrd	○	○	○						○				
rddire	○	○	○		○	○							
rdimp	○	○	○									○	
rdpipe	○	○			○								
rdres	○	○			○								
rdseq	○	○	○								○		
resp	○	○	○		○	○				○			
rlatn	○												
scm2inp	○		○	○									
secom2dqfm	○	○	○	○									
seisin	○	○	○	○				○					
setcgv	○		○			○			○				
skipdata	○	○											
smrninp	○	○	○			○							
spline	○		○										
stprmptbl	○		○			○							
syspfl	○	○	○	○		○	○			○			
timeout		○											
usersr	○												
vranu	○												
vranul	○	○											
vranuls	○	○	○										
vranus	○		○										
vranuv	○	○											
vranuvs	○	○	○										

Table 2. 5 Description of include files used in SECOM2-DQFM

Include File	Description
DBL_INC	Include file to declare double precision
NUNITINC	Include file to define unit number of input files and output files
PARAMINC	Include file to define maximum numbers
MCNTLINC	Include file to define variables for calculation control
INFMKINC	Include file to define variables for basic event information (Variables for media, not used directly in probability calculation)
COMPINC	Include file to define variables for basic events
GATEINC	Include file to define variables for FT
HZDININC	Include file to define input parameters for seismic hazard
CORRINC	Include file to define variables for analysis using correlation coefficients
MONTEINC	Include file to define variables for DQFM calculation
MNTSEQINC	Include file to define variables for accident sequence analysis
MNTIMPINC	Include file to define variables for importance analysis
SEQIMPINC	Include file to define variables used in both accident sequence analysis and importance analysis

Table 2. 6　List of Unit Numbers

Include File	Unit Number	Variable Name	Description	I/O
NUNITINC	0	NUNIT00	Standard Output(Monitor)	Output
	1	NUNIT01	Basic Event Occurrence Recording File	In/Out
	2	NUNIT02	Output List File	Output
	5	NUNIT05	Input from Keyboard	Input
	11	NUNIT11	NAMELIST Format Input File	Input
	20	NUNIT20	SECOM2 Format Calculation Control Data File	Input
	21	NUNIT21	SECOM2 Format COMPONEN Data File	Input
	22	NUNIT22	SECOM2 Format HAZARD Data File	Input
	23	NUNIT23	SECOM2 Format FT Data File	Input
	24	NUNIT24	SECOM2 Format SETCOR Data File	Input
	25	NUNIT25	SECOM2 Format MONSET Data File	Input
	26	NUNIT26	SECOM2 Format SEQDATA Data File	Input
	27	NUNIT27	SECOM2 Format CMPSLCT Data File	Input
	30	NUNIT30	Output of NAMELIST Format Input File	Output

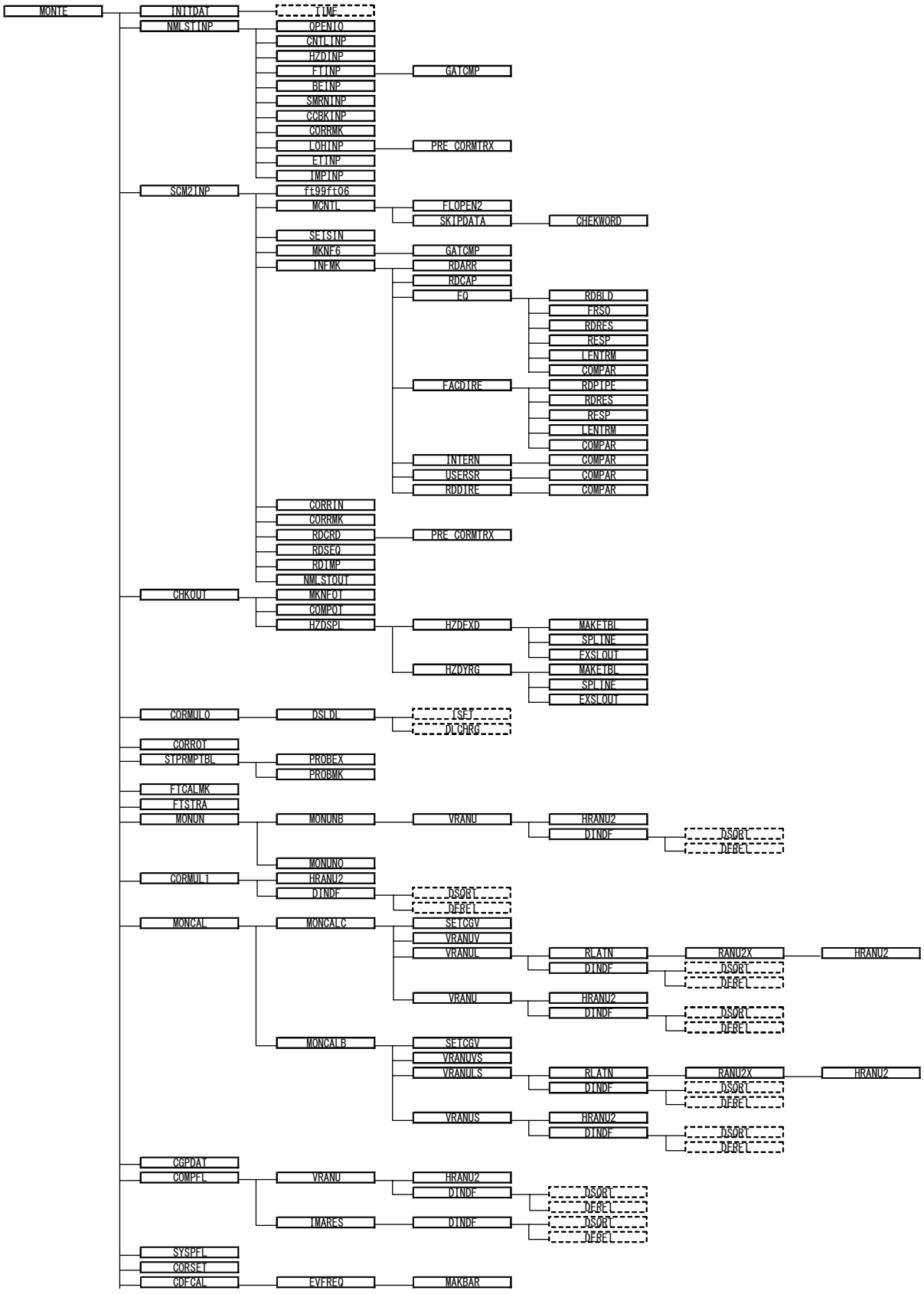


Fig. 2 1 Tree Structure of Subroutines in SECOM2-DQFM

3. SECOM2 Format Inputs

3.1 Introduction

Input data including a seismic PSA model consists of the following information sets:

- Basic events and their information sets that are necessary to calculate occurrence probabilities,
- Fault Tree (FT),
- Event Tree (ET),
- Correlation coefficients between responses and between capacities,
- Seismic hazard,
- Calculation control flags, etc.

Most of the input files are available not only in SECOM2-DQFM but also in SECOM2 code system because they have the same formats. Table 3-1 lists the input files.

Table 3. 1 SECOM2 format data input files

Data Name	Contents	Necessary /Optional	Difference between SECOM2-DQFM and SECOM2 code system (JAERI– Data/Code 2002-011)
Calculation Control Data	Specification of file names, calculation conditions, and flags	Necessary	Nothing
COMPONEN	Information which is necessary to calculate occurrence probabilities of basic events	Necessary	Nothing
HAZARD	Seismic hazard	Necessary	Nothing
FT	FT	Necessary	Nothing
SETCOR	Correlation coefficients	Optional	correlation coefficients between capacities are added
MONSET	Specification to apply the same random variables to response subfactors and capacities	Optional	Nothing
SEQDATA	ET	Optional	accident sequences group, conditional probability of containment failure, and source term release quantities are added
CMPSLCT	Specification of importance measure and target events	Optional	RA(Risk Achievement) and RR(Risk Reduction) are added

All files except SEQDATA and CMPSLCT are divided by data lines with "$" (e.g. $TITLE) into many data blocks. Comment lines can be inserted anywhere by placing "<" at the beginnings of lines.

The following sections describe data parameters and their formats.

3.2 Calculation Control Data

Calculation control data consists of two parts: a common part to SECOM2 code system and a special part to SECOM2-DQFM code. The former is introduced in Section 3.2.1, and the latter is described in Section 3.2.2.

3.2.1 Common Part to SECOM2 Code System in Calculation Control Data File

The common part to SECOM2 code system consists of calculation title, directory name and file name for each kind of input, and seismic motion levels for analysis. These data must be given in order. The data formats are shown with the following explanatory notes.

**********Explanatory Notes**********

(#)[Input item]

[Description of the input item]

<Feature>

[Description of the feature controlled in the input item]

(Omitted if there is no explicit feature)

<Parameters>

[Description about parameters and flags]

<Format>

[Description of formats such as data type, column, etc.]

Fixed format is shown using edit descriptor in Fortran.

(Example)

(A8,2X,I2,2F8.0) : 8 characters of character type, 2 blank characters, 2 characters of integer type, a pair of 8 characters of real type

<Example>

Example may be shown if the format is complicated.

****

(1) Calculation Title

The user can give an adequate name that means a calculation case or date of a calculation to specify the calculation case later. This calculation title can be a mark in output list because it is redirected to output list.

<Format>

"$TITLE" is given in the first line of the calculation control data, and a calculation title is given at the next line with the following format.

(A80)

(2) Directory Name and File Name for Each Kind of Input

Sets of data names shown in Table 3-2 and the paths are given. One set must be given in one line. A path consists of a directory name and a file name based on the file specification rule in MS-DOS.

<Format>

A set of the data name and the path is repeated after the next line of "$DATASET" with the following format.

(A8,2X,A40)

(3) Seismic Motion Levels for Analysis

Conditional occurrence probabilities of events are calculated at seismic motion levels specified in this data block. Seismic motion means maximum acceleration induced by an earthquake. Gal is a default unit for seismic motion levels. 980Gal is equal to the gravity acceleration, 1G.

<Format>

"$SEISMICLEVEL" is given at first, and then seismic motion levels for analysis with the following format are given with ascending order. The maximum number of levels is 8 in 1 line, more levels are given in the next line.

(8(F8.0,2X))

After data blocks shown in (1), (2), and (3) are specified, "/EOD" is given in the next line which means the end of common part to SECOM2 code system.

3.2.2 Special Part to SECOM2-DQFM code in Calculation Control Data

(4) Old Name of the Code

<Format>

Old name of the code "MONTE" must be given from the first column.

(5) Controlling Calculation Condition

<Feature>

Specify number of iteration, flag of correlation analysis, etc.

<Parameters>

1) Flag of correlation analysis: ICRFLG

ICRFLG = 0: Consider no correlation

= 1: Consider correlation by assigning the same value to to response subfactors or capacities (Use MONSET data)

= 2: Consider correlation with correlation coefficients method (Use SETCOR data)

2) Number of iteration: IREPR

Normally, Total number of iteration for every seismic motion level may be specified. If number of iteration is changed by seismic motion levels as shown in the input item (6), summation of the numbers of iteration must be specified.

3) Design basis seismic motion (Gal): BADS

4) Dummy flag: IUNCRT

It must be 0.

5) Flag for LHS option: IFLGLTN

IFLGLTN=0: Do not use LHS option

=1: Use LHS option

<Format>

1)～5) are given in turn with the following format.

(I2,2X,I8,2X,F8.0,2X,I1,2X,I1)

(6) Numbers of Iteration for Different Seismic Motion Levels

<Feature>

The user can specify the numbers of iteration for different seismic motion levels. It is necessary to improve resolution by increasing the number of iteration because conditional probabilities of seismic failures are very low at a small seismic motion level. On the other hand, such a high resolution is not required for analysis at a big seismic motion level because of high probabilities of seismic failures. To answer such specific inclination in seismic PSA, SECOM2-DQFM has a feature to change the number of iteration for different seismic motion levels. If the feature is used, summation of the numbers of iteration must be given in IREPR. When the feature is not used, IREPR is applied for every seismic motion level.

<Parameters>

1) Maximum seismic motion level at which 2) is applied (in the Gal)

2) Number of iteration that is applied at 1) or less

3) The end of data (must be 0.0)

<Format>

The set of 1) and 2) in one line is repeated with the following format, and finally 3) is given with the format (F8.0). If the feature is not used, only 3) is required.

(F8.0,2X,I8)

<Example>

If 50,000 is applied from 0Gal to 600Gal, 30,000 is applied from over 600Gal to 900Gal, and 20,000 is applied from over 900Gal to 2100Gal, the following example is available by giving 100,000 to IREPR.

```
 600.0    50000
 900.0    30000
2100.0    20000
   0.0
```

(7) Seismic Hazard ID

<Feature>

Seismic hazard ID means a seismic hazard curve name. An ID must be selected for a calculation from IDs in HAZARD data shown in Section 3.4.

<Parameters>

Seismic hazard ID

<Format>

It is given with the following format.

(A8)

(8) Optional Output Flags for Check

<Feature>

Output options can be specified with flags for input redirection and checking calculation.

<Parameters>

The user can select 0 (write output) or 1 (do not write output) for the following flags:

1) Flag to activate output option for basic event information: IINP1
2) Flag to activate FT output option: IINP2
3) Flag to activate output option for correlation information: IINP3
4) Flag to activate output option for seismic hazard: IINP4
5) Flag to activate checking output option for basic event names: IOUP1
6) Flag to activate checking output option for correlation coefficients: IOUP2
7) Flag to activate checking output option for conditional occurrence probabilities of basic events and intermediate events: IOUP3

<Format>

The flags from 1) to 4) are given with the following format.

(4I2)

The flags from 5) to 7) are given with the following format in the next line.

(3I2)

(9) Names of the Events of Which Conditional Occurrence Probabilities are Calculated

<Feature>

Conditional occurrence probabilities of basic events and intermediate events are calculated if the event names are specified by the user. The names must be the same as those defined in FT data. Maximum number of events should be no more than 30.

<Parameters>

Basic event names and Intermediate event names: CGOUNM

<Format>

The maximum number of the names is 8 in 1 line, more names are given in the next line. They are given with the following format:

(8(2X,A8))

A sample of calculation control data in SECOM2-DQFM code is shown in Table 3.2.

Table 3. 2 Sample of Calculation Control Data in SECOM2-DQFM Code

```
$TITLE
<---------------------------------- TITLE ----------------------------------
<                                        A80                                  >
SAMPLE CONTROL DATA FOR SECOM2-DQFM CODE
$DATASET
< KIND >   <---------- DATA SET NAME ---------->
<   A8   >  <                    A40                    >
COMPONEN   ..¥..¥dat¥COMPONEN¥COMPONEN
FT         ..¥..¥dat¥FT¥FT1
HAZARD     ..¥..¥dat¥HAZARD¥HAZARD
SETCOR     ..¥..¥dat¥SETCOR¥SETCOR
MONSET     ..¥..¥dat¥MONSET¥MONSET
$SEISMICLEVEL
<F8.0  >  <F8.0  >  <F8.0  >  <F8.0  >  <F8.0  >  <F8.0  >  <F8.0  >  <F8.0  >
     30.0       60.0       90.0      120.0      150.0      180.0      210.0      240.0
    270.0      300.0      330.0      360.0      390.0      420.0      450.0      480.0
    510.0      540.0      570.0      600.0      630.0      660.0      690.0      720.0
    750.0      780.0      810.0      840.0      870.0      900.0      930.0      960.0
    990.0     1020.0     1050.0     1080.0     1110.0     1140.0     1170.0     1200.0
   1230.0     1260.0     1290.0     1320.0     1350.0     1380.0     1410.0     1440.0
   1470.0     1500.0     1530.0     1560.0     1590.0     1620.0     1650.0     1680.0
   1710.0     1740.0     1770.0     1800.0     1830.0     1860.0     1890.0     1920.0
   1950.0     1980.0     2010.0
/EOD
MONTE
<I   <   I8   >   < F8.0 >   I   I
 2      100000        180.0   0   0
<SEISMIC LEVEL , NUMBER OF TRIAL
< F8.0 >   <   I8   >
       0.0
<HAZID
<   A8   >
MDL
<INPUT DATA TO OUTLIST
<I<I<I<I
 1 1 1 1
<OUTPUT DATA OPTION
<I<I<I
 1 1 1
<CALC. GATE OR COMP
< <   A8   >   <   A8   >   <   A8   >   <   A8   >   <   A8   >   <   A8   >   <   A8   >   <   A8   >
```

In the above sample the number of iteration is 100,000, the design basis seismic motion is 180Gal, and correlation analysis with given correlation coefficients specified in SETCOR data is used. The range of seismic motion levels for analysis is from 30Gal to 2010Gal with an interval of 30Gal.

3.3 COMPONEN Data

A COMPONEN data file includes information sets which are necessary to calculate conditional occurrence probabilities of all basic events. The basic events consist of seismic failure events, random failure events, etc.

(1)Structure of COMPONEN Data

A COMPONEN data consists of 10 kinds of data blocks which begin with data lines with "$" as follows.

1) Data Block for Title ($TITLE)
2) Data Block for Basic Event ($ARRANGEMENT)
3) Data Block for Capacity or Random Failure ($CAPACITY)
4) Data Block for Design Response($DESIGNRESPONSE)
5) Data Block for Response Spectrum($RESPONSESPECTRUM)
6) Data Block for Response Factor($RESPONSEFACTOR)
7) Data Block for Response Subfactor($SUBRESPONSEFACTOR)
8) Data Block for Table of Occurrence Probabilities ($DIRECTPROBABILITY)
9) Data Block for Table of Response Factors or Subfactors ($RESPONSETABLE)

Data block 1) must be given only one time in one data file, the others can be given as many times as necessary. Data block 2) is specified more than the number of basic events in FT. Basic events which are not used in FT can be added, but they are not used in the calculation. Data block 3) is necessary for each basic event specified at 2), but the number of 3) can be reduced by using the same 3) at more than one of 2). Data blocks from 4) to 8) are not necessary for every basic event. The necessity of the data blocks from 4) to 8) depends on the kind of basic event and the way to calculate probabilities. Number of the data blocks from 4) to 8) can be reduced in the same way as the data block 3).

The kind of basic events and data blocks required for each kind are listed in Table 3.3. ID for the kinds of basic events must be given in data block 3) and used for identification of the kinds. Especially, parameters given in data block 3) are different depending on the kinds of basic events. The parameters in data block 3) are described for each kind of basic event.

Data block 9) is used only when response factors or response subfactors are changed for each seismic motion level. They are not required unless flags for changing the factors are raised in data block 6). Using data block 9) makes accident sequence analysis and importance analysis unavailable.

Table 3. 3 The basic event type and data blocks required for each type

	Basic Event Type	Basic Event Type ID	Required Data Blocks *
①	Seismic Failure of Component (Use response spectrum)	RESP.FAC.EQ	2)$ARRANGEMENT 3)$CAPACITY 5)$RESPONSESPECTRUM 6)$RESPONSEFACTOR 7)$SUBRESPONSEFACTOR
②	Seismic Failure of Component (Do not use response spectrum)	RESP.FAC.DIRE	2)$ARRANGEMENT 3)$CAPACITY 4)$DESIGNRESPONSE 6)$RESPONSEFACTOR 7)$SUBRESPONSEFACTOR
③	Seismic Failure of Pipe (Do not use response spectrum)	RESP.FAC.PIPE	2)$ARRANGEMENT 3)$CAPACITY 4)$DESIGNRESPONSE 6)$RESPONSEFACTOR 7)$SUBRESPONSEFACTOR
④	Random Failure	INTERNAL	2)$ARRANGEMENT 3)$CAPACITY
⑤	Basic Event Defined by Function (Step function and ramp function generating probability for each seismic motion level are available)	FUNCTION	2)$ARRANGEMENT 3)$CAPACITY
⑥	Basic Event Defined by Table (Table generating probability for each seismic motion level is given)	PROB.DIRE	2)$ARRANGEMENT 3)$CAPACITY 8)$DIRECTPROBABILITY

* : The numbers with parentheses in front of data block names correspond with the item numbers in this section.

The data formats are shown based on the following explanatory notes in this section.

**********Explanatory Notes**********

<Parameters>

[Description about parameters and flags]

<Format>

[Description for format such as data type, column, etc.]

Fixed format is shown using edit descriptor in Fortran.

(Example)

(A8,2X,I2,2F8.0) : 8 characters of character type, 2 characters of blank, 2 characters of integer type, a pair of 8 characters of real type

<Example>

Example may be shown if the format is complicated.

****

(2)Parameters and Their Formats in COMPONEN Data

1)Data Block for Title ($TITLE)

<Parameters>

Title of the COMPONEN data file is given.

The user can give an adequate name that shows contents of the data.

<Format>

"$TITLE" is given in the first line of the COMPONEN data and a title is given in the next line with the following format:

(A80)

2) Data Block for Basic Event ($ARRANGEMENT)

<Parameters>

The following parameters from (a) to (f) are required if the ID for the basic event type is "RESP.FAC.EQ" in $CAPACITY data block. The parameters from (a) to (e) are required for "RESP.FAC.DIRE" or "RESP.FAC.PIPE". The parameters from (a) to (c) are required for "INTERNAL", "FUNCTION", or "PROB.DIRE". The parameters which are not required can be left blank.

(a) Description of basic event

The user can give an adequate description.

Blank is available if the user needs no description.

(b) Basic event name

(c) Capacity name assigned to basic event

Capacity name must be defined in $CAPACITY data block.

(d) Response factor name assigned to basic event

Response factor name must be defined in $RESPONSEFACTOR data block

(e) Building name or design response name

A basic event whose type ID is “RESP.FAC.EQ” requires a building name. The building name must be defined in $RESPONSESPECTRUM data block.

A basic event whose type ID is “RESP.FAC.DIRE” or “RESP.FAC.PIPE” requires a design response name. The design response name must be defined in $DESIGNRESPONSE data block.

(f) Installation floor name

Basic event of seismic failure referring to a response spectrum requires specification of installation floor. The installation floor must be defined in $RESPONSESPECTRUM data block.

<Format>

The parameters from (a) to (f) is given in the next line of ”$ARRANGEMENT” with the following format:

(A30,2X,A8,2X,A8,2X,A8,2X,A8,2X,A2)

3) Data Block for Capacity or Random Failure ($CAPACITY)

Parameters for Capacity or Random Failure, basic event type ID etc. are given in this $CAPACITY data block. The parameters are shown respectively for each basic event type because the parameters in this data block depend on the basic event types as follows.

(a)Parameters and their formats for “RESP.FAC.EQ”

<Parameters>

a) Description of capacity or random failure

The user can give an adequate description.

Blank is available if the user needs no description.

b) Capacity name required in $ARRANGEMENT data block

c) Abbreviated capacity name in 3 characters

d) Basic event type ID

Use ID in Table 3.3. “RESP.FAC.EQ” is adequate in this case.

e) Median of capacity in the Gal

f) Uncertainty due to randomness of capacity

g) Uncertainty due to lack of knowledge of capacity

h) Damping coefficient

i) Upper bound of natural frequency

j) Lower bound of natural frequency

Both of i) and j) are required because the average of i) and j) is used in the calculation.

<Formats>

a) is given in the next line of "$CAPACITY" with the following format:

(A80)

Parameters from b) to g) are given in the next line of above with the following format:

(A8,2X,A3,7X,A14,6X,F8.0,2X,F8.0,2X,F8.0)

Parameters from h) to j) are given in the next line of above with the following format:

(10X,F8.0,2X,F8.0,2X,F8.0)

(b) Parameters and their formats for "RESP.FAC.DIRE" or "RESP.FAC.PIPE"

<Parameters>

a) Description of capacity

The user can give an adequate description.

Blank is available if the user needs no description.

b) Capacity name required in $ARRANGEMENT data block

c) Abbreviated capacity name in 3 characters

d) Basic event type ID

Use ID in Table 3.3.

"RESP.FAC.DIRE" or "RESP.FAC.PIPE" are adequate in this case.

e) Median of capacity in the Gal

f) Uncertainty due to randomness of capacity

g) Uncertainty due to lack of knowledge of capacity

<Formats>

a) is given in the next line of "$CAPACITY" with the following format:

(A80)

Parameters from b) to g) are given in the next line of above with the following format:

(A8,2X,A3,7X,A14,6X,F8.0,2X,F8.0,2X,F8.0)

(c) Parameters and their formats for "INTERNAL"

<Parameters>

a) Description of capacity

The user can give an adequate description.

Blank is available if the user needs no description.

b) Capacity name required in $ARRANGEMENT data block

c) Basic event type ID

Use ID in Table 3.3. “INTERNAL” is adequate in this case.

d) Median of random failure

e) Uncertainty due to randomness of random failure

f) Uncertainty due to lack of knowledge of random failure

<Formats>

a) is given in the next line of ”$CAPACITY” with the following format:

(A80)

Parameters from b) to f) are given in the next line of above with the following format:

(A8,12X,A14,6X,F8.0,2X,F8.0,2X,F8.0)

(d) Parameters and their formats for “FUNCTION”

Probability defined in the step function or the ramp function must increase as seismic motion increases.

<Parameters>

a) Description of capacity

The user can give an adequate description.

Blank is available if the user needs no description.

b) Capacity name required in $ARRANGEMENT data block

c) Basic event type ID

Use ID in Table 3.3. “FUNCTION” is adequate in this case.

d) Probability before increase

e) Seismic motion level at the beginning of probability increase for ramp and step function

f) Probability after increase

g) Seismic motion level at the end of probability increase for ramp function

(0.0 for step function)

<Formats>

a) is given in the next line of ”$CAPACITY” with the following format:

(A80)

Parameters from b) to g) are given in the next line with the following format:

(A8,12X,A14,6X,F8.0,2X,F8.0,2X,F8.0,2X,F8.0)

(e) Parameters and their formats for “PROB.DIRE”

<Parameters>

a) Description of capacity

The user can give an adequate description.

Blank is available if the user needs no description.

b) Capacity name required in $ARRANGEMENT data block

c) Basic event type ID

Use ID in Table 3.3. “PROB.DIRE” is adequate in this case.

<Formats>

a) is given in the next line of ”$CAPACITY” with the following format:

(A80)

b) and c) are given in the next line of above with the following format:

(A8,12X,A14)

4) Data Block for Design Response ($DESIGNRESPONSE)

<Parameters>

Design response is given in this data block for a basic event whose type ID is “RESP.FAC.DIRE” or “RESP.FAC.PIPE”. The following parameters from (a) to (c) are required for “RESP.FAC.DIRE”. The following parameters from (a) to (d) are required for “RESP.FAC.PIPE”.

(a) Design response name

(b) Abbreviated design response name in 3 characters

(c) Design response in the Gal

(d) Constant member of design response in the Gal

<Format>

Parameters from a) to b) are given in the next line of ”$DESIGNRESPONSE” with the following format:

(A8,2X,A3,7X,F8.0,2X,F8.0)

5) Data Block for Response Spectrum ($RESPONSESPECTRUM)

<Parameters>

Response spectrum is given in $RESPONSESPECTRUM data block for a basic event whose type ID is “RESP.FAC.EQ”. All response spectrums for a damping coefficient in a building must be included in a $RESPONSESPECTRUM data block. It means that one data block includes response spectrums for all defined natural periods on all

floors in a building.

(a) Building name in $ARRANGEMENT data block
(b) Abbreviated building name in 1 character
(c) Damping coefficient
(d) Floor name in $ARRANGEMENT data block in 2 characters
(e) Natural period
(f) Floor response in the Gal

<Formats>

Parameters from (a) to (c) are given in the next line of "$RESPONSESPECTRUM" with the following format:
(A8,2X,A1,9X,F8.0)
All floors of (d) are given in the next line of above with the following format:
(16(A2,3X))
(e) and all floors of (f) are given after the next line of above with the following format:
(8(F8.0,2X))
If number of (f) exceeds 8, remained (f) are given in the next line of above with the following format:
(10X,7(F8.0,2X))

The sets of (e) and (f) can be given as many as the user's needs.

6) Data Block for Response Factor ($RESPONSEFACTOR)

<Parameters>

One response factor and its response subfactors are given in one $RESPONSEFACTOR data block for a basic event whose ID is "RESP.FAC.EQ", "RESP.FAC.DIRE", or "RESP.FAC.PIPE".

(a) Response factor name in $ARRANGEMENT data block
(b) Abbreviated response factor name in 2 characters
(c) Flag for response factor table
Response factor table must be prepared in $RESPONSETABLE data block if 1 is given in this flag. Blank is available in this flag when response factor table is not used.
(d) Response subfactor name
Response subfactor name must be the same as the name in $SUBRESPONSEFACTOR data block. The name must begin with "F" and the

second character must be a number. The user can name it arbitrarily after the third character.

(e) Flag for response subfactor table

Response subfactor table must be prepared in $RESPONSETABLE data block if 1 is given in this flag. Blank is available in this flag when response factor table is not used. (e) is ignored by the code when both (c) and (e) are raised in a response factor.

<Formats>

Parameters from (a) to (c) are given in the next line of "$RESPONSEFACTOR" with the following format:

(A8,2X,A2,8X,I1)

The set of (d) and (e) is repeated for each response subfactor after above with the following format:

(A8,12X,I1)

7) Data Block for Response Subfactor ($SUBRESPONSEFACTOR)

<Parameters>

All response subfactor names and the values which are necessary for one COMPONEN data are given in one $SUBRESPONSEFACTOR data block for a basic event whose ID is "RESP.FAC.EQ", "RESP.FAC.DIRE", or "RESP.FAC.PIPE".

(a) Response subfactor name

(b) Median of response subfactor

(c) Uncertainty due to randomness of response subfactor

(d) Uncertainty due to lack of knowledge of response subfactor

<Format>

The set of parameters from (a) to (d) is repeated for all response subfactors after the next line of "$SUBRESPONSEFACTOR" with the following format:

(A8,2X,F8.0,2X,F8.0,2X,F8.0)

8) Data Block for Table of Occurrence Probabilities ($DIRECTPROBABILITY)

<Parameters>

Conditional occurrence probabilities of a basic event are given in one $DIRECTPROBABILITY data block for a basic event whose ID is "PROB.DIRE".

(a) Capacity name specified in $ARRANGEMENT data block

(b) Seismic motion level in the Gal

(c) Conditional occurrence probability

<Formats>

(a) is given in the next line of "$DIRECTPROBABILITY" with the following format:
(A8)

The set of (b) and (c) is repeated for each seismic motion level after above with the following format:
(F8.0,2X,F8.0)

9) Data Block for Table of Response Factors or Subfactors ($RESPONSETABLE)

<Parameters>

A table of response factor or response subfactor is given in a $RESPONSETABLE data block.

(a) Response factor name or response subfactor name
(b) Seismic motion level in the Gal
(c) Median of response factor or response subfactor
(d) Uncertainty due to randomness of response factor or response subfactor
(e) Uncertainty due to lack of knowledge of response factor or response subfactor

<Formats>

(a) is given in the next line of "$DIRECTPROBABILITY" with the following format:
(A8)

The set of parameters from (b) to (e) is repeated for each seismic motion level with the following format:
(F8.1,3(2X,F8.3))

A sample of COMPONEN data is shown in Table 3.4, which includes 9 basic events shown in Figure 3.1.

Table 3. 4 Sample of COMPONEN Data (1/8)

```
$TITLE
SAMPLE COMPONEN DATA FOR SECOM2-DQFM MANUAL
$ARRANGEMENT
LOSP INITIATOR                    LOSP      LOSP      RESPA11   GROUND1
$ARRANGEMENT
RHR HEAT EXCHANGER A              KHXA      RHRHX     RESPD11   MAIN      B1
$ARRANGEMENT
RHR HEAT EXCHANGER B              KHXB      RHRHX     RESPD11   MAIN      B1
$ARRANGEMENT
RHR PUMP A                        KPUMPA1   RHRPUMP   RESPD11   MAIN      B2
$ARRANGEMENT
RHR PUMP B                        KPUMPB1   RHRPUMP   RESPD11   MAIN      B2
$ARRANGEMENT
RHR VALVE A                       KMOVA12   LMOV      RESPD11   MAIN      6F
$ARRANGEMENT
RHR VALVE B                       KMOVB11   LMOV      RESPD11   MAIN      6F
$ARRANGEMENT
LPCI A INTERNAL                   KINRHRA   INT-RHRA
$ARRANGEMENT
LPCI A INTERNAL                   KINRHRB   INT-RHRB
<-------------------------------------------------------------------
$CAPACITY
LOSP INITIATOR (CERAMIC INSULATOR)
LOSP      LSP       RESP.FAC.DIRE          650.      0.25      0.25
$CAPACITY
LARGE MORTOR OPERATED VALVE
LMOV      MOV       RESP.FAC.EQ            6468.     0.26      0.60
            2.0      28.6      28.6
$CAPACITY
RHR HEAT EXCHANGER
RHRHX     RHX       RESP.FAC.EQ            2638.     0.20      0.35
            2.0      28.6      28.6
$CAPACITY
RHR PUMP
RHRPUMP   RPP       RESP.FAC.EQ            2225.     0.22      0.32
            2.0     100.0     100.0
$CAPACITY
RHR A INTERNAL
INT-RHRA  INT-RHRA  INTERNAL               .110E-01  0.25      0.25
$CAPACITY
RHR B INTERNAL
INT-RHRB  INT-RHRB  INTERNAL               .110E-01  0.23      0.23
<-------------------------------------------------------------------
$RESPONSESPECTRUM
MAIN      M                 0.5
6F    3F    2F    1F    B1    B2
  0.0000  296.099  166.276  146.944  131.681  127.673  123.724
  0.0294  296.099  166.276  146.944  131.681  127.673  123.724
  0.0323  299.866  167.778  147.554  137.083  125.755  125.099
  0.0357  347.017  184.095  173.548  137.636  147.202  126.855
  0.0400  303.276  172.841  160.162  139.960  135.545  128.891
  0.0455  299.157  169.798  155.864  136.974  141.350  139.285
  0.0500  322.316  177.539  159.851  154.167  152.807  152.423
  0.0556  308.363  206.321  170.004  146.394  162.303  150.972
  0.0588  341.038  212.222  182.957  153.639  173.905  167.720
  0.0625  383.357  274.287  224.685  169.804  193.353  194.195
  0.0667  406.040  259.427  254.844  195.986  163.584  191.027
  0.0690  414.675  255.114  274.813  238.673  198.721  207.553
  0.0714  460.619  264.744  285.161  246.217  190.656  174.378
  0.0741  496.657  272.599  359.281  331.287  255.904  191.325
  0.0769  468.182  236.094  288.410  282.914  255.756  189.809
  0.0800  356.844  224.399  247.166  262.478  240.901  202.346
  0.0833  422.774  230.695  225.097  249.385  256.686  226.906
  0.0870  373.447  325.030  254.789  284.267  315.148  331.328
  0.0909  417.314  501.590  328.835  278.880  327.345  390.778
  0.0952  357.647  581.355  393.128  266.101  255.802  360.376
  0.1000  358.320  745.705  543.781  374.572  234.343  344.842
  0.1053  401.097  753.392  612.862  460.992  248.041  249.112
  0.1111  413.588  634.862  549.725  447.337  280.854  203.944
  0.1176  409.952  451.195  429.823  380.018  277.878  189.422
  0.1250  704.431  742.579  814.146  779.273  601.995  388.569
  0.1290  783.541  743.041  804.948  795.123  652.899  451.075
  0.1333  756.707  698.089  800.345  793.705  654.856  449.009
```

Table 3.4 Sample of COMPONEN Data (2/8)

```
  0.1379    736.354    590.592    685.844    699.920    613.006    453.253
  0.1429    705.831    487.244    573.523    585.473    511.645    394.546
  0.1481    908.635    606.477    724.027    752.278    713.781    563.028
  0.1538    977.861    611.232    767.248    820.950    768.923    620.318
  0.1600    949.749    533.838    694.275    765.074    744.681    625.580
  0.1667    976.422    543.828    748.314    845.444    839.774    715.859
  0.1739   1335.235    590.679    834.817    957.794    972.274    871.754
  0.1818   1259.008    485.388    682.264    786.654    826.691    761.060
  0.1905   1002.588    364.327    493.993    577.634    612.919    597.657
  0.2000   1302.283    412.576    564.496    701.178    789.558    784.344
  0.2083   1237.034    368.561    511.585    626.079    699.049    695.330
  0.2174   1703.210    398.989    545.152    718.754    843.688    878.869
  0.2273   1691.308    428.141    549.019    718.133    865.886    931.290
  0.2381   2119.867    491.160    596.116    790.076    968.930   1058.281
  0.2500   1807.352    504.116    473.809    575.313    734.954    829.507
  0.2632   2249.975    623.962    470.196    618.516    786.726    896.497
  0.2778   2455.475    830.701    564.310    556.087    691.734    800.962
  0.2899   2645.932    899.222    588.521    515.741    574.097    710.970
  0.3030   2451.591    939.820    653.318    548.423    549.009    630.168
  0.3175   2486.890   1067.641    757.515    572.190    500.300    536.686
  0.3333   3513.254   1601.516   1171.435    874.456    678.516    641.233
  0.3448   3680.295   1826.315   1395.392   1078.248    826.464    696.739
  0.3571   4305.189   2213.089   1729.092   1371.743   1064.217    864.578
  0.3704   3977.586   2090.918   1650.604   1322.949   1033.937    833.773
  0.3846   3360.469   1890.397   1550.053   1284.177   1030.877    822.988
  0.4000   4145.294   2421.065   2006.231   1684.129   1386.139   1141.963
  0.4167   3258.974   1933.589   1620.043   1383.080   1158.753    974.798
  0.4348   3012.922   1948.107   1686.601   1481.223   1280.424   1109.118
  0.4545   1946.076   1320.303   1166.390   1044.466    923.922    816.892
  0.4762   3818.457   2636.043   2341.858   2108.468   1874.585   1664.019
  0.5000   2261.888   1640.116   1483.705   1358.141   1231.396   1115.045
  0.5263   2508.637   1837.535   1670.150   1535.212   1398.299   1273.210
  0.5556   1154.376    897.082    831.882    778.874    724.446    673.442
  0.5882   1545.278   1238.843   1161.348   1098.166   1033.184    971.741
  0.6250   1359.254   1073.810   1002.695    945.302    889.388    843.303
  0.6667   1193.557    981.307    927.655    884.570    840.586    799.379
  0.7143   1176.770    994.052    947.436    909.712    870.744    833.552
  0.7692    713.378    616.421    594.824    576.962    558.276    540.067
  0.8333   1045.974    912.843    878.953    851.446    823.428    796.969
  0.9091    458.365    419.440    409.551    401.436    393.099    384.996
  1.0000    636.634    593.261    582.057    572.764    562.982    553.440
  1.1111    388.294    355.201    346.809    339.955    332.885    326.148
  1.2500    465.124    442.452    436.637    431.841    426.808    421.845
  1.4286    250.998    237.466    233.988    231.123    228.131    225.230
  1.6667    279.439    268.950    266.281    264.101    261.823    259.621
  2.0000    137.321    130.544    128.841    127.458    126.047    124.730
  2.5000    120.270    118.506    118.066    117.691    117.265    116.811
  3.3333     29.876     29.235     29.069     28.929     28.778     28.628
  5.0000     15.213     14.488     14.349     14.283     14.215     14.150
$RESPONSESPECTRUM
MAIN        M                  1.0
6F    3F    2F    1F    B1    B2
  0.0000    296.106    166.311    146.955    131.506    124.744    124.238
  0.0294    296.106    166.311    146.955    131.506    124.744    124.238
  0.0323    299.609    168.797    146.778    135.237    125.124    124.083
  0.0357    313.903    179.878    161.597    136.420    133.536    125.247
  0.0400    298.785    170.349    156.495    136.282    133.308    126.734
  0.0455    297.003    171.001    152.314    134.935    132.907    133.124
  0.0500    312.597    176.559    157.337    145.415    143.757    139.220
  0.0556    298.744    189.085    160.051    140.067    148.951    143.864
  0.0588    330.441    198.860    173.826    149.059    153.915    153.416
  0.0625    336.073    242.884    197.846    154.114    165.389    162.952
  0.0667    375.699    251.704    246.797    189.248    158.991    174.877
  0.0690    361.077    226.630    243.278    211.417    183.706    189.813
  0.0714    412.102    224.461    253.518    225.324    172.707    159.901
  0.0741    420.216    226.252    266.297    249.665    198.859    172.890
  0.0769    419.433    222.546    237.812    224.224    201.832    158.784
  0.0800    362.590    220.352    202.877    213.154    193.192    174.230
  0.0833    392.007    215.198    200.367    235.235    242.883    213.471
  0.0870    365.007    294.634    226.597    248.620    267.312    277.199
  0.0909    369.991    397.571    273.237    220.516    258.649    319.892
  0.0952    337.911    478.216    345.879    249.759    211.922    280.381
  0.1000    360.946    566.657    428.981    315.252    204.546    267.486
```

Table 3.4 Sample of COMPONEN Data (3/8)

```
   0.1053    381.891    653.032    531.308    401.646    225.765    223.770
   0.1111    383.639    500.200    427.590    353.127    233.728    172.231
   0.1176    424.976    381.389    360.718    318.733    236.289    180.645
   0.1250    618.075    575.537    631.967    606.351    479.998    322.421
   0.1290    659.320    606.111    672.944    665.619    555.557    388.474
   0.1333    644.984    555.580    624.975    621.126    522.871    366.122
   0.1379    671.511    461.046    547.451    563.068    495.951    373.184
   0.1429    602.590    419.369    485.015    498.033    439.743    331.286
   0.1481    759.889    499.298    584.946    597.461    574.970    461.567
   0.1538    735.416    446.746    558.983    601.964    567.499    460.634
   0.1600    745.455    441.962    567.173    623.799    607.681    513.592
   0.1667    862.614    480.957    655.110    737.422    733.031    629.081
   0.1739   1071.483    478.567    664.951    763.165    796.420    716.834
   0.1818    940.827    365.241    483.001    556.340    589.545    539.146
   0.1905    824.029    319.910    399.299    455.442    478.007    456.140
   0.2000   1088.975    335.105    453.497    555.736    610.588    605.732
   0.2083    925.434    296.078    381.568    478.874    556.810    564.549
   0.2174   1345.446    333.777    399.994    532.468    627.084    654.721
   0.2273   1259.992    365.096    437.504    532.275    632.555    671.665
   0.2381   1526.110    384.153    438.323    568.561    682.153    735.150
   0.2500   1388.428    401.926    407.741    475.427    593.754    670.822
   0.2632   1846.914    528.503    378.907    499.833    627.158    709.750
   0.2778   2071.561    719.546    488.384    443.189    521.823    589.814
   0.2899   1969.595    682.068    509.485    465.439    505.827    565.254
   0.3030   1991.551    795.425    556.066    475.506    472.028    502.355
   0.3175   2015.440    881.463    631.302    478.234    426.067    442.552
   0.3333   2770.124   1270.659    932.676    714.763    556.511    509.011
   0.3448   2802.594   1358.790   1050.270    821.440    625.967    538.820
   0.3571   3164.773   1642.108   1288.848   1027.114    799.637    649.018
   0.3704   3202.801   1677.747   1321.872   1056.027    822.457    674.675
   0.3846   2605.683   1442.177   1174.722    971.365    775.611    614.303
   0.4000   3170.257   1848.037   1531.979   1289.572   1059.933    881.980
   0.4167   2633.936   1553.628   1303.255   1112.165    932.775    785.618
   0.4348   2488.487   1615.555   1403.128   1235.043   1071.866    929.457
   0.4545   1745.626   1175.699   1035.004    923.834    813.251    714.492
   0.4762   2671.576   1838.099   1632.502   1467.848   1302.952   1155.378
   0.5000   1934.318   1386.477   1250.256   1142.626   1034.169    936.468
   0.5263   1916.068   1397.309   1266.948   1162.510   1057.163    959.950
   0.5556    960.776    745.248    690.831    646.608    601.264    558.863
   0.5882   1187.262    904.225    834.419    783.639    738.239    695.287
   0.6250   1074.478    841.573    783.576    737.461    691.071    648.699
   0.6667   1029.760    843.485    797.604    760.433    723.077    687.987
   0.7143    954.365    803.145    764.656    733.485    701.377    670.755
   0.7692    601.259    529.294    510.770    495.445    479.410    463.770
   0.8333    784.150    678.864    652.159    630.706    608.766    588.191
   0.9091    408.329    363.715    352.607    343.634    334.490    325.732
   1.0000    517.084    481.909    472.908    465.451    457.606    449.936
   1.1111    353.571    322.836    315.027    308.704    302.191    295.983
   1.2500    360.450    340.131    335.756    332.126    328.296    324.495
   1.4286    223.731    214.854    212.591    210.734    208.805    206.939
   1.6667    230.439    221.075    218.698    216.748    214.732    212.792
   2.0000    121.758    118.099    117.154    116.370    115.546    114.743
   2.5000    104.426    102.895    102.519    102.191    101.822    101.415
   3.3333     27.938     27.295     27.130     26.993     26.844     26.697
   5.0000     14.764     14.024     13.849     13.741     13.670     13.602
$RESPONSESPECTRUM
MAIN       M                2.0
6F    3F    2F    1F    B1    B2
   0.0000    296.015    166.301    146.990    131.054    124.658    124.355
   0.0294    296.015    166.301    146.990    131.054    124.658    124.355
   0.0323    299.223    168.520    147.094    133.230    125.234    124.418
   0.0357    307.859    175.996    155.466    134.485    130.402    126.024
   0.0400    297.173    169.650    153.843    134.588    129.274    126.052
   0.0455    295.318    170.589    151.531    134.344    129.955    131.132
   0.0500    304.279    172.991    154.797    141.440    136.968    134.558
   0.0556    298.181    181.660    157.807    138.844    142.321    139.713
   0.0588    321.097    190.669    165.196    144.135    145.741    145.934
   0.0625    325.222    219.032    178.171    149.174    153.685    152.253
   0.0667    350.197    216.632    208.622    172.643    152.528    161.426
   0.0690    341.587    208.544    209.683    186.750    167.919    171.690
   0.0714    367.970    212.187    216.776    192.264    161.717    155.004
   0.0741    370.310    216.302    225.171    205.098    175.480    161.126
   0.0769    383.279    216.635    208.384    191.722    173.710    150.452
```

Table 3.4 Sample of COMPONEN Data (4/8)

```
   0.0800    357.604    218.139    191.608    186.146    172.332    158.050
   0.0833    373.731    219.216    191.423    197.788    203.590    181.631
   0.0870    353.986    273.829    209.043    203.225    216.814    218.511
   0.0909    356.185    345.715    245.348    196.834    209.007    252.995
   0.0952    340.565    400.170    293.500    216.582    183.416    229.819
   0.1000    358.227    437.814    334.478    256.479    179.251    216.544
   0.1053    373.016    479.251    396.195    307.276    196.215    187.610
   0.1111    373.104    390.218    339.347    282.980    203.173    163.285
   0.1176    410.167    343.799    320.896    285.364    218.941    167.785
   0.1250    521.091    413.705    440.439    421.302    342.337    248.515
   0.1290    555.619    431.452    471.499    466.400    397.258    291.232
   0.1333    554.177    414.632    455.810    451.125    382.639    278.663
   0.1379    571.623    357.494    402.806    415.577    372.320    290.118
   0.1429    536.537    346.336    387.702    389.536    350.359    274.096
   0.1481    628.576    388.282    436.917    443.792    414.947    344.366
   0.1538    603.169    357.412    434.181    461.248    433.334    352.178
   0.1600    604.994    357.246    443.567    478.998    461.012    386.300
   0.1667    679.865    380.453    483.031    538.430    533.683    459.884
   0.1739    811.439    362.969    460.750    520.114    546.889    499.279
   0.1818    800.570    297.451    369.112    408.482    430.439    398.685
   0.1905    779.909    281.208    332.216    371.676    385.302    379.595
   0.2000    923.765    286.813    344.081    406.218    444.375    444.006
   0.2083    828.944    270.462    313.281    379.863    443.021    449.730
   0.2174   1070.272    296.780    328.273    400.571    456.549    478.099
   0.2273   1015.523    321.995    350.332    401.300    468.870    493.874
   0.2381   1117.626    336.356    344.612    406.950    481.183    511.676
   0.2500   1063.176    352.835    337.380    366.805    424.080    472.430
   0.2632   1294.622    428.678    318.884    359.401    428.482    485.353
   0.2778   1564.067    580.087    404.937    364.990    401.162    438.695
   0.2899   1526.414    579.728    431.945    385.131    403.617    436.821
   0.3030   1598.610    647.688    468.446    398.725    393.778    414.648
   0.3175   1655.413    723.147    529.085    414.668    371.837    386.422
   0.3333   1996.147    919.780    685.224    540.602    438.502    407.063
   0.3448   2003.708    991.911    775.855    616.410    478.794    413.740
   0.3571   2165.331   1135.485    893.433    720.821    570.469    468.090
   0.3704   2202.645   1173.996    932.477    753.169    599.675    500.991
   0.3846   1975.192   1094.293    889.368    733.375    585.465    473.508
   0.4000   2143.477   1241.294   1037.149    887.674    745.651    631.550
   0.4167   1929.562   1179.316   1001.647    863.979    732.782    622.645
   0.4348   1887.315   1231.008   1070.659    943.788    819.928    711.501
   0.4545   1461.053    984.213    866.618    773.428    681.133    598.738
   0.4762   1667.790   1139.084   1012.174    912.624    814.626    726.855
   0.5000   1368.105    965.728    872.650    800.436    727.601    661.811
   0.5263   1300.389    968.766    885.280    817.942    749.552    686.115
   0.5556    834.131    650.717    604.078    566.070    527.075    490.291
   0.5882    879.212    676.462    626.521    588.713    553.243    520.051
   0.6250    782.321    619.460    579.378    547.658    515.812    486.472
   0.6667    740.646    607.864    575.077    548.480    521.447    496.074
   0.7143    685.688    566.592    536.607    512.373    487.745    465.944
   0.7692    482.312    426.097    411.530    399.420    386.656    374.126
   0.8333    549.389    473.623    455.137    440.587    426.066    412.631
   0.9091    367.182    326.085    316.195    308.222    300.041    292.225
   1.0000    385.838    357.105    349.758    343.747    337.460    331.402
   1.1111    300.071    273.409    266.714    261.308    255.794    250.599
   1.2500    275.474    259.250    255.463    252.326    249.033    245.767
   1.4286    197.463    187.178    184.669    182.682    180.693    178.853
   1.6667    175.717    169.187    167.537    166.185    164.766    163.360
   2.0000    111.278    107.899    107.002    106.254    105.457    104.675
   2.5000     76.496     74.488     74.004     73.603     73.170     72.733
   3.3333     25.526     24.612     24.382     24.203     24.029     23.875
   5.0000     13.826     12.852     12.621     12.468     12.358     12.286
$RESPONSESPECTRUM
MAIN       M                 4.0
6F    3F    2F    1F    B1    B2
   0.0000    295.923    166.291    147.024    130.604    124.572    124.472
   0.0294    295.923    166.291    147.024    130.604    124.572    124.472
   0.0323    298.837    168.243    147.411    131.253    125.345    124.753
   0.0357    301.932    172.198    149.567    132.577    127.341    126.806
   0.0400    295.570    168.953    151.236    132.915    125.362    125.372
   0.0455    293.644    170.179    150.753    133.755    127.068    129.170
   0.0500    296.182    169.495    152.299    137.573    130.499    130.052
   0.0556    297.618    174.526    155.593    137.631    135.987    135.682
   0.0588    312.017    182.816    156.994    139.374    138.001    138.817
```

Table 3. 4 Sample of COMPONEN Data (5/8)

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  0.0625   314.721   197.522   160.452   144.393   142.810   142.258
  0.0667   326.425   186.448   176.352   157.495   146.328   149.009
  0.0690   323.150   191.902   180.727   164.962   153.488   155.297
  0.0714   328.563   200.584   185.358   164.055   151.427   150.256
  0.0741   326.332   206.790   190.397   168.487   154.850   150.162
  0.0769   350.241   210.881   182.598   163.932   149.505   142.557
  0.0800   352.686   215.947   180.964   162.561   153.725   143.374
  0.0833   356.308   223.309   182.879   166.302   170.654   154.541
  0.0870   343.298   254.493   192.848   166.119   175.856   172.248
  0.0909   342.894   300.622   220.305   175.695   168.893   200.087
  0.0952   343.240   334.861   249.054   187.811   158.744   188.376
  0.1000   355.530   338.267   260.794   208.663   157.084   175.305
  0.1053   364.347   351.715   295.442   235.078   170.534   157.294
  0.1111   362.859   304.419   269.315   226.767   176.613   154.804
  0.1176   395.873   309.914   285.470   255.488   202.866   155.840
  0.1250   439.325   297.377   306.956   292.728   244.156   191.550
  0.1290   468.229   307.123   330.356   326.807   284.064   218.332
  0.1333   476.155   309.441   332.433   327.653   280.016   212.096
  0.1379   486.594   277.199   296.378   306.720   279.509   225.541
  0.1429   477.724   286.021   309.914   304.675   279.143   226.779
  0.1481   519.955   301.950   326.349   329.648   299.460   256.925
  0.1538   494.704   285.942   337.244   353.426   330.888   269.257
  0.1600   490.999   288.770   346.900   367.809   349.743   290.557
  0.1667   535.832   300.951   356.152   393.136   388.548   336.194
  0.1739   614.506   275.293   319.258   354.469   375.540   347.750
  0.1818   681.223   242.244   282.077   299.920   314.272   294.818
  0.1905   738.152   247.187   276.403   303.317   310.576   315.895
  0.2000   783.619   245.481   261.064   296.927   323.408   325.459
  0.2083   742.514   247.063   257.215   301.323   352.485   358.262
  0.2174   851.377   263.883   269.412   301.346   332.391   349.123
  0.2273   818.487   283.982   280.529   302.554   347.541   363.144
  0.2381   818.479   294.507   270.935   291.276   339.421   356.134
  0.2500   814.117   309.741   279.160   283.000   302.893   332.711
  0.2632   907.484   347.708   268.370   258.424   292.745   331.902
  0.2778  1180.900   467.658   335.748   300.590   308.401   326.295
  0.2899  1182.954   492.743   366.206   318.679   322.059   337.570
  0.3030  1283.197   527.390   394.633   334.343   328.500   342.254
  0.3175  1359.699   593.265   443.419   359.551   324.509   337.411
  0.3333  1438.420   665.793   503.424   408.878   345.517   325.534
  0.3448  1432.547   724.091   573.139   462.555   366.224   317.695
  0.3571  1481.515   785.166   619.330   505.867   406.979   337.600
  0.3704  1514.814   821.499   657.789   537.168   437.238   372.019
  0.3846  1497.260   830.326   673.330   553.694   441.934   364.982
  0.4000  1449.249   833.756   702.149   611.029   524.557   452.228
  0.4167  1413.554   895.186   769.840   671.177   575.669   493.481
  0.4348  1431.374   937.993   816.967   721.218   627.207   544.655
  0.4545  1222.871   823.914   725.627   647.509   570.479   501.736
  0.4762  1041.154   705.899   627.562   567.417   509.317   457.268
  0.5000   967.634   672.663   609.090   560.724   511.912   467.708
  0.5263   882.543   671.653   618.590   575.504   531.449   490.394
  0.5556   724.179   568.177   528.220   495.563   462.040   430.134
  0.5882   651.090   506.070   470.421   442.273   414.605   388.979
  0.6250   569.604   455.968   428.393   406.706   384.999   364.815
  0.6667   532.703   438.063   414.633   395.604   376.042   357.695
  0.7143   492.650   399.712   376.571   357.916   339.183   323.670
  0.7692   386.897   343.020   331.572   322.006   311.847   301.810
  0.8333   384.911   330.433   317.636   307.778   298.197   289.471
  0.9091   330.180   292.348   283.544   276.459   269.140   262.165
  1.0000   287.905   264.623   258.678   253.866   248.858   244.096
  1.1111   254.666   231.550   225.811   221.189   216.521   212.173
  1.2500   210.532   197.602   194.370   191.699   188.907   186.141
  1.4286   174.279   163.067   160.413   158.363   156.366   154.578
  1.6667   133.990   129.477   128.344   127.417   126.426   125.412
  2.0000   101.701    98.580    97.730    97.016    96.248    95.490
  2.5000    56.036    53.923    53.420    53.013    52.580    52.163
  3.3333    23.321    22.193    21.913    21.701    21.509    21.352
  5.0000    12.948    11.779    11.503    11.313    11.172    11.098
$RESPONSESPECTRUM
MAIN       M                5.0
6F    3F    2F    1F    B1    B2
  0.0000   295.894   166.287   147.035   130.459   124.544   124.510
  0.0294   295.894   166.287   147.035   130.459   124.544   124.510
  0.0323   298.713   168.154   147.513   130.623   125.381   124.862
```

Table 3.4 Sample of COMPONEN Data (6/8)

0.0357	300.049	170.993	147.716	131.969	126.371	127.059
0.0400	295.055	168.730	150.406	132.381	124.128	125.154
0.0455	293.107	170.047	150.503	133.566	126.152	128.545
0.0500	293.622	168.385	151.503	136.351	128.482	128.634
0.0556	297.437	172.290	154.887	137.242	134.009	134.409
0.0588	309.148	180.357	154.442	137.876	135.598	136.601
0.0625	311.413	191.057	155.132	142.886	139.475	139.181
0.0667	319.121	177.655	167.065	152.907	144.386	145.219
0.0690	317.429	186.832	172.284	158.503	149.112	150.360
0.0714	316.798	196.986	176.247	155.886	148.256	148.759
0.0741	313.316	203.818	180.388	158.152	148.739	146.794
0.0769	340.223	209.061	174.996	155.873	142.455	140.105
0.0800	351.117	215.247	177.666	155.623	148.173	138.945
0.0833	350.873	224.643	180.210	157.273	161.229	146.710
0.0870	339.927	248.563	187.906	155.679	164.394	159.549
0.0909	338.721	287.396	212.800	169.386	157.695	185.531
0.0952	344.105	316.195	236.230	179.389	151.531	176.694
0.1000	354.665	311.311	240.717	195.253	150.548	163.778
0.1053	361.599	318.371	268.811	215.659	163.003	148.617
0.1111	359.621	281.032	250.003	211.163	168.824	152.168
0.1176	391.379	299.733	274.920	246.552	197.947	152.179
0.1250	415.837	267.392	273.272	260.350	218.984	176.149
0.1290	443.132	275.290	294.609	291.450	254.991	198.993
0.1333	453.453	281.622	300.314	295.599	253.237	194.253
0.1379	462.008	255.403	268.503	278.148	254.864	207.981
0.1429	460.198	268.934	288.358	281.504	259.452	213.358
0.1481	489.149	278.469	297.090	299.557	269.610	233.804
0.1538	464.119	266.125	310.900	324.393	303.368	246.964
0.1600	459.083	269.650	320.506	337.826	319.985	265.100
0.1667	496.299	279.076	322.873	355.280	350.809	303.941
0.1739	561.901	251.849	283.694	313.308	332.739	309.528
0.1818	646.723	226.751	258.684	271.527	284.007	267.520
0.1905	725.190	237.136	260.512	284.106	289.751	297.756
0.2000	743.192	233.486	238.860	268.431	291.961	294.491
0.2083	716.654	239.969	241.395	279.672	327.475	332.974
0.2174	790.917	254.089	252.807	274.961	300.106	315.517
0.2273	763.579	272.727	261.162	276.257	315.603	328.920
0.2381	740.379	282.175	250.747	261.547	303.349	316.919
0.2500	747.084	297.020	262.646	260.328	271.792	297.199
0.2632	809.402	325.047	253.876	232.391	258.957	293.682
0.2778	1078.758	436.322	316.094	282.380	283.367	296.637
0.2899	1089.756	467.618	347.249	299.829	299.486	310.690
0.3030	1195.544	493.634	373.439	315.915	309.880	321.753
0.3175	1276.232	556.634	418.908	343.416	310.594	322.996
0.3333	1294.414	600.009	455.857	373.722	319.999	302.934
0.3448	1285.866	654.323	519.900	421.713	335.949	291.796
0.3571	1311.132	697.240	550.416	451.364	365.055	303.887
0.3704	1342.822	732.300	587.893	481.789	394.958	338.027
0.3846	1369.510	759.721	615.633	505.797	403.679	335.642
0.4000	1277.683	733.497	619.285	541.811	468.404	406.126
0.4167	1278.807	819.168	707.293	618.775	532.641	457.894
0.4348	1309.461	859.395	748.851	661.398	575.373	499.759
0.4545	1154.783	778.085	685.311	611.507	538.832	473.984
0.4762	894.623	605.120	538.052	486.923	437.849	393.890
0.5000	865.547	598.737	542.512	500.018	457.127	418.255
0.5263	779.011	596.946	551.170	513.923	475.756	440.140
0.5556	691.964	543.900	505.886	474.789	442.861	412.384
0.5882	591.078	460.932	428.966	403.369	377.836	354.263
0.6250	514.289	413.136	388.715	369.554	350.401	332.534
0.6667	479.081	394.217	373.191	356.106	338.478	321.950
0.7143	442.908	357.247	335.994	318.877	301.750	287.848
0.7692	360.392	319.888	309.295	300.429	290.991	281.645
0.8333	343.254	294.273	282.905	274.210	265.835	258.251
0.9091	319.081	282.248	273.767	266.947	259.885	253.161
1.0000	262.008	240.283	234.738	230.265	225.616	221.213
1.1111	241.564	219.488	214.027	209.633	205.209	201.103
1.2500	193.076	181.062	177.999	175.469	172.828	170.212
1.4286	167.410	155.986	153.304	151.245	149.254	147.487
1.6667	122.792	118.794	117.792	116.974	116.093	115.180
2.0000	98.797	95.754	94.919	94.217	93.459	92.708
2.5000	50.693	48.597	48.099	47.698	47.274	46.870
3.3333	22.653	21.466	21.173	20.952	20.755	20.598
5.0000	12.677	11.453	11.164	10.964	10.815	10.740

Table 3.4 Sample of COMPONEN Data (7/8)

```
$RESPONSESPECTRUM
MAIN      M                7.0
6F    3F    2F    1F    B1    B2
  0.0000  295.849  166.282  147.052  130.242  124.502  124.566
  0.0294  295.849  166.282  147.052  130.242  124.502  124.566
  0.0323  298.527  168.020  147.667  129.679  125.434  125.025
  0.0357  297.231  169.192  144.968  131.057  124.922  127.441
  0.0400  294.282  168.393  149.164  131.579  122.290  124.827
  0.0455  292.298  169.848  150.127  133.282  124.783  127.608
  0.0500  289.803  166.725  150.311  134.529  125.500  126.524
  0.0556  297.165  168.972  153.829  136.659  131.080  132.513
  0.0588  304.873  176.712  150.671  135.646  132.053  133.325
  0.0625  306.491  181.707  147.441  140.644  134.594  134.668
  0.0667  308.416  165.175  153.978  146.240  141.506  139.685
  0.0690  308.994  179.439  160.293  149.240  142.748  143.211
  0.0714  299.849  191.681  163.348  144.330  143.599  146.530
  0.0741  294.666  199.417  166.281  143.755  139.978  141.857
  0.0769  325.657  206.347  164.127  144.463  132.448  136.486
  0.0800  348.765  214.195  172.805  145.718  140.179  132.525
  0.0833  342.835  226.669  176.259  144.577  147.993  135.647
  0.0870  334.906  239.883  180.693  141.165  148.506  142.148
  0.0909  332.526  268.545  201.965  160.297  142.197  165.560
  0.0952  345.415  289.996  218.131  167.397  141.268  160.435
  0.1000  353.366  274.670  213.328  176.644  141.204  147.814
  0.1053  357.495  273.972  233.123  189.367  152.273  136.431
  0.1111  354.794  249.120  223.468  189.641  157.724  148.279
  0.1176  384.698  285.010  259.743  233.666  190.754  146.820
  0.1250  382.771  227.796  229.338  218.171  185.849  155.236
  0.1290  407.809  233.416  247.884  245.235  216.680  173.021
  0.1333  421.253  244.329  257.652  253.096  217.621  170.146
  0.1379  427.265  225.735  231.348  240.018  221.749  184.053
  0.1429  434.979  245.080  258.655  249.853  232.355  194.606
  0.1481  446.114  246.469  257.856  259.297  230.131  202.814
  0.1538  421.538  238.810  275.015  285.062  266.137  216.788
  0.1600  414.837  243.186  284.455  297.173  279.831  230.869
  0.1667  442.133  249.060  278.478  304.978  300.718  261.061
  0.1739  490.969  220.218  237.416  260.099  277.244  259.687
  0.1818  597.978  205.242  227.027  233.714  243.790  231.062
  0.1905  706.075  222.748  238.261  257.414  260.959  272.354
  0.2000  686.142  216.499  208.898  230.548  250.228  253.274
  0.2083  679.354  229.656  219.360  249.929  293.078  298.177
  0.2174  707.772  240.004  229.684  239.478  257.256  270.859
  0.2273  687.670  256.592  234.458  240.862  272.906  283.314
  0.2381  636.474  264.550  223.114  222.355  256.074  265.797
  0.2500  656.296  278.820  239.572  229.529  230.827  250.686
  0.2632  681.179  293.638  233.488  198.008  215.237  244.207
  0.2778  941.199  392.996  288.613  256.985  249.409  256.935
  0.2899  962.920  432.134  320.505  273.492  268.404  274.150
  0.3030 1074.564  446.775  343.615  290.030  283.781  293.137
  0.3175 1159.961  505.631  384.486  320.445  290.732  302.415
  0.3333 1104.063  512.898  392.492  326.343  285.040  271.788
  0.3448 1092.588  561.622  448.825  366.843  294.963  256.681
  0.3571 1090.534  582.917  460.723  380.078  309.859  259.309
  0.3704 1119.683  615.770  496.285  408.888  338.806  292.552
  0.3846 1197.189  664.444  537.844  441.293  352.164  295.799
  0.4000 1056.604  604.643  512.453  451.976  394.889  345.342
  0.4167 1099.515  716.571  622.455  547.391  473.763  409.026
  0.4348 1144.978  753.152  656.725  580.445  505.200  438.960
  0.4545 1059.214  713.754  628.716  560.969  494.401  435.013
  0.4762  711.720  479.693  426.629  386.610  348.588  314.535
  0.5000  731.608  502.338  455.623  420.678  385.401  353.394
  0.5263  645.398  499.708  463.144  433.297  402.616  373.931
  0.5556  646.076  509.241  473.983  445.099  415.436  386.994
  0.5882  510.880  400.366  373.261  351.080  328.464  307.683
  0.6250  440.869  356.035  335.724  319.850  304.019  289.178
  0.6667  408.256  336.259  318.398  303.876  288.810  274.689
  0.7143  377.235  301.588  282.923  267.911  252.968  241.187
  0.7692  323.820  287.923  278.502  270.597  262.150  253.758
  0.8333  288.807  247.089  237.581  230.386  223.555  217.424
  0.9091  303.046  267.674  259.659  253.220  246.529  240.166
  1.0000  227.295  207.748  202.763  198.760  194.609  190.699
  1.1111  223.072  202.478  197.411  193.339  189.259  185.493
  1.2500  169.452  158.702  155.883  153.557  151.133  148.733
```

Table 3.4 Sample of COMPONEN Data (8/8)

```
   1.4286    157.562    145.887    143.176    141.112    139.136    137.405
   1.6667    107.650    104.328    103.499    102.822    102.086    101.309
   2.0000     94.573     91.646     90.833     90.148     89.404     88.665
   2.5000     43.585     41.543     41.060     40.674     40.268     39.885
   3.3333     21.681     20.414     20.103     19.871     19.668     19.511
   5.0000     12.279     10.978     10.673     10.459     10.299     10.223
$DESIGNRESPONSE
GROUND1    G1F              220.0          0.0
$RESPONSEFACTOR
RESPA11    A4
F1
F21A3
F22A3
F23A3
F4A1
$RESPONSEFACTOR
RESPD11    D4
F1
F21A2
F22D2
F31X2
F32X2
$SUBRESPONSEFACTOR
F1              0.936       0.125        0.00
F21A2            1.00        0.00        0.45
F21A3            1.03        0.00        0.45
F22A3            0.96        0.00        0.25
F22D2            1.00        0.00        0.25
F23A3            1.00        0.00        0.00
F31X2            1.01        0.00        0.01
F32X2            0.89        0.00        0.22
F4A1             1.00        0.00        0.00
```

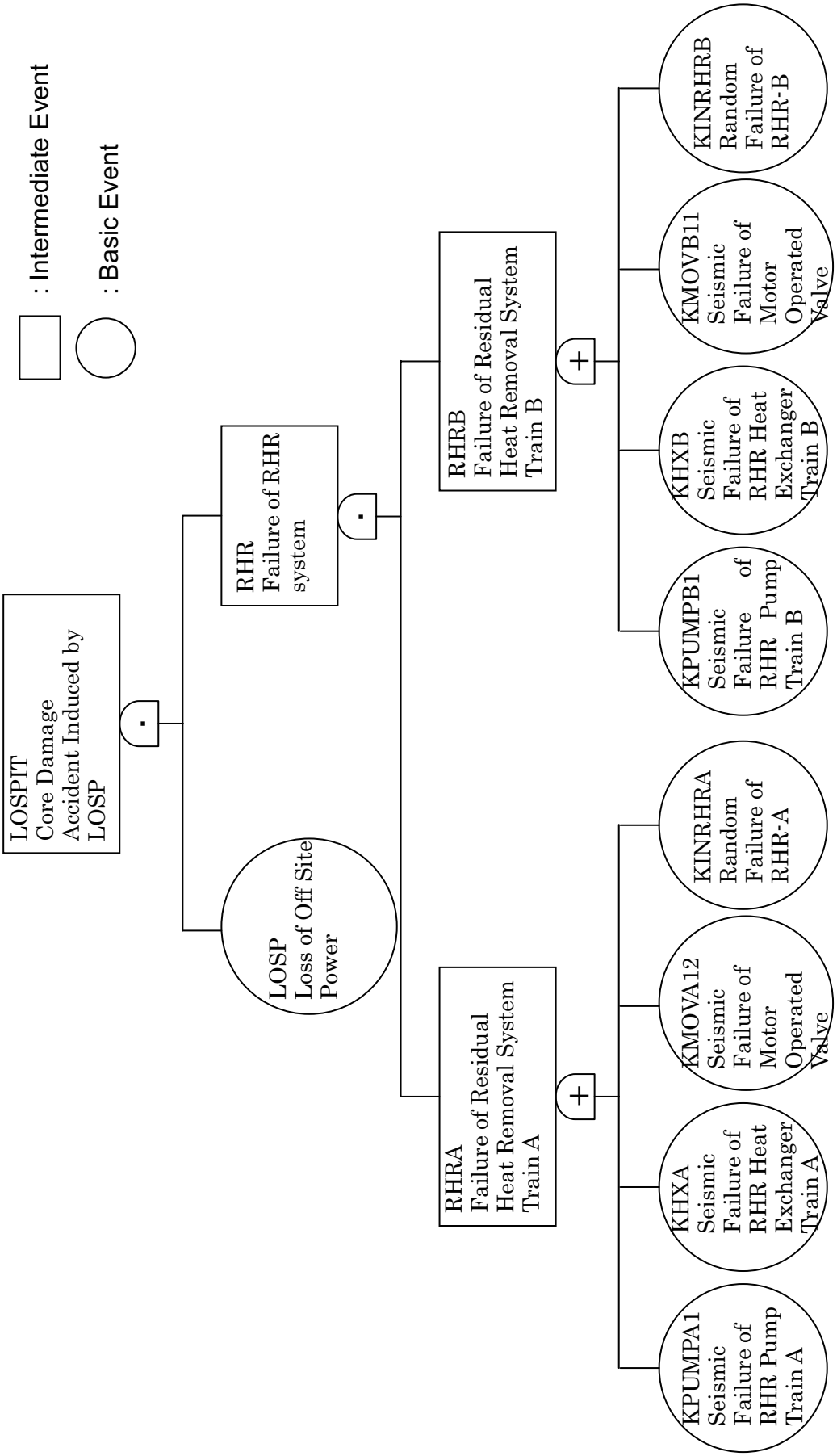


Fig. 3. 1 Sample of a fault tree model

3.4 HAZARD Data

Seismic hazard is given as the unit of excessive occurrence frequency or occurrence frequency per Gal in HAZARD data.

(1) Structure of HAZARD Data

HAZARD data consists of the following 4 kinds of data blocks which begin with data lines with "$".

1) Data Block of Title ($TITLE)
2) Data Block of Seismic Motion Level ($SEISMICLEVEL)
3) Data Block of Excessive Occurrence Frequency ($HAZARD)
4) Data Block of Occurrence Frequency per Gal ($H1/YG)

1) and 2) are given only once in one HAZARD data. 3) and 4) are given once or more with seismic hazard ID for each. Seismic hazard ID can be named by the user arbitrarily, and selected in calculation control data. Each seismic hazard ID must be unique in one HAZARD data.

(2) Parameters in HAZARD data

1) Data Block of Title ($TITLE)

<Parameters>

Title of the HAZARD data can be given.
The user can give an adequate name that shows contents of the data.

<Format>

"$TITLE" is given in the first line of the HAZARD data and a title is given in the next line with the following format:
(A80)

2) Data Block of Seismic Motion Level ($SEISMICLEVEL)

<Parameters>

Seismic motion level: SLVL

<Format>

"$SEISMICLEVEL" is given at first, and seismic motion levels for analysis are given from the small value in order with the following format. The maximum number of levels is 8 in 1 line, more levels are continued in the next line.
(8(F8.0,2X))

3) Data Block of Excessive Occurrence Frequency ($HAZARD)

<Parameters>

(a) Seismic hazard ID: HAZID

(b) Excessive occurrence frequency: HAZD

<Formats>

(a) is given in the next line of "$HAZARD" with the following format:

(A8)

Excessive occurrence frequency is given for each seismic motion level specified in $SEISMICLEVEL data block with the following format. The maximum number of frequencies is 8 in 1 line, more frequencies are continued in the next line.

(8E10.3)

4) Data Block of Occurrence Frequency per Gal ($H1/YG)

<Parameters>

(a) Seismic hazard ID: HAZID

(b) Occurrence Frequency per Gal: HAZD

<Formats>

(a) is given in the next line of "$H1/YG" with the following format:

(A8)

Occurrence frequency per Gal are given for each seismic motion level specified in $SEISMICLEVEL data block with the following format. The maximum number of frequencies is 8 in 1 line, more frequencies are continued in the next line.

(8E10.3)

A sample of HAZARD data is shown Table 3. 5. Seismic hazard "MDL" is given from 30 Gal to 2250 Gal with an equal interval of 30 Gal in this sample.

Table 3. 5 Sample of HAZARD data

```
$TITLE
SAMPLE HAZARD DATA FOR SECOM2-DQFM MANUAL
$SEISMICLEVEL
     0.0     30.0     60.0     90.0    120.0    150.0    180.0    210.0
   240.0    270.0    300.0    330.0    360.0    390.0    420.0    450.0
   480.0    510.0    540.0    570.0    600.0    630.0    660.0    690.0
   720.0    750.0    780.0    810.0    840.0    870.0    900.0    930.0
   960.0    990.0   1020.0   1050.0   1080.0   1110.0   1140.0   1170.0
  1200.0   1230.0   1260.0   1290.0   1320.0   1350.0   1380.0   1410.0
  1440.0   1470.0   1500.0   1530.0   1560.0   1590.0   1620.0   1650.0
  1680.0   1710.0   1740.0   1770.0   1800.0   1830.0   1860.0   1890.0
  1920.0   1950.0   1980.0   2010.0   2040.0   2070.0   2100.0   2130.0
  2160.0   2190.0   2220.0   2250.0
$HAZARD
MDL
 5.174E-01 1.546E-01 3.784E-02 1.560E-02 8.060E-03 4.679E-03 2.917E-03 1.910E-03
 1.295E-03 9.016E-04 6.409E-04 4.632E-04 3.395E-04 2.518E-04 1.887E-04 1.427E-04
 1.087E-04 8.352E-05 6.458E-05 5.025E-05 3.933E-05 3.095E-05 2.448E-05 1.946E-05
 1.554E-05 1.246E-05 1.004E-05 8.114E-06 6.585E-06 5.363E-06 4.383E-06 3.594E-06
 2.957E-06 2.440E-06 2.019E-06 1.676E-06 1.394E-06 1.163E-06 9.732E-07 8.161E-07
 6.860E-07 5.779E-07 4.880E-07 4.130E-07 3.502E-07 2.976E-07 2.534E-07 2.161E-07
 1.847E-07 1.581E-07 1.356E-07 1.165E-07 1.003E-07 8.647E-08 7.466E-08 6.456E-08
 5.591E-08 4.850E-08 4.212E-08 3.664E-08 3.191E-08 2.784E-08 2.431E-08 2.126E-08
 1.861E-08 1.632E-08 1.432E-08 1.258E-08 1.107E-08 9.750E-09 8.597E-09 7.588E-09
 6.705E-09 5.930E-09 5.251E-09 4.654E-09
```

3.5 FT Data

Information of Fault Tree models is given in the FT data file. SECOM2-DQFM can calculate up to 400 basic events in a FT model.

(1)Structure of FT Data

FT data consists of the following 2 kinds of data blocks which begin with data lines with "$".

1) Data Block of Title ($TITLE)

2) Data Block of Fault Tree ($FT)

1) and 2) are given only once in one FT data. In $FT data block, the set of top event and the lower events is given at first, and then the lower events are developed in order. Gate types allowed in FT data are as follows:

$$X = Y \text{ OR } Z \quad : \quad X = Y \cup Z$$

$$X = Y \text{ AND } Z \quad : \quad X = Y \cap Z$$

(2)Parameters in FT data

1) Data Block of Title ($TITLE)

<Parameters>

Title of the FT data can be given.

The user can give an adequate name that shows contents of the data.

<Format>

"$TITLE" is given in the first line of the FT data and a title is given in the next line with the following format:

(A80)

2) Data Block of Fault Tree ($FT)

<Parameters>

The sets of parameters from (a) to (d) are repeated for building a FT.

(a) Description for top event or intermediate event

The user can give an adequate description of the event.

Blank is available if no description is necessary.

(b) Name of top event or intermediate event

(c) Gate type

Select OR or AND.

(d)Lower intermediate name or basic event name

<Format>

The sets of parameters from (a) to (d) are repeated for each top event or intermediate event with the following format after "$FT". (d) can not be given more than 4 in one line. (d) from 5th to 8th must be given in the next line with (a), (b), and (c) left blank. Maximum number of (d) is 8 for each (b).

(A24,2X,A8,2X,A4,2X,4(A8,2X))

Table 3.6 shows a sample of FT data based on the Figure 3.1

Table 3. 6 Sample of FT Data

```
$TITLE
SAMPLE FT DATA FOR SECOM2-DQFM MANUAL
$FT
                        LOSPIT    AND   RHR        LOSP
                        RHR       AND   RHRA       RHRB
                        RHRA      OR    KPUMPA1    KMOVA12   KHXA      KINRHRA
                        RHRB      OR    KPUMPB1    KMOVB11   KHXB      KINRHRB
```

3.6 SETCOR Data

Correlation coefficients are given in SETCOR data. 1.0 is given for a fully correlated basic event group. Correlation coefficients can be given by the user between groups. Parameters which can be made to be correlated are realistic response and capacity.

(1)Structure of SETCOR Data

SETCOR data consists of the following 3 kinds of data blocks which begin with data lines with "$".

1) Data Block of Title ($TITLE)
2) Data Block of Groups in Which Responses are Fully Correlated ($SCORSET)
3) Data Block of Groups in Which Capacities are Fully Correlated ($CCORSET)
4) Data Block of Response Correlation Coefficients between Groups ($RCORFAC)
5) Data Block of Capacity Correlation Coefficients between Groups ($CCORFAC)

1) can be omitted. 2) and 3) can be specified up to 30 groups by repeating the data block. The sets of two groups and correlation coefficient between two groups are repeated in a data block 4) or 5).

(2)Parameters in SETCOR Data

1) Data Block of Title ($TITLE)

<Parameters>

Title of the SETCOR data can be given.

The user can give an adequate name that shows contents of the data.

<Format>

"$TITLE" is given in the first line of the SETCOR data and a title is given in the next line with the following format:

(A80)

2) Data Block of Groups in Which Responses are Fully Correlated ($SCORSET)

<Parameters>

(a)Group name : SCRGRP

(b)Basic event names whose responses are fully correlated in the group: SCORCOM

<Formats>

(a) is given in the next line of "$SCORSET" with the following format:

(A8)

(b) is given with the following format. The maximum number of basic events is 8 in 1 line, more basic events are continued in the next line.

(8(A8,2X))

3) Data Block of Groups in Which Capacities are Fully Correlated ($CCORSET)

<Parameters>

(a) Group name: SCRGRP

(b) Basic event names whose capacities are fully correlated in the group: SCORCOM

<Format>

(a) is given in the next line of "$CCORSET" with the following format:

(A8)

(b) is given with the following format. The maximum number of basic events is 8 in 1 line, more basic events are given in the next line.

(8(A8,2X))

4) Data Block of Response Correlation Coefficients between Groups ($RCORFAC)

<Parameters>

(a)The first group name: SCRGP1

(b)The second group name: SCRGP2

(c)Response correlation coefficient between group (a) and (b): RGPFAC

<Format>

The set of (a),(b), and (c) are repeated after the next line of "$RCORFAC" with the following format. Only one correlation coefficient can be given in one line.

(2(A8,2X),F8.0)

5) Data Block of Capacity Correlation Coefficients between Groups ($CCORFAC)

<Parameters>

(a) The first group name: SCRGP1

(b) The second group name: SCRGP2

(c) Capacity correlation coefficient between group (a) and (b): RGPFAC

<Format>

The set of (a),(b), and (c) are repeated after the next line of "$CCORFAC" with the following format. Only one correlation coefficient can be given in one line.

(2(A8,2X),F8.0)

A sample of SETCOR data is shown in Table 3.7.

Table 3. 7 Sample of SETCOR Data

```
$SCORSET
RCORR012
KMOVA12    KMOVB11
$SCORSET
RCORR021
KHXA       KHXB
$SCORSET
RCORR024
KPUMPA1    KPUMPB1
$SCORSET
RCORR025
LOSP
$RCORFAC
RCORR012   RCORR021      0.75
RCORR012   RCORR024      0.75
RCORR021   RCORR024      0.75
```

Table 3.7 shows the correlation relationships between 6 components shown in Figure 3.1. Responses between the same kind of components are fully correlated, and 0.75 are set to different kinds of components in the sample.

NOTE:

Cholesky decomposition is not always available for some given correlation coefficients. For example, the following case is not realistic: one correlation coefficient is given as 1.0 between component A and B, the other is given as 1.0 between B and C, and another is given as 0.0 between A and C. In this case, Cholesky decomposition can not be performed. The user should examine correlation coefficients again in such conditions.

3.7 MONSET Data

MONSET data is required when the user considers correlations by applying the same random variable to response subfactors or capacities. The same random variable can be applied to five parameters, capacity and response subfactors from F1 to F4.

SECOM2-DQFM has one more feature: inverse calculation of correlation coefficients by sampling random variables. The specification for this feature can be also given in MONSET data.

(1) Structure of MONSET Data

MONSET data consists of the following 3 kinds of data blocks which begin with data lines with "$".

1) Data block of correlation using the same random variable ($CORRELATION)
2) Data block of inverse calculation of capacity correlation coefficients ($CAPCCAL)
3) Data block of inverse calculation of response correlation coefficients ($RESCCAL)

All 3 kinds of data blocks can be given once or more in one MONSET data. Data block 1) is not necessary if correlation is not considered applying the same random variable. Data block 2) and 3) are not necessary if inverse calculation of correlation coefficients is not required by the user.

(2) Parameters in MONSET Data

1) Data block of correlation using the same random variable ($CORRELATION)

<Parameters>

(a) Group name in which the same random variable is applied: CRGPNM1

(b) Flag to specify a parameter: ICORFLG

ICORFLG=1: Apply the same random variable to capacity
=2: Apply the same random variable to response subfactor F1
=3: Apply the same random variable to response subfactor F2
=4: Apply the same random variable to response subfactor F3
=5: Apply the same random variable to response subfactor F4

(c) Basic event name in group CRGPNM1: CCOMPN

<Formats>

The set of (a) and (b) is given in the next line of "$CORRELATION" with the following format:

(A8,2X,I2)

(c) are given with the following format. The maximum number of basic events is 8 in 1 line, more basic events are given in the next line.
(8(A8,2X))

2) Data block of inverse calculation of capacity correlation coefficients ($CAPCCAL)
<Parameters>
(a) Group name for inverse calculation of capacity correlation coefficient: CGNAME
(b) Basic event name in group CGNAME: CRFNM1

<Formats>
(a) is given in the next line of "$CAPCCAL" with the following format:
(A8)

(b) are given with the following format. The maximum number of basic events is 8 in 1 line, more basic events are given in the next line.
(8(A8,2X))

3) Data block of inverse calculation of response correlation coefficients ($RESCCAL)
<Parameters>
(a) Group name for inverse calculation of response correlation coefficient: CGNAME
(b) Basic event name in group CGNAME: CRFNM1

<Formats>
(a) is given in the next line of "$RESCCAL" with the following format:
(A8)

(b) are given with the following format. The maximum number of basic events is 8 in 1 line, more basic events are given in the next line.
(8(A8,2X))

A sample of MONSET data is shown in Table 3.8.

Table 3. 8 Sample of MONSET Data

```
$CORRELATION
CORF1      2
KHXA       KHXB       KPUMPA1    KPUMPB1    KMOVA12    KMOVB11    LOSP
```

Table 3.8 is an example in which a partial correlation relationship is considered between component failures shown in Figure 3.1, by applying the same random variable to response

subfactor F1.

3.8 SEQDATA Data

The event tree defining accident sequences is given in SEQDATA data. Conditional probabilities of containment failure and source term release quantities can also be given for accident sequence analysis and importance analysis.

(1) Parameters in SEQDATA Data

The following 2), 3), and 4) can be omitted from SEQDATA data if they are not necessary.

<Parameters>

1) Parameters defining accident sequences

(a) Position of top event in FT: IOUT

The order from the beginning of FT data is specified.

(b) Number of headings in ET: NSYS

(c) Name of heading: SNAM

(d) Number of accident sequences: NTAC

The set of parameters from (e) to (h) is repeated NTAC times.

(e) Name of accident sequence: ACNAM

(f) Number of branches in ACNAM: NISEQ

The set of (g) and (h) is repeated NISEQ times.

(g) Heading name of the branch: CANAM

(h) Branching condition at CANAM: ISEQ

ISEQ=0: Occur

=1: Not occur

2) Parameters defining accident sequence groups

(i) Number of accident sequence groups: NGROUP

(j) Accident sequence group name: GROUP

(k) Number of accident sequence included in GROUP: NGRPIN

(l) Accident sequence name included in GROUP: GRPSEQ

3) Parameters for conditional probabilities of containment failure

(m) Flag for conditional probabilities of containment failure: NTAC2

NTAC2=0: Conditional probabilities of containment failure are not given.

=NTAC: Use conditional probabilities of containment failure

(n) Number of containment failure mode: NCCVFP

(o) Conditional probability of containment failure: CCVFP

4) Parameters for source term release quantities

(p) Flag for source term release quantities: NTAC3

NTAC3=0 : Source term release quantities are not given

=NTAC: Use source term release quantities

(q) Number of containment failure mode: NSTERM

(r) Source term release quantity: STERM

<Format>

Character variables are enclosed by single quotes " ' " in SEQDATA data. Two or more variables in the same line are divided with commas " , " between variables.

1) Parameters defining accident sequences

(a) is given by integer in the first line.

(b) is given by integer in the second line.

(c) is repeated in the third line as many as the number specified at (b).

(d) is given by integer in the fourth line.

(e), (f), and the sets of (g) and (h) repeated as many as the number specified at (f) are given after the fifth line. It means that one accident sequence is given in one line.

2) Parameters defining accident sequence groups

(i) is given in the next line of 1).

The sets of (j), (k), and (l) is given after the next line of (i). It means that one accident sequence group is given in one line. (l) is repeated as many as the number specified at (k).

3) Parameters for conditional probabilities of containment failure

(m) is given in the next line of 2).

The sets of (n) and (o) is given after the next line of (i). It means that conditional probabilities for one accident sequence are given in one line. (o) is repeated as many as the number specified at (n).

4) Parameters for source term release quantities

(p) is given in the next line of 3).

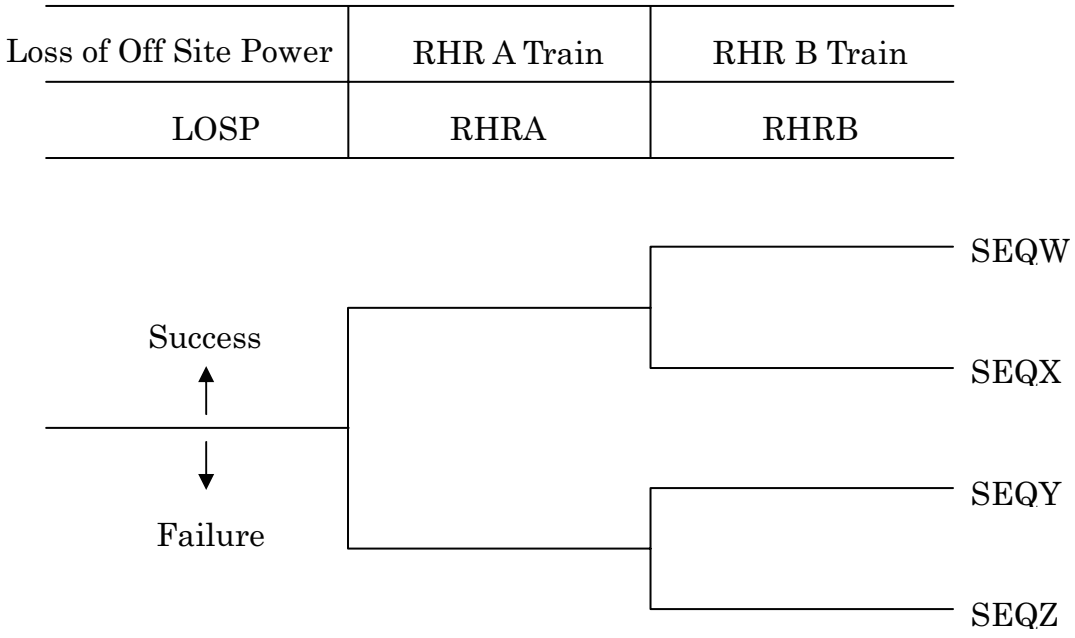
The sets of (q) and (r) is given after the next line of (i). It means that release quantities for one accident sequence are given in one line. (r) is repeated as many as the number specified at (q).

Table 3.9 shows a sample of SEQDATA based on ET shown in Fig. 3.2. Text after the

character "/" in Table 3.9 are comments and they are not necessary for the code.

Table 3. 9 Sample of SEQDATA Data

```
1/GATE-NUMBER
2/ANALYZING-SYSTEM
'LOSP','RHRA','RHRB'
4/SEQUENCE-NUMBER
'SEQW',3,'LOSP',0,'RHRA',1,'RHRB',1
'SEQX',3,'LOSP',0,'RHRA',1,'RHRB',0
'SEQY',3,'LOSP',0,'RHRA',0,'RHRB',1
'SEQZ',3,'LOSP',0,'RHRA',0,'RHRB',0
2/SEQUENCE-GROUP
'NOCD',3,'SEQW','SEQX','SEQY'
'CD',1,'SEQZ'
4/CONDITIONAL-CV-FAIL-PROB
1,0.5
1,0.5
1,0.5
1,0.5
4/SOURCE-TERM-RELEASE-FRACTION
1,0.5
1,0.5
1,0.5
1,0.5
```



Note : Only SEQZ results core damage accident

Fig. 3. 2 Example of an Event Tree

3.9 CMPSLCT Data

Information of basic events which are specified for importance analysis is included in CMPSLCT data. Individual basic events or groups of basic events can be specified as targets for importance analysis. The user can select either one of the five importance measures: FV, RAW, RRW, RR, and RA.

(1)Parameters in CMPSLCT data

<Parameters>

1) Position of top event in FT: IOUT

The position of the event in the FT model is specified.

2) Flag to select importance measure: IKIN

IKIN=1: Select RAW

=2: Select FV

=3: Select RRW

=4: Select RA

=5: Select RR

3)Number of basic event groups: ISNU

4)Number of basic events in the group: NCIM

5)Basic event name: COMIN

<Format>

Character variables are enclosed by single quotes " ' " in CMPSLCT data. Two or more variables in the same line are divided with commas " , " between variables.

1) is given with integer in the first line.

2) is given with integer in the second line.

3) is given with integer in the third line.

The sets of 4) and 5) are given after the next line of 3). It means that basic events in one group are given in one line. 5) is repeated as many as the numbers specified at 4).

A sample of CMPSLCT data is shown in Table 3.10. In this sample the measure FV is calculated for seven basic events.

Table 3. 10 Sample of CMPSLCT data

```
1
2
7
1,'KMOVA12'
1,'KMOVB11'
1,'KHXA'
1,'KHXB'
1,'KPUMPA1'
1,'KPUMPB1'
1,'LOSP'
```

4. NAMELIST Format Inputs

4.1 Introduction

Input data in which seismic PSA model is represented includes basic events, their information necessary for calculating their occurrence probabilities, fault tree, event tree, correlation coefficients of responses and capacities, calculation conditions, etc. The whole model can be given with NAMELIST format input. The input format is shown in this chapter.

4.1.1 General Form of NAMELIST Format

NAMELIST format input consists of the following 4 elements:

(1) Variable group name
(2) Variable name
(3) Parameter
(4) Comment

A variable is defined by a combination of a variable name and its parameter(s). One or more variables are included in a variable group. The whole NAMELIST format input data includes several variable groups shown in this chapter. Comments can be placed optionally in NAMELIST format input data.

An equal sign must be given between a variable name and a parameter as follows:

VARIABLENAME = PARAMETER

Two or more parameters in a variable array can be given from the i^{th} parameter with the following way:

VARIABLENAME(i) = i^{th} PARAMETER, $i+1^{th}$ PARAMETER, $i+2^{th}$ PARAMETER

Two or more variables can be given in one line by placing blanks or commas between variables.

An ampersand "&" with a variable group name (e.g. "&GROUP") is a sign of the beginning of the variable group. An end of variable group can be given with a slash mark "/" or "&END". Variables in a group can be defined between the beginning and the end, and given an arbitrary order. If the user gives a variable twice or more with different parameters, the last one becomes active.

Order of variable groups must be the same as the orders given in the following sections. In

addition, any variable groups can not be skipped.

An exclamation mark "!" means the beginning of a comment. Comments can be inserted optionally unless a combination of a variable name and parameter(s) is divided. Characters between "!" and the end of the line are counted as a comment.

The rules mentioned above are just an abstract of NAMELIST format inputs for explaining how to make inputs with this manual. Details of NAMELIST format can be seen in the following sections.

4.1.2 NAMELIST Format Data Input for SECOM2-DQFM

The following descriptions about NAMELIST format input for SECOM2-DQFM are divided into several sections for every variable group. In each section all of the variables in a variable group are shown. Format information of variables is given with single characters such as: I is a integer type, R is a real type, and A is a character type.

SECOM2-DQFM requires only one input file for each calculation using NAMELIST format at this stage. It is possible that SECOM2-DQFM may require additional files (e.g. minimal cut set files) in the future.

An input file name must be "INPUT", and an output file name is fixed to "OUTPUT". Necessary variable groups for calculations are shown from Section.4.2 to Section 4.10. Variable groups from Section 4.11 to Section 4.18 are optional. The user can skip the contents of variable groups but the start sign and the end signs (i.e. &GROUP and &END) if the contents are not necessary for the calculation case.

4.2 Calculation Title (Variable group name: CNTLTITLE)

The user can give an adequate name that means the calculation case or date of the calculation to specify the calculation case later. This calculation title can be a mark in output list because it is redirected to output list.

(Variable Name)	(Format)	(Parameter)
CTITLE	A80	Calculation Title

4.3 Calculation Control Flags (Variable group name: CNTLFLG)

Calculation Control Flags are given for selection of analysis options and output options available in SECOM2-DQFM.

(Variable Name)	(Format)	(Parameter)
ICRFLG	I	Correlation analysis flag =0, No correlation is considered. =1, Correlation considered by assigning the same value to a response subfactors or capacity of different components. (Use SAMERND and CORCTBK) =2, Correlation considered by assigning a correlation coefficient to different component directly (Use LOHDATA, SAMERND, and CORCTBK)
IMTSEQ	I	Accident sequence analysis flag =0, No accident sequence analysis =1, Accident sequence analysis is done. (Use ETDATA and SEQGRP)
IMTIMP	I	Importance analysis flag =0, No importance analysis =1, Importance analysis is done (Use IMPDATA)
IFLGLTN	I	Flag for selecting Monte Carlo / LHS =0, Use Monte Carlo method =1, Use LHS method (Correlation analysis is unavailable.)
IINP1	I	Flag to activate output option for basic event information =0, No output =1, Activate output option
IINP2	I	Flag to activate output option FT data =0, No output =1, Write it on output file
IINP3	I	Flag to activate output option for correlation information =0, No output =1, Activate output option

IINP4	I	Flag to activate output option for seismic hazard =0, No output =1, Activate output option
IOUP1	I	Flag to activate checking output option for basic event names =0, No output =1, Activate output option
IOUP2	I	Flag to activate checking output option for correlation coefficients =0, No output =1, Activate output option
IOUP3	I	Flag to activate checking output option for conditional occurrence probabilities of basic events and intermediate events =0, No output =1, Activate output option

4.4 Event Names for Which Conditional Occurrence Probabilities Are Calculated : (Variable group name: CNTLCGOUT)

Basic event names and intermediate event names are given if the conditional occurrence probabilities of these events are required by the user. The names must be the same as the names given in FT data. Allowed maximum number of events is 30.

(Variable Name)	(Format)	(Parameter)
MCGOUP	I	Number of Events
CGOUNM(I)	I	Basic event name or intermediate event name

4.5 Calculation Condition (Variable group name : CNTLCOND)

Calculation condition in SECOM2-DQFM consists of design basis seismic motion and number of iteration.

(Variable Name)	(Format)	(Parameter)
BADS	R	Design basis seismic motion (in the Gal)
IREPR	I	Number of iteration

4.6 Seismic Motion Levels for Analysis (Variable group name: CNTLSLVL)

Conditional occurrence probabilities of events are calculated at seismic motion levels specified in this variable group. Seismic motion means maximum acceleration induced by an earthquake. Gal is assumed to be given as the unit for seismic motion levels. 980Gal is equal to the gravity acceleration, 1G.

(Variable Name)	(Format)	(Parameter)
NOFSLV	I	Number of seismic motion levels for analysis
SEISML(I)	R	Seismic motion level for analysis (in the Gal)

4.7 Seismic Hazard (Variable group name: HAZARD)

A seismic hazard curve is given as the unit of excessive occurrence frequency or occurrence frequency per Gal in this variable group.

(Variable Name)	(Format)	(Parameter)
ITYPHZD	I	Unit of seismic hazard =0, Excessive occurrence frequency =1, Occurrence frequency per Gal
ISLVL	I	Number of data points
SLVL(I)	R	Seismic motion level (in the Gal)
HAZD(I)	R	Excessive occurrence frequency or occurrence frequency per Gal

4.8 Fault Tree (Variable group name: FTDATA)

Fault Tree for PSA model is given in variable group FTDATA. SECOM2-DQFM is available for modeling up to 400 basic events in FT. Integrated Fault Tree in which top event is core damage is assumed to be given to SECOM2-DQFM. It means that GTNAME(1), the first variable in intermediate event name array, must be top event. Number of characters for events is up to 8.

(Variable Name)	(Format)	(Parameter)
MGATE	I	Number of intermediate events
GTNAME(I)	A8	Intermediate event name
GTTYPE(I)	A4	Gate type (AND or OR)
NIN(I)	I	Number of lower intermediate events or basic events under GTNAME(I)
INNAME(J,I)	A8	the J^{th} Lower intermediate event name or basic event name under GTNAME(I)

4.9 Basic Event Reference Information (Variable group name: BEREF)

Variable group BEREF gives links between basic events in FT and basic event information shown in Section 4.10. Basic events which are not defined in FT can be specified in this group, but they are not used for analysis.

(Variable Name)	(Format)	(Parameter)
NTCOMP	I	Number of basic events
KNAME3(I)	A8	Basic event name
IKNAME3(I)	I	Ordinal number of KNAME3(I) in variable group BEDATA shown in Section 4.10

4.10 Basic Event Information (Variable group name: BEDATA)

Variable group BEDATA includes information sets which are necessary to calculate conditional occurrence probabilities of all basic events. The basic events consist of seismic failure events, random failure events, etc.

Information sets for basic events depend on the basic event types, ICAPFLG.

(Variable Name)	(Format)	(Parameter)
KTCOMP	I	Number of basic event information sets

<<In the case of ICAPFLG = 1, 2, or 3 : for basic events of seismic failures >>

KNAMED(I)	I	Basic event information set name (Only for output for check, not used in calculation) It means Basic event name using combination of abbreviated names in SECOM2 format input.
ICAPFLG(I)	I	Basic event type, 1, 2, or 3 can be specified (There is no difference between 1, 2, and 3 in NAMELIST format input)
DESRES(I)	R	Design response in Gal
CMEDI(I)	R	Median of capacity
CRAND(I)	R	Uncertainty due to randomness of capacity
CUNCE(I)	R	Uncertainty due to lack of knowledge of capacity
RMEDI1(J,I)	R	Median response subfactor F1 at the J^{th} seismic motion level
RRAND1(J,I)	R	Uncertainty due to randomness of F1 at the J^{th}

		seismic motion level
RUNCE1(J,I)	R	Uncertainty due to lack of knowledge of F1 at the J^{th} seismic motion level
RMEDI2(J,I)	R	Median response subfactor F2 at the J^{th} seismic motion level
RRAND2(J,I)	R	Uncertainty due to randomness of F2 at the J^{th} seismic motion level
RUNCE2(J,I)	R	Uncertainty due to lack of knowledge of F2 at the J^{th} seismic motion level
RMEDI3(J,I)	R	Median response subfactor F3 at the J^{th} seismic motion level
RRAND3(J,I)	R	Uncertainty due to randomness of F3 at the J^{th} seismic motion level
RUNCE3(J,I)	R	Uncertainty due to lack of knowledge of F3 at the J^{th} seismic motion level
RMEDI4(J,I)	R	Median response subfactor F4 at the J^{th} seismic motion level
RRAND4(J,I)	R	Uncertainty due to randomness of F4 at the J^{th} seismic motion level
RUNCE4(J,I)	R	Uncertainty due to lack of knowledge of F4 at the J^{th} seismic motion level

Note:

Response subfactors can not be changed for all of seismic motion levels at this stage when NAMELIST format input is used. It means that response factor table or response subfactor table in SECOM2 format input is not available in NAMELIST format input. Response subfactor at first seismic motion level (J=1) is always applied to all of seismic level in NAMELIST format input.

<<In the case of ICAPFLG = 4: for basic events of random failures >>

KNAMED(I)	I	Basic event information set name (Only for output for check, not used in calculation) Basic event name using combination of abbreviated names in SECOM2 format input
ICAPFLG(I)	I	Basic event type, 4 is specified in this case.
PROBIN(I)	R	Mean value of random failure probability
IRAND(I)	R	Uncertainty due to randomness of random failure probability

IUNCE(I)	R	Uncertainty due to lack of knowledge of random failure probability

<<In the case of ICAPFLG = 5: for basic events using step probability function or ramp probability function >>

KNAMED(I)	I	Basic event information set name (Only for output for check, not used in calculation) Basic event name using combination of abbreviated names in SECOM2 format input
ICAPFLG(I)	I	Basic event type, 5 is specified in this case.
MLEV(I)	I	Number of data points, it must be 2 in this case.
SLEVEL(J,I)	R	J=1: Seismic motion level at the beginning of probability increase for ramp and step function (in the Gal) J=2: Seismic motion level at the end of probability increase for ramp function (in the Gal, 0.0 for step function)
DIPRBE(J,I)	R	J=1: Probability before the increase of step (ramp) function J=2: Probability at the end of the increase of step (ramp) function.

<<In the case of ICAPFLG = 6: for basic events using probability table >>

KNAMED(I)	I	Basic event information set name (Only used for check, not used in calculation) Basic event name using combination of abbreviated names in SECOM2 format input
ICAPFLG(I)	I	Basic event type, 6 is specified in this case.
MLEV(I)	I	Number of data points in probability table.
SLEVEL(J,I)	R	Seismic motion level at which DIPRBE(J,I) is applied (in Gal)
DIPRBE(J,I)	R	Conditional occurrence probability of basic event

4.11 Correlations Considered by Specifying the Same Random Variables (Variable group name : SAMERND)

Variable group SAMERND is required when the user needs to consider correlation by applying the same random variable to response subfactors, etc. The same random variable can be applied to five parameters, capacity and response subfactors from F1 to F4.

(Variable Name)	(Format)	(Parameter)
NUMCG	I	Number of correlation groups
CRGPNM1(I)	A8	Correlation group name
ICORFLG(I)	I	Flag selecting a parameter applied the same random variable =1, Apply the same random variable to capacity =2, Apply the same random variable to response subfactor F1 =3, Apply the same random variable to response subfactor F2 =4, Apply the same random variable to response subfactor F3 =5, Apply the same random variable to response subfactor F4
NUMC(I)	I	Number of basic events in the I^{th} correlation group
CCOMPN(J,I)	A8	the I^{th} Basic event name in the I^{th} correlation group

4.12 Specification for Inverse Calculation of Correlation Coefficients (Variable group name: CORCTBK)

Variable group CORCTBK is for inverse calculation of correlation coefficients. The user can check correlation coefficients of responses and capacities by grouping basic events when variable group SAMERND is used.

(Variable Name)	(Format)	(Parameter)
CFGNUM	I	Number of groups for inverse calculation
IGCAL(I)	I	Flag selecting a parameter =1 Calculate response correlation coefficient =2 Calculate capacity correlation coefficient
CGNAME(I)	A8	the I^{th} Group name
IGNUM(I)	I	Number of basic events in the I^{th} group
CRFNM1(J,I)	A8	the J^{th} Basic event name in the I^{th} group

4.13 Correlation Coefficients (Variable group name: LOHDATA)

Basic events which are fully correlated are grouped, and then correlation coefficients between groups are given by the user in the variable group LOHDATA. Correlation can be considered for response or capacity, or both response and capacity.

Variables with I=1 are for responses, variables with I=2 are for capacities in the following description.

(Variable Name)	(Format)	(Parameter)
ISCRG(I)	I	Number of correlation group
SCRGRP(J,I)	A8	Correlation group name
ISCRGC(J,I)	I	Number of basic events in J^{th} correlation group
SCRCOM(K,J,I)	A8	Basic event name in the I^{th} correlation group
ISCR(I)	I	Number of give correlation coefficients
SCRGP1(L,I)	A8	1st correlation group name
SCRGP2(L,I)	A8	2nd correlation group name
RGPFAC(L,I)	R	Correlation coefficient between SCRGP1(L,I) and SCRGP2(L,I)

4.14. Event Tree (Variable group name: ETDATA)

Event Tree defining accident sequences is given in SEQDATA data. It is not necessary to define event tree when accident sequence analysis is not required. Headings in ET are specified with the same names as events in FT. Branching conditions such as success or failure are also specified at headings of all accident sequences. Notice that the specifications of the branching condition in ETDATA because they are opposite from general codes. In ETDATA data file, Success=1and Failure =0.

(Variable Name)	(Format)	(Parameter)
NSYS	I	Number of headings in ET
SNAM(I)	A8	the I^{th} heading name
NTAC	I	Number of accident sequences
ACNAM(I)	A8	the I^{th} accident sequence name
NISEQ(I)	I	Number of branches in ACNAM(I)
CANAM(J,I)	A8	Heading name at the J^{th} branch in ACNAM(I)
ISEQ(J,I)	I	Branching condition at CANAM(J,I) =0, Failure =1, Success

4.15 Grouping of Accident Sequence (Variable group name: SEQGRP)

Accident sequences defined in variable group ETDATA can be grouped when subtotals of conditional occurrence probabilities and occurrence frequencies are required by the user.

(Variable Name)	(Format)	(Parameter)
NGROUP	I	Number of accident sequence groups
GROUP(I)	A8	the I^{th} accident sequence group name
NGRPIN(I)	I	Number of accident sequences in GROUP(I)
GRPSEQ(J,I)	A8	the J^{th} accident sequence name in GROUP(I)

4.16 Conditional Probabilities of Containment Failure (Variable group name: NLCCVFP)

Conditional probabilities of containment failure are given for all accident sequences and containment failure modes when occurrence frequencies of accident sequence are necessary to be weighted.

(Variable Name)	(Format)	(Parameter)
NTAC2	I	Flag to use conditional probabilities of containment failure =0, Do not use conditional probabilities of containment failure =NTAC, Use conditional probabilities of containment failure
NCCVFP(I)	I	Number of containment failure modes in Ith accident sequence
CCVFP(J,I)	R	Conditional probability at the J^{th} containment failure mode in the I^{th} accident sequence

4.17 Source Term Release Quantities (Variable group name: NLSTERM)

Source term release quantities are given for all accident sequences and containment failure modes when occurrence frequencies of accident sequence need to be weighted.

(Variable Name)	(Format)	(Parameter)
NTAC3	I	Flag to use source term release quantities =0, Do not use source term release quantities =NTAC, Use source term release quantities
NSTERM(I)	I	Number of containment failure modes in the I^{th} accident sequence
STERM(J,I)	R	Source term release quantity at the J^{th} containment failure mode in the I^{th} accident sequence

4.18 Specifications of Calculation Target and Importance Measures (Variable group name: IMPDATA)

Which basic events and which measures are used for importance analysis can be specified in the variable group IMPDATA. Individual basic events or groups of basic events can be specified as targets of importance analysis. The user can select one of the five importance measure: FV, RAW, RRW, RR, and RA.

(Variable Name)	(Format)	(Parameter)
IOUT	I	Ordinal number of top event from the beginning of FT
IKIN	I	Flag to select importance measure

=1, RAW
=2, FV
=3, RRW

ISNU	I	Number of basic event groups
NCIM(I)	I	Number of basic events in I^{th} group
COMIN(J,I)	I	Basic event name in I^{th} group

4.19 Sample of NAMELIST Format Input

Table 4.1 shows a sample of NAMELIST format input that is equivalent to SECOM2 format input files shown in Chapter 3.

Table 4. 1 Sample of Namelist format input data(1/4)

```
&CNTLTITLE
CTITLE      =   'SAMPLE CONTROL DATA FOR SECOM2-DQFM CODE                                                    '
&END
&CNTLFLG
ICRFLG          =          2
IMNTSEQ     =   1
IMNTIMP     =   1
IFLGLTN     =   0
IINP1       =   1
IINP2       =   1
IINP3       =   1
IINP4       =   1
IOUP1       =   1
IOUP2       =   1
IOUP3       =   1
&END
&CNTLCGOUT
MCGOUP      =   0
CGOUNM      =
&END
&CNTLCOND
BADS        =   180.000
IREPR       =   100000
&END
&CNTLSLVL
NOFSLV      =   67
SEISML      =     30.000   60.000   90.000  120.000  150.000  180.000  210.000  240.000  270.000  300.000
            330.000  360.000  390.000  420.000  450.000  480.000  510.000  540.000  570.000  600.000
            630.000  660.000  690.000  720.000  750.000  780.000  810.000  840.000  870.000  900.000
            930.000  960.000  990.000 1020.000 1050.000 1080.000 1110.000 1140.000 1170.000 1200.000
           1230.000 1260.000 1290.000 1320.000 1350.000 1380.000 1410.000 1440.000 1470.000 1500.000
           1530.000 1560.000 1590.000 1620.000 1650.000 1680.000 1710.000 1740.000 1770.000 1800.000
           1830.000 1860.000 1890.000 1920.000 1950.000 1980.000 2010.000
&END
&HAZARD
IHAZTYP     =   0
ISLVL       =   76
SLVL        =      0.000    30.000    60.000    90.000   120.000   150.000   180.000   210.000   240.000   270.000
            300.000   330.000   360.000   390.000   420.000   450.000   480.000   510.000   540.000   570.000
            600.000   630.000   660.000   690.000   720.000   750.000   780.000   810.000   840.000   870.000
            900.000   930.000   960.000   990.000  1020.000  1050.000  1080.000  1110.000  1140.000  1170.000
           1200.000  1230.000  1260.000  1290.000  1320.000  1350.000  1380.000  1410.000  1440.000  1470.000
           1500.000  1530.000  1560.000  1590.000  1620.000  1650.000  1680.000  1710.000  1740.000  1770.000
           1800.000  1830.000  1860.000  1890.000  1920.000  1950.000  1980.000  2010.000  2040.000  2070.000
           2100.000  2130.000  2160.000  2190.000  2220.000  2250.000
```

Table 4.1 Sample of Namelist format input data(2/4)

```
HAZD      =   5.174E-01 1.546E-01 3.784E-02 1.560E-02 8.060E-03 4.679E-03 2.917E-03 1.910E-03 1.295E-03 9.016E-04
              6.409E-04 4.632E-04 3.395E-04 2.518E-04 1.887E-04 1.427E-04 1.087E-04 8.352E-05 6.458E-05 5.025E-05
              3.933E-05 3.095E-05 2.448E-05 1.946E-05 1.554E-05 1.246E-05 1.004E-05 8.114E-06 6.585E-06 5.363E-06
              4.383E-06 3.594E-06 2.957E-06 2.440E-06 2.019E-06 1.676E-06 1.394E-06 1.163E-06 9.732E-07 8.161E-07
              6.860E-07 5.779E-07 4.880E-07 4.130E-07 3.502E-07 2.976E-07 2.534E-07 2.161E-07 1.847E-07 1.581E-07
              1.356E-07 1.165E-07 1.003E-07 8.647E-08 7.466E-08 6.456E-08 5.591E-08 4.850E-08 4.212E-08 3.664E-08
              3.191E-08 2.784E-08 2.431E-08 2.126E-08 1.861E-08 1.632E-08 1.432E-08 1.258E-08 1.107E-08 9.750E-09
              8.597E-09 7.588E-09 6.705E-09 5.930E-09 5.251E-09 4.654E-09
&END
&FTDATA
MGATE=  4
GTNAME( 1)   =   LOSPIT    GTTYPE( 1)=AND   NIN( 1)= 2 INNAME(1, 1)=RHR         LOSP
GTNAME( 2)   =   RHR       GTTYPE( 2)=AND   NIN( 2)= 2 INNAME(1, 2)=RHRA        RHRB
GTNAME( 3)   =   RHRA      GTTYPE( 3)=OR    NIN( 3)= 4 INNAME(1, 3)=KPUMPA1   KMOVA12   KHXA       KINRHRA
GTNAME( 4)   =   RHRB      GTTYPE( 4)=OR    NIN( 4)= 4 INNAME(1, 4)=KPUMPB1   KMOVB11   KHXB       KINRHRB
&END
&BEREF
NTCOMP       =  9
KNAME3(  1)  =  LOSP       IKNAME3(  1)=  1
KNAME3(  2)  =  KHXA       IKNAME3(  2)=  2
KNAME3(  3)  =  KHXB       IKNAME3(  3)=  2
KNAME3(  4)  =  KPUMPA1    IKNAME3(  4)=  3
KNAME3(  5)  =  KPUMPB1    IKNAME3(  5)=  3
KNAME3(  6)  =  KMOVA12    IKNAME3(  6)=  4
KNAME3(  7)  =  KMOVB11    IKNAME3(  7)=  4
KNAME3(  8)  =  KINRHRA    IKNAME3(  8)=  5
KNAME3(  9)  =  KINRHRB    IKNAME3(  9)=  6
&END
&BEDATA
KTCOMP=  6
KNAMED(      1)=LSPA4G1F   ICAPFLG(      1)=      2   DESRES(      1)=2.200000E+02   CMEDI(      1)=6.500000E+02   CRAND(      1)=2.500000E-01
CUNCE(  1)=2.500000E-01
RMEDI1(1,   1)=9.360000E-01 RRAND1(1,   1)=1.250000E-01 RUNCE1(1,   1)=0.000000E+00
RMEDI2(1,   1)=9.888000E-01 RRAND2(1,   1)=0.000000E+00 RUNCE2(1,   1)=5.147815E-01
RMEDI3(1,   1)=1.000000E+00 RRAND3(1,   1)=0.000000E+00 RUNCE3(1,   1)=0.000000E+00
RMEDI4(1,   1)=1.000000E+00 RRAND4(1,   1)=0.000000E+00 RUNCE4(1,   1)=0.000000E+00
KNAMED(      2)=RHXD4MB1   ICAPFLG(      2)=      1   DESRES(      2)=1.292849E+02   CMEDI(      2)=2.638000E+03   CRAND(      2)=2.000000E-01
CUNCE(  2)=3.500000E-01
RMEDI1(1,   2)=9.360000E-01 RRAND1(1,   2)=1.250000E-01 RUNCE1(1,   2)=0.000000E+00
RMEDI2(1,   2)=1.000000E+00 RRAND2(1,   2)=0.000000E+00 RUNCE2(1,   2)=5.147815E-01
RMEDI3(1,   2)=8.989000E-01 RRAND3(1,   2)=0.000000E+00 RUNCE3(1,   2)=2.202272E-01
RMEDI4(1,   2)=1.000000E+00 RRAND4(1,   2)=0.000000E+00 RUNCE4(1,   2)=0.000000E+00
KNAMED(      3)=RPPD4MB2   ICAPFLG(      3)=      1   DESRES(      3)=1.243550E+02   CMEDI(      3)=2.225000E+03   CRAND(      3)=2.200000E-01
CUNCE(  3)=3.200000E-01
RMEDI1(1,   3)=9.360000E-01 RRAND1(1,   3)=1.250000E-01 RUNCE1(1,   3)=0.000000E+00
RMEDI2(1,   3)=1.000000E+00 RRAND2(1,   3)=0.000000E+00 RUNCE2(1,   3)=5.147815E-01
```

Table 4.1 Sample of Namelist format input data(3/4)

```
RMEDI3(1,   3)=8.989000E-01 RRAND3(1,   3)=0.000000E+00 RUNCE3(1,   3)=2.202272E-01
RMEDI4(1,   3)=1.000000E+00 RRAND4(1,   3)=0.000000E+00 RUNCE4(1,   3)=0.000000E+00
KNAMED(      4)=MOVD4M6F   ICAPFLG(      4)=      1   DESRES(      4)=3.059922E+02   CMEDI(      4)=6.468000E+03   CRAND(      4)=2.600000E-01
CUNCE(   4)=6.000000E-01
RMEDI1(1,   4)=9.360000E-01 RRAND1(1,   4)=1.250000E-01 RUNCE1(1,   4)=0.000000E+00
RMEDI2(1,   4)=1.000000E+00 RRAND2(1,   4)=0.000000E+00 RUNCE2(1,   4)=5.147815E-01
RMEDI3(1,   4)=8.989000E-01 RRAND3(1,   4)=0.000000E+00 RUNCE3(1,   4)=2.202272E-01
RMEDI4(1,   4)=1.000000E+00 RRAND4(1,   4)=0.000000E+00 RUNCE4(1,   4)=0.000000E+00
KNAMED(   5)=INT-RHRA ICAPFLG(   5)=   4 PROBIN(   5)=1.100E-02 IRAND(   5)=2.500E-01 IUNCE(   5)=2.500E-01
KNAMED(   6)=INT-RHRB ICAPFLG(   6)=   4 PROBIN(   6)=1.100E-02 IRAND(   6)=2.300E-01 IUNCE(   6)=2.300E-01
&END
&SAMERND
NUMCG=   1
CRGPNM1( 1)  =   CORF1
ICORFLG( 1)  =   2
NUMC( 1)  =   7
CCOMPN(1, 1) =   KHXA      KHXB      KPUMPA1   KPUMPB1   KMOVA12   KMOVB11   LOSP
&END
&CORCTBK
CFGNUM       =   0
&END
&LOHDATA
ISCRG(1)   =   4
SCRGRP( 1,1)  =   RCORR012
ISCRGC( 1,1)  =   2
SCRCOM(1, 1,1)    =   KMOVA12   KMOVB11
SCRGRP( 2,1)  =   RCORR021
ISCRGC( 2,1)  =   2
SCRCOM(1, 2,1)    =   KHXA      KHXB
SCRGRP( 3,1)  =   RCORR024
ISCRGC( 3,1)  =   2
SCRCOM(1, 3,1)    =   KPUMPA1   KPUMPB1
SCRGRP( 4,1)  =   RCORR025
ISCRGC( 4,1)  =   1
SCRCOM(1, 4,1)    =   LOSP
ISCR(1)    =   3
SCRGP1( 1,1)  =   RCORR012 SCRGP2( 1,1)= RCORR021 RGPFAC( 1,1)=       0.75
SCRGP1( 2,1)  =   RCORR012 SCRGP2( 2,1)= RCORR024 RGPFAC( 2,1)=       0.75
SCRGP1( 3,1)  =   RCORR021 SCRGP2( 3,1)= RCORR024 RGPFAC( 3,1)=       0.75
&END
&ETDATA
```

Table 4.1 Sample of Namelist format input data(4/4)

```
NSYS       =   2
SNAM       =   LOSP       RHRA
NTAC       =   4
ACNAM( 1) =   SEQW      NISEQ( 1)=    3 CANAM(1, 1)= LOSP       RHRA       RHRB
ISEQ(1, 1)  =   0   1   1
ACNAM( 2) =   SEQX      NISEQ( 2)=    3 CANAM(1, 2)= LOSP       RHRA       RHRB
ISEQ(1, 2)  =   0   1   0
ACNAM( 3) =   SEQY      NISEQ( 3)=    3 CANAM(1, 3)= LOSP       RHRA       RHRB
ISEQ(1, 3)  =   0   0   1
ACNAM( 4) =   SEQZ      NISEQ( 4)=    3 CANAM(1, 4)= LOSP       RHRA       RHRB
ISEQ(1, 4)  =   0   0   0
&END
&SEQGRP
NGROUP     =    2
GROUP( 1) =   NOCD      NGRPIN( 1)=    3 GRPSEQ(1, 1)= SEQW       SEQX       SEQY
GROUP( 2) =   CD        NGRPIN( 2)=    1 GRPSEQ(1, 2)= SEQZ
&END
&NLCCVFP
NTAC2      =   4
NCCVFP( 1)     =    1 CCVFP(1, 1)= 5.000E-01
NCCVFP( 2)     =    1 CCVFP(1, 2)= 5.000E-01
NCCVFP( 3)     =    1 CCVFP(1, 3)= 5.000E-01
NCCVFP( 4)     =    1 CCVFP(1, 4)= 5.000E-01
&END
&NLSTERM
NTAC3      =   4
NSTERM( 1)     =    1 STERM(1, 1)= 5.000E-01
NSTERM( 2)     =    1 STERM(1, 2)= 5.000E-01
NSTERM( 3)     =    1 STERM(1, 3)= 5.000E-01
NSTERM( 4)     =    1 STERM(1, 4)= 5.000E-01
&END
&IMPDATA
IOUT       =   1
IKIN       =   2
ISNU       =   7
NCIM( 1)    =   1 COMIN(1, 1)=KMOVA12
NCIM( 2)    =   1 COMIN(1, 2)=KMOVB11
NCIM( 3)    =   1 COMIN(1, 3)=KHXA
NCIM( 4)    =   1 COMIN(1, 4)=KHXB
NCIM( 5)    =   1 COMIN(1, 5)=KPUMPA1
NCIM( 6)    =   1 COMIN(1, 6)=KPUMPB1
NCIM( 7)    =   1 COMIN(1, 7)=LOSP
&END
```

5. Summary

SECOM2-DQFM is developed for performing seismic PSA of complex engineering system, such as nuclear power plants.

Given that the seismic hazard curve of the location site of a plant and the fault tree / event tree (FT/ET) models of this plant were known, if the capacities and responses of components were available, the conditional occurrence probability (or frequency) of the top event of the FT models could be estimated with SECOM2-DQFM. In addition, the importance of each basic event as well as the occurrence frequency of each accident sequence can also be obtained.

In order to evaluate the concurrent failure probability of multiple components due to earthquake, the method of Direct Quantification of Fault Tree using Monte Carlo simulation (DQFM) is adopted in SECOM2-DQFM. Correlations of component failures include correlations of component responses and correlations of component responses. In most existed seismic system reliability analysis codes, correlations of component responses (or capacities) can only be assumed as fully correlated or fully independent. However, in SECOM2-DQFM, partial correlation of component failures can also be generated by assigning partial correlation coefficients to the responses (or capacities) of two components. In addition, the effect of correlations on the union and intersection of the failures of multiple components are also taken into consideration in SECOM2-DQFM.

In the Seismic PSA Standard issued by Atomic Energy Society of Japan, the DQFM method is prescribed as one of the methods in which correlations of component failures can be considered. To the authors' knowledge, SECOM2-DQFM (as well as its mother version SECOM2) is the only code system in which the DQFM method is implemented. Opening SECOM2-DQFM to the public will promote the widespread utilization of the DQFM method and activate the world-wide study of seismic PSA. Therefore, for the potential user's convenience, the user's manual of SECOM2-DQFM is summarized in this report.

References

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国際単位系（SI）

表１．SI 基本単位

基本量	SI 基本単位	
	名称	記号
長さ	メートル	m
質量	キログラム	kg
時間	秒	s
電流	アンペア	A
熱力学温度	ケルビン	K
物質量	モル	mol
光度	カンデラ	cd

表２．基本単位を用いて表されるSI組立単位の例

組立量	SI 基本単位	
	名称	記号
面積	平方メートル	m^2
体積	立法メートル	m^3
速さ，速度	メートル毎秒	m/s
加速度	メートル毎秒毎秒	m/s^2
波数	毎メートル	m^{-1}
密度（質量密度）	キログラム毎立法メートル	kg/m^3
質量体積（比体積）	立法メートル毎キログラム	m^3/kg
電流密度	アンペア毎平方メートル	A/m^2
磁界の強さ	アンペア毎メートル	A/m
（物質量の）濃度	モル毎立方メートル	mol/m^3
輝度	カンデラ毎平方メートル	cd/m^2
屈折率	（数の）1	1

表５．SI 接頭語

乗数	接頭語	記号	乗数	接頭語	記号
10^{24}	ヨタ	Y	10^{-1}	デシ	d
10^{21}	ゼタ	Z	10^{-2}	センチ	c
10^{18}	エクサ	E	10^{-3}	ミリ	m
10^{15}	ペタ	P	10^{-6}	マイクロ	μ
10^{12}	テラ	T	10^{-9}	ナノ	n
10^{9}	ギガ	G	10^{-12}	ピコ	p
10^{6}	メガ	M	10^{-15}	フェムト	f
10^{3}	キロ	k	10^{-18}	アト	a
10^{2}	ヘクト	h	10^{-21}	ゼプト	z
10^{1}	デカ	da	10^{-24}	ヨクト	y

表３．固有の名称とその独自の記号で表されるSI組立単位

組立量	SI 組立単位			
	名称	記号	他のSI単位による表し方	SI基本単位による表し方
平面角	ラジアン(a)	rad		$m \cdot m^{-1}=1$(b)
立体角	ステラジアン(a)	sr(c)		$m^2 \cdot m^{-2}=1$(b)
周波数	ヘルツ	Hz		s^{-1}
力	ニュートン	N		$m \cdot kg \cdot s^{-2}$
圧力，応力	パスカル	Pa	N/m^2	$m^{-1} \cdot kg \cdot s^{-2}$
エネルギー，仕事，熱量	ジュール	J	N・m	$m^2 \cdot kg \cdot s^{-2}$
工率，放射束	ワット	W	J/s	$m^2 \cdot kg \cdot s^{-3}$
電荷，電気量	クーロン	C		s・A
電位差（電圧），起電力	ボルト	V	W/A	$m^2 \cdot kg \cdot s^{-3} \cdot A^{-1}$
静電容量	ファラド	F	C/V	$m^{-2} \cdot kg^{-1} \cdot s^4 \cdot A^2$
電気抵抗	オーム	Ω	V/A	$m^2 \cdot kg \cdot s^{-3} \cdot A^{-2}$
コンダクタンス	ジーメンス	S	A/V	$m^{-2} \cdot kg^{-1} \cdot s^3 \cdot A^2$
磁束	ウエーバ	Wb	V・s	$m^2 \cdot kg \cdot s^{-2} \cdot A^{-1}$
磁束密度	テスラ	T	Wb/m^2	$kg \cdot s^{-2} \cdot A^{-1}$
インダクタンス	ヘンリー	H	Wb/A	$m^2 \cdot kg \cdot s^{-2} \cdot A^{-2}$
セルシウス温度	セルシウス度(d)	℃		K
光束	ルーメン	lm	cd・sr(c)	$m^2 \cdot m^{-2} \cdot cd=cd$
照度	ルクス	lx	lm/m^2	$m^2 \cdot m^{-4} \cdot cd=m^{-2} \cdot cd$
（放射性核種の）放射能	ベクレル	Bq		s^{-1}
吸収線量，質量エネルギー分与，カーマ	グレイ	Gy	J/kg	$m^2 \cdot s^{-2}$
線量当量，周辺線量当量，方向性線量当量，個人線量当量，組織線量当	シーベルト	Sv	J/kg	$m^2 \cdot s^{-2}$

(a)ラジアン及びステラジアンの使用は、同じ次元であっても異なった性質をもった量を区別するときの組立単位の表し方として利点がある。組立単位を形作るときのいくつかの用例は表４に示されている。
(b)実際には、使用する時には記号rad及びsrが用いられるが、習慣として組立単位としての記号“１”は明示されない。
(c)測光学では、ステラジアンの名称と記号srを単位の表し方の中にそのまま維持している。
(d)この単位は、例としてミリセルシウス度m℃のようにSI接頭語を伴って用いても良い。

表４．単位の中に固有の名称とその独自の記号を含むSI組立単位の例

組立量	SI 組立単位		
	名称	記号	SI 基本単位による表し方
粘度	パスカル秒	Pa・s	$m^{-1} \cdot kg \cdot s^{-1}$
力のモーメント	ニュートンメートル	N・m	$m^2 \cdot kg \cdot s^{-2}$
表面張力	ニュートン毎メートル	N/m	$kg \cdot s^{-2}$
角速度	ラジアン毎秒	rad/s	$m \cdot m^{-1} \cdot s^{-1}=s^{-1}$
角加速度	ラジアン毎平方秒	rad/s^2	$m \cdot m^{-1} \cdot s^{-2}=s^{-2}$
熱流密度，放射照度	ワット毎平方メートル	W/m^2	$kg \cdot s^{-3}$
熱容量，エントロピー	ジュール毎ケルビン	J/K	$m^2 \cdot kg \cdot s^{-2} \cdot K^{-1}$
質量熱容量（比熱容量），質量エントロピー	ジュール毎キログラム毎ケルビン	J/(kg・K)	$m^2 \cdot s^{-2} \cdot K^{-1}$
質量エネルギー（比エネルギー）	ジュール毎キログラム	J/kg	$m^2 \cdot s^{-2} \cdot K^{-1}$
熱伝導率	ワット毎メートル毎ケルビン	W/(m・K)	$m \cdot kg \cdot s^{-3} \cdot K^{-1}$
体積エネルギー	ジュール毎立方メートル	J/m^3	$m^{-1} \cdot kg \cdot s^{-2}$
電界の強さ	ボルト毎メートル	V/m	$m \cdot kg \cdot s^{-3} \cdot A^{-1}$
体積電荷	クーロン毎立方メートル	C/m^3	$m^{-3} \cdot s \cdot A$
電気変位	クーロン毎平方メートル	C/m^2	$m^{-2} \cdot s \cdot A$
誘電率	ファラド毎メートル	F/m	$m^{-3} \cdot kg^{-1} \cdot s^4 \cdot A^2$
透磁率	ヘンリー毎メートル	H/m	$m \cdot kg \cdot s^{-2} \cdot A^{-2}$
モルエネルギー	ジュール毎モル	J/mol	$m^2 \cdot kg \cdot s^{-2} \cdot mol^{-1}$
モルエントロピー，モル熱容量	ジュール毎モル毎ケルビン	J/(mol・K)	$m^2 \cdot kg \cdot s^{-2} \cdot K^{-1} \cdot mol^{-1}$
照射線量（X線及びγ線）	クーロン毎キログラム	C/kg	$kg^{-1} \cdot s \cdot A$
吸収線量率	グレイ毎秒	Gy/s	$m^2 \cdot s^{-3}$
放射強度	ワット毎ステラジアン	W/sr	$m^4 \cdot m^{-2} \cdot kg \cdot s^{-3}=m^2 \cdot kg \cdot s^{-3}$
放射輝度	ワット毎平方メートル毎ステラジアン	$W/(m^2 \cdot sr)$	$m^2 \cdot m^{-2} \cdot kg \cdot s^{-3}=kg \cdot s^{-3}$

表６．国際単位系と併用されるが国際単位系に属さない単位

名称	記号	SI 単位による値
分	min	1 min=60s
時	h	1h =60 min=3600 s
日	d	1 d=24 h=86400 s
度	°	1° =(π/180) rad
分	’	1’ =(1/60)° =(π/10800) rad
秒	”	1” =(1/60)’ =(π/648000) rad
リットル	l、L	1l=1 $dm^3=10^{-3}m^3$
トン	t	$1t=10^3$ kg
ネーパ	Np	1Np=1
ベル	B	1B=(1/2)ln10(Np)

表７．国際単位系と併用されこれに属さない単位で SI単位で表される数値が実験的に得られるもの

名称	記号	SI 単位であらわされる数値
電子ボルト	eV	$1eV=1.60217733(49) \times 10^{-19}J$
統一原子質量単位	u	$1u=1.6605402(10) \times 10^{-27}kg$
天文単位	ua	$1ua=1.49597870691(30) \times 10^{11}m$

表８．国際単位系に属さないが国際単位系と 併用されるその他の単位

名称	記号	SI 単位であらわされる数値
海里		1海里=1852m
ノット		1ノット=1海里毎時=(1852/3600)m/s
アール	a	1 a=1 $dam^2=10^2m^2$
ヘクタール	ha	1 ha=1 $hm^2=10^4m^2$
バール	bar	1 bar=0.1MPa=100kPa=1000hPa=10^5Pa
オングストローム	Å	1 Å=0.1nm=10^{-10}m
バーン	b	1 b=100$fm^2=10^{-28}m^2$

表９．固有の名称を含むCGS組立単位

名称	記号	SI 単位であらわされる数値
エルグ	erg	1 erg=10^{-7} J
ダイン	dyn	1 dyn=10^{-5}N
ポアズ	P	1 P=1 dyn・s/cm^2=0.1Pa・s
ストークス	St	1 St =1$cm^2/s=10^{-4}m^2/s$
ガウス	G	1 G ≙10^{-4}T
エルステッド	Oe	1 Oe ≙(1000/4π)A/m
マクスウェル	Mx	1 Mx ≙10^{-8}Wb
スチルブ	sb	1 sb =1cd/$cm^2=10^4cd/m^2$
ホト	ph	1 ph=10^4lx
ガル	Gal	1 Gal =1cm/$s^2=10^{-2}m/s^2$

表10．国際単位に属さないその他の単位の例

名称	記号	SI 単位であらわされる数値
キュリー	Ci	1 Ci=3.7×10^{10}Bq
レントゲン	R	1 R = 2.58×10^{-4}C/kg
ラド	rad	1 rad=1cGy=10^{-2}Gy
レム	rem	1 rem=1 cSv=10^{-2}Sv
X線単位		1X unit=1.002×10^{-4}nm
ガンマ	γ	1γ=1 nT=10^{-9}T
ジャンスキー	Jy	1 Jy=$10^{-26}W \cdot m^{-2} \cdot Hz^{-1}$
フェルミ		1 fermi=1 fm=10^{-15}m
メートル系カラット		1 metric carat = 200 mg = 2×10^{-4}kg
トル	Torr	1 Torr = (101 325/760) Pa
標準大気圧	atm	1 atm = 101 325 Pa
カロリー	cal	
ミクロン	μ	1 μ =1μm=10^{-6}m

（第７版，1998年改訂）

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