UNIVERSITY OF CANTERBURY
Department of Civil Engineering

COMPUTER PROGRAM LIBRARY

Program name:– **HYSTERES**	Program type:– Displacement History	Program code:– ANSI Fortran77
Author:– Athol J Carr		Date:– April 30, 2002

HYSTERES

Hysteresis Loop Verification or Tuning

Purpose

The program HYSTERES takes a displacement history and computes the associated hysteresis loop for a specified stiffness, yield strength and post-yield behaviour. Virtually all of the hysteresis models in RUAUMOKO may be specified.

This program may be used to see how a particular rule works but may also be used to determine the best choice of loop parameters to obtain the most suitable hysteresis loop for use in a RUAUMOKO analysis.

The choice of input displacement histories is available:

All data is prompted for and is reasonably self-explanatory.

In Windows95, Windows98 or WindowsNT etc. to get hard copies of the graphs use the pull down 'file' menu and select the Print or Save options to send the graph to the printer or to save the plot as a bitmap file (**.BMP)**. On unix systems using GKS graphics select the Hard-copy option from the Choice window.

Running the program HYSTERES.

To run the program call the program by the method appropriate to your operating system. On a personal computer just type **HYSTERES** assuming that the files **HYSTERES.EXE** and the associated **.DLL** and **.HLP** files are in your current directory or path.

In Microsoft Windows operating systems another option is to create a shortcut on the desktop and for this purpose a suitable icon for HYSTERES, **Hysteres.ico**, is supplied with the program.

The program prompts for responses to a series of questions. Default responses, where appropriate, are enclosed in square brackets, **[ ]**. File names must match the conventions of your operating system but file names, with paths where necessary, must not exceed 60 characters in length and must not contain blanks.

The first question asks for the name of the output file. The default is the computer console or terminal screen.

To get hard copies of the plots.

In Microsoft Windows operating systems to get hard copies of the graphs use the pull down 'file' menu and select the Print or Save options to send the graph to the printer or to save the plot as a bitmap file (**.BMP**).
On unix systems using GKS graphics select the Hard-copy option from the Choice window

Input data for Hysteresis.

Note: In the following user guide, each line of required data is indicated by a box containing the data items. Below each box is a description of the data items. The data items on each line may be separated by commas or blank spaces. The format for the items are indicated by the letter at the end of each descriptive line with **A** indicating a character string, **I** indicating an integer value and **F** indicating a floating point number. A floating point number may or may not have a decimal point and may also take a scientific or exponent form such as 1.5E6 which could also be expressed as 1500000.0. Character strings will be upper-cased unless enclosed in double or single quotes and will terminate at the first blank space unless the string is enclosed in quotes.

1 Output file name: supply any suitable file name.

2 Section Properties

STIFF BILIN YP YN

STIFF	Stiffness		**F**
BILIN	Bilinear factor < 1.0	(or Ramberg Osgard function > 1.0)	**F**
YP	Positive Yield Force	(> 0.0)	**F**
YN	Negative Yield Force	(< 0.0)	**F**

3 Hysteresis Choice

IHYST

IHYST	Hysteresis Rule choice, see RUAUMOKO manual for choices **Note:** That Rule 22 cannot be run from HYSTERES	**I**

Some hysteresis rules will require extra data.

3a **IHYST=23** BOUC

DT

DT	Equivalent Time Step	**F**

3b **IHYST = 24** (Remennikov)

LENGTH E A

LENGTH	Member Length	**F**
E	Elastic Modulus	**F**
A	Cross-sectional Area	**F**

3c **IHYST = 33** Masonry Strut

LENGTH

LENGTH	Strut Length	**F**

4 Strength Degradation (only if rules allow degradation – see Appendix B in RUAUMOKO manual)

ILOS

ILOS	= 0	No strength degradation. See Appendix A of RUAUMOKO manual	**I**
	= 1	Strength reduction in each direction based on its ductility factor	
	= 2	Strength reduction based on number of cycles	
	= 3	Strength reduction based on maximum ductility	

At this point the program will prompt for data on strength degradation if **ILOS > 0** and for hysteresis rule data if required (see RUAUMOKO manual Appendices A and B).

5 Initial Displacement

DINIT

DINIT	= Initial displacement	(Default = 0.0)	**F**

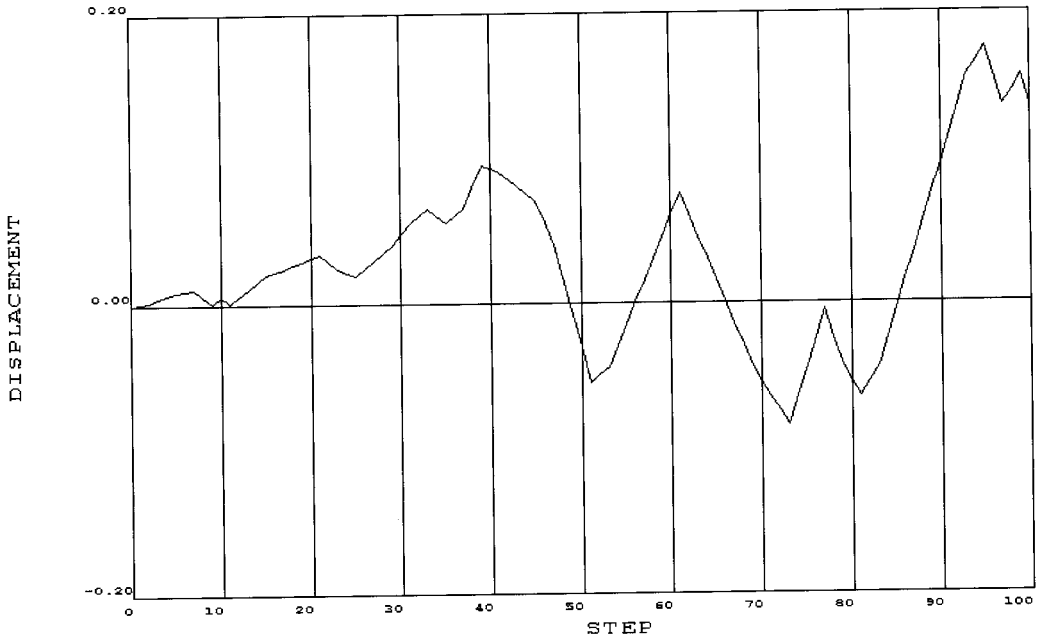
6 Displacement History Choice

IHIST SCALE

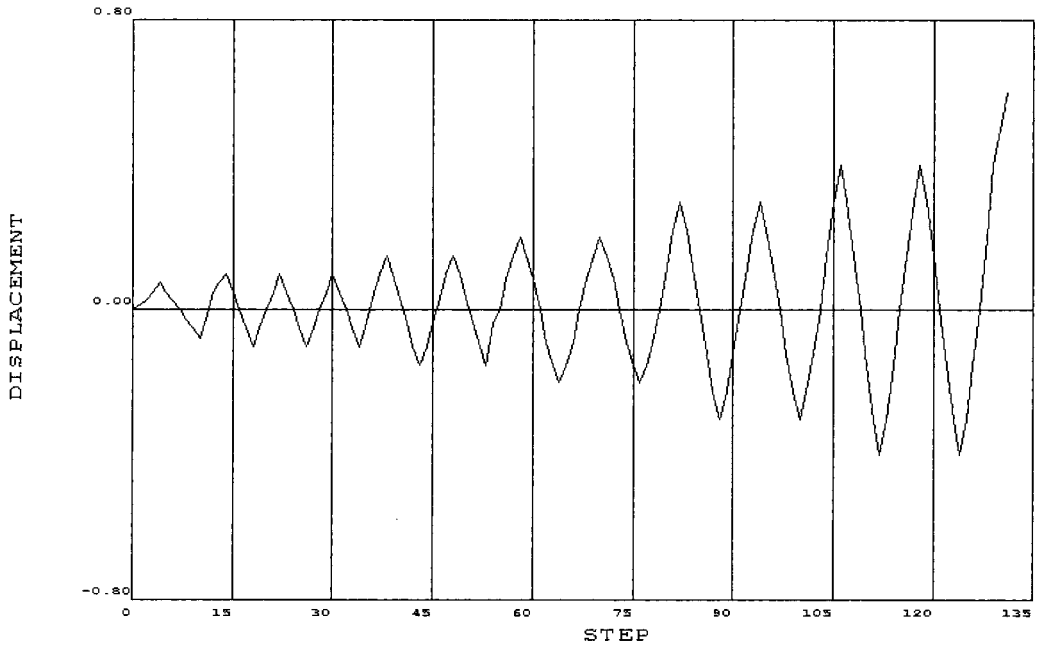
IHIST	= 0	Built-in Displacement History	**I**
	= 1	Built-in Laboratory-Test-like Displacement History	
		1 cycle ductility 0.75	
		3 cycles ductility 1.0	
		2 cycles ductility 1.5	
		2 cycles ductility 2.0	
		2 cycles ductility 3.0	
		2 cycles ductility 4.0	
		then to ductility 6.0	
	= 2	Building in Sine Wave Displacement History	
	= 3	User Supplied Incremental Displacement History	
	= 4	User Supplied Displacement History	
	= 5	User Supplied Displacement History with Measured Force	
	= 6	User Supplied Displacement History with Measured Force	
	= 7	CUREe Abbreviated Cyclic Displacement History	
	= 8	CUREe Near-Field Cyclic Displacement History	
	= 9	CUREe Standard Cyclic Displacement History	
	= 10	ISO Deformation Protocol	
	= 11	SPD Deformation Protocol	
	= 12	ATC-24 Displacement Protocol	
SCALE	Multiplier on displacement and experimental forces (Default value = 1.0) (Not used for **IHIST** = 7, 8, 9, 10, 11 or 12)		**F**

Notes:

1. The CUREe (California Universities for Research in Earthquake Engineering) Displacement Histories were developed for the Wood-Frame project. They are considered appropriate for the displacement testing of wood structures and components.
2. The ISO Protocol (1997) was prepared by Group 7 of the ISO Technical Committee on Timber Structures, originally for joint testing but later considered appropriate for testing wood-framed shear-walls. The loading history is based on the displacement at ultimate load.
3. The SPD (Sequential Phased Displacement) protocol was developed in 1987 by the Technical Coordinating Committee on Masonry Research (TCCMAR) and this has been modified and accepted by the Structural Engineers Association of Southern California (SEAOSC). The protocol is based on what is called the First Major Event (FME) which can generally be considered as the displacement corresponding to the yield state of the specimen.
4. The ATC-24 Protocol(1992) was developed by Krawinkler for the testing of steel components. The displacement history is controlled by the yield displacement of the specimen.



IHIST = 0 Built-in Displacement History



IHIST = 1 Built-in Displacement History
(In this example the yield displacement is ± 0.08.)

7 Displacement History (only if **IHIST** $ 2)

7a if **IHIST** = 2

AMP OMEGA DT DUR

AMP	=	Amplitude of Displacement Wave	**F**
OMEGA	=	Period (seconds)	**F**
DT	=	Time Each Step (seconds)	**F**
DUR	=	Duration (seconds)	**F**

7b **IHIST** = 3

DR1 DR2 … DRN

DR1	=	First displacement increment	**F**
DR2	=	Second displacement increment	**F**
…			
DRN	=	Nth displacement increment	**F**

Use as many lines as required, minimum of one displacement increment per line.
End with word **STOP** as last displacement increment.

7c **IHIST** = 4

R1 R2 … RN

R1	=	First displacement	**F**
R2	=	Second displacement	**F**
…			
RN	=	Nth displacement	**F**

Use as many lines as required, minimum of one displacement per line.
End with word **STOP** as last displacement.

7d **IHIST** = 5

Ri Fi

Ri	=	Displacement	**F**
Fi	=	Experimental Force	**F**

One line per displacement step.
End with line where **Ri** is word **STOP**

7e **IHIST** = 6

Ni Ri Fi

Ni	=	Line number	**I**
Ri	=	Displacement	**F**
Fi	=	Experimental Force	**F**

One line per displacement step.
End with line where **Ni** is word **STOP**

The program will compute hysteresis rule behaviour outputting Force, Displacement stiffness and plot flag values at each step.

After **STOP** is encountered in the input the program will plot
a. The displacement history
b. The force history compiled by the hysteresis rule
c. The hysteresis loop generated.

If **IHIST** is 5 or 6 above the last two plots will show the experimental force history and experimental loop in red.

7f **IHIST** = 7, 8 or 9 CUREe Displacement History.
(California Universities for Research in Earthquake Engineering)

DREF

DREF	Reference deformation. This is usually taken as 60% of the deformation where the load carrying ability of the system has fallen to 80% of the maximum load sustained by the system.	**F**

7g **IHIST** = 10 ISO Deformation Protocol.

DMAX

DMAX	Delta Maximum.	**F**

7h **IHIST** = 11 SPD Deformation Protocol.

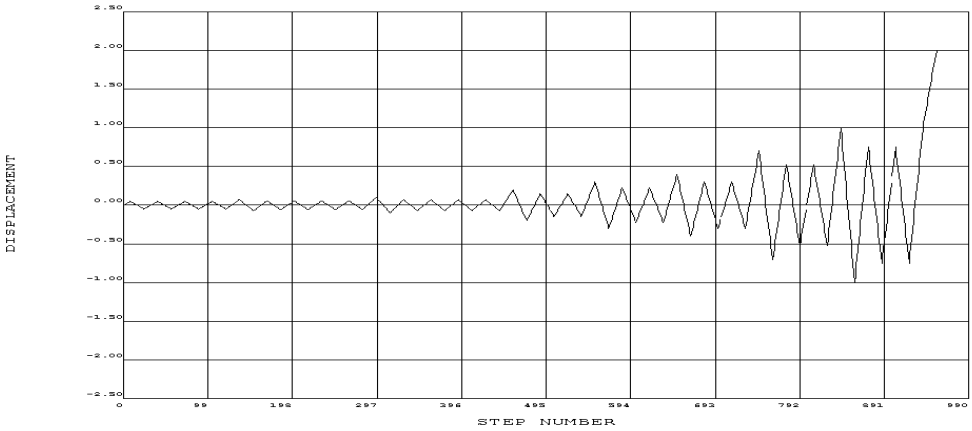
DFME

DFME FME Displacement (Default = 0.75). **F**

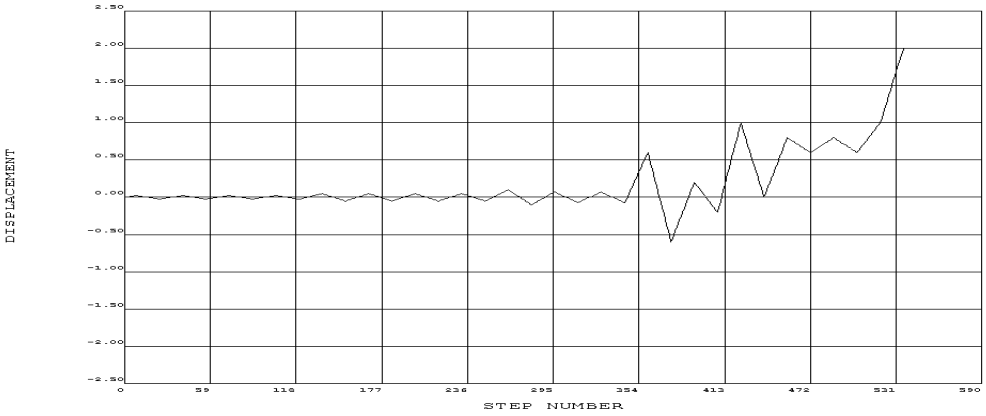
7i **IHIST** = 12 ATC-24 Deformation Protocol.

DYIELD

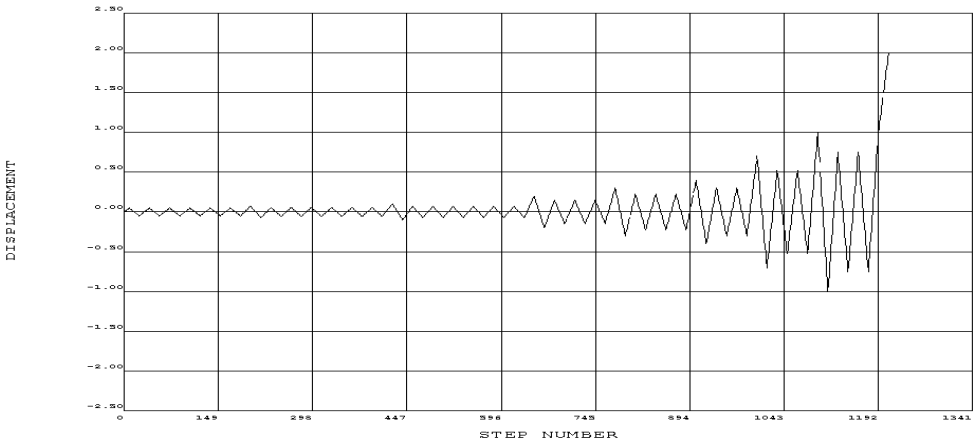
DYIELD Yield Displacement **F**



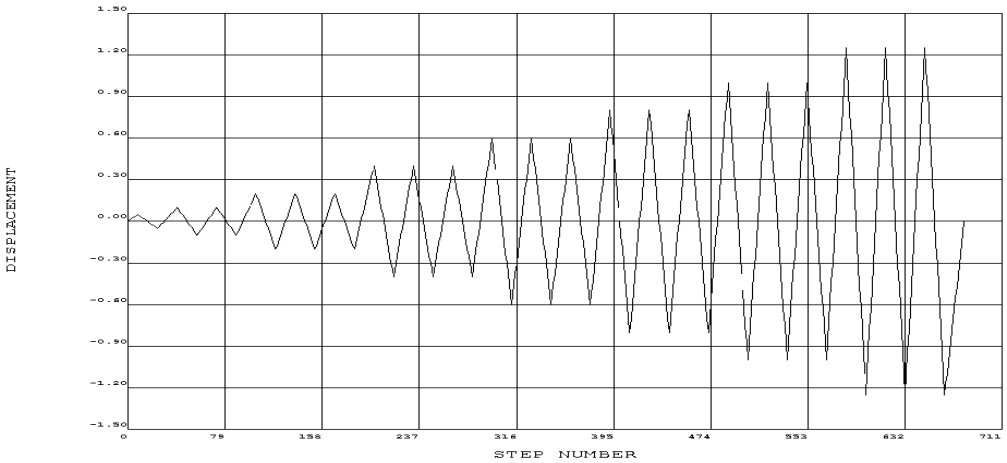
CUREe Abridged Displacement History (to be multiplied by DREF)



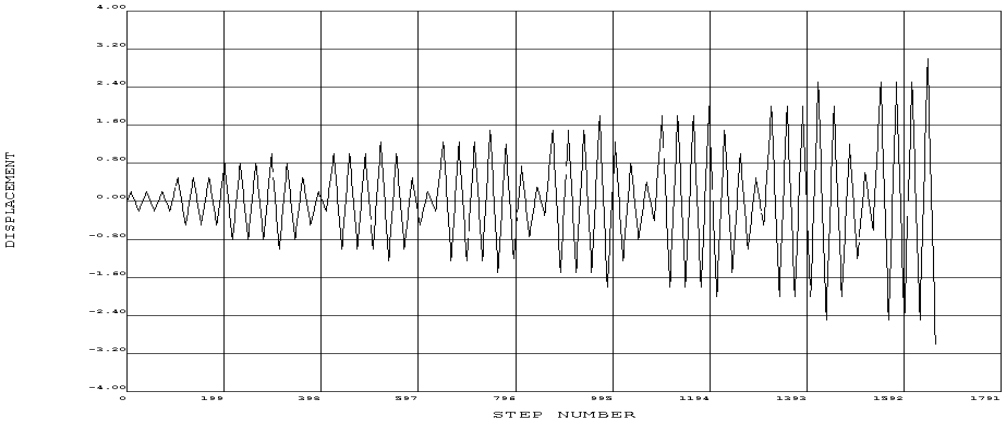
CUREe Near-Field Displacement History (to be multiplied by DREF)



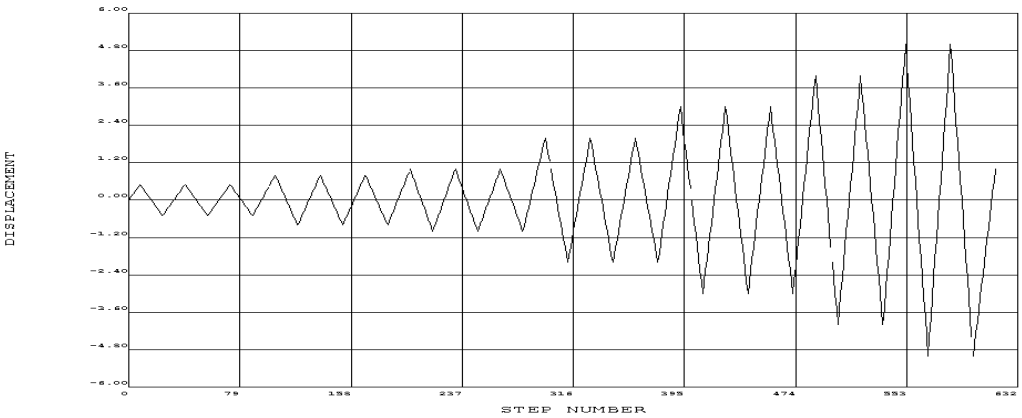
CUREeE Standard Displacement History (to be multiplied by DREF)



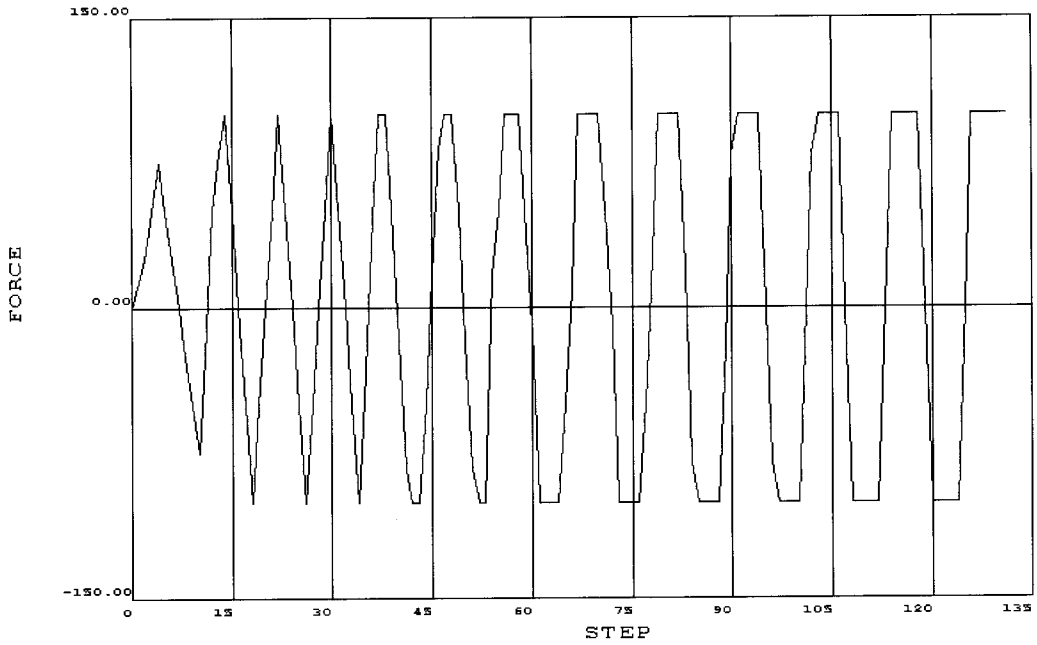
ISO Displacement Protocol (to be multiplied by DMAX)



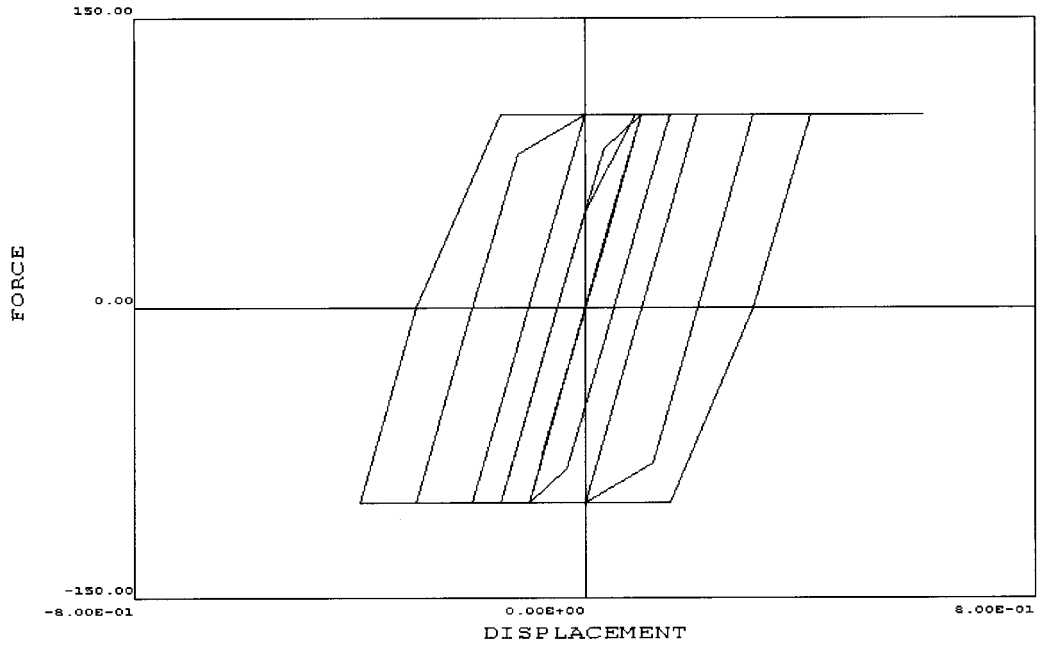
SPD Displacement Protocol (to be multiplied by DFME)



ATC-24 Displacment Protocol (to be multiplied by DYIELD)



Example of Force Versus Step Output
for system following **IHIST** = 1 Built-in Displacement History



Example of Bi-linear Hysteresis Loop
for system following **IHIST** = 1 Built-in Displacement History

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