Using MSC/XL to Perform MSC/NASTRAN Results Processing

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Abstract

MSC/XL Version 1 allowed the user to access analysis results data directly from the MSC/NASTRAN-generated graphics database and produce a variety of results processing displays. Version 2 extends the display capabilities and supports the use of external files. In addition to deformation, line contour, fringe contour and fill color displays, MSC/XL now generates arrow (vector) displays and XY plots. Results processing data can now be imported from external sources. Therefore, the user is not limited to MSC/NASTRAN results databases for the purpose of generating results processing displays.

Introduction

The results of an MSC/NASTRAN analysis are stored in a "results database file," a file produced by the DBC module of MSC/NASTRAN Version 66. This file is a relational database organized in a specific hierarchy for fast, efficient data access. In MSC/XL Version 1 an easy-to-use tool for accessing data from the results database file was introduced. This tool was called the "Results Table."

In MSC/XL Version 1, through the use of a Results Table, the user could access the data from the results database file and produce various types of structural plots. The structural plot options included deformed plots, contour plots (both line and fringe contours), and fill color plots.

In MSC/XL Version 2, there have been several enhancements to the results processing capabilities. The results processing display capabilities have been extended to support both structural plots and XY plots. The structural plots include deformation and contour plots, as in Version 1, along with the capability to produce vector or arrow plots. The Results Table has been extended to support not only direct data access from a results database file, but data access from external "import" files as well. The results processing menus have changed slightly to provide consistency as well as additional functionality. From any of the results processing display menus, the user may generate the desired display as well as quickly edit the current Results Table in order to obtain different displays without traversing the cascade menus. Finally, an export capability has been introduced which will allow the user to write the results data to an external file, an "export" file.

Results Tables

The Results Table is the tool used to access all results data. Due to the new capabilities in MSC/XL Version 2, the Results Table has grown in functionality. The Results Table supports three operating modes: ResultsDB, ResultsCalculator and ResultsImport. ResultsDB is the default operating mode. The ResultsDB operating mode is the interface to results values accessed directly from the results database file. The ResultsCalculator operating mode allows the user to perform calculations on data accessed directly from particular datablocks on the MSC/NASTRAN results database file. The ResultsImport operating mode does not associate the Results Table with an

MSC/NASTRAN results database file. It does however allow access to results data contained in an external file, this file is known as an "import" file. The import file is an ASCII file with results values specified for each element or grid point.

In results processing the first step for the user is to determine which operating mode to choose for the Results Table. A connection must then be established between the Results Table and either a results database file or an import file. The Results Table functions as a window into the results database file, allowing the user to select certain results quantities to use for any of the various results processing displays. For an import file, the Results Table functions as a selection mechanism allowing the user to specify which group of data to read. The connection to either file type may be made by using the menus or via the Edit ResultsTable command. If the connection is made to a results database file, the Results Table interrogates the results database file, determining exactly what results data it contains. The Results Table only allows the user to choose results quantities that are available on the results database file.

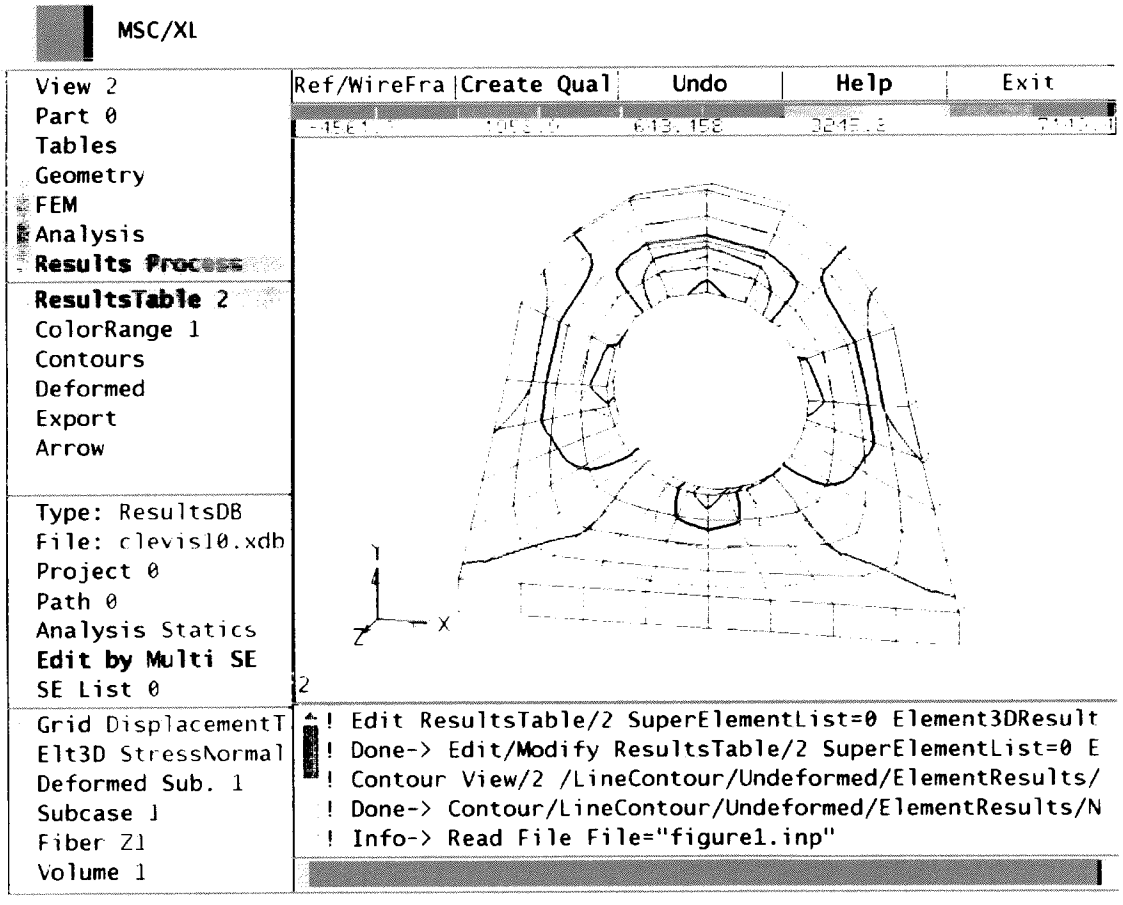

Figure 1: Results Table - ResultsDB

Figure 1 shows Results Table 2 set to an operating mode of ResultsDB. Its associated results database file is clevis10.xdb. Visible in the fourth cascading menu are the settings for grid points and 3D elements, along with other data.

Figure 2 shows Results Table 1 set to the ResultsCalculator operating mode. Settings for the Results Table calculator are visible in the fourth cascade menu.

Figure 3 shows Results Table 3 set to the ResultsImport operating mode. The associated import file is *Data.ext*. Specifications of data sections and columns are visible in the fourth cascading menu.

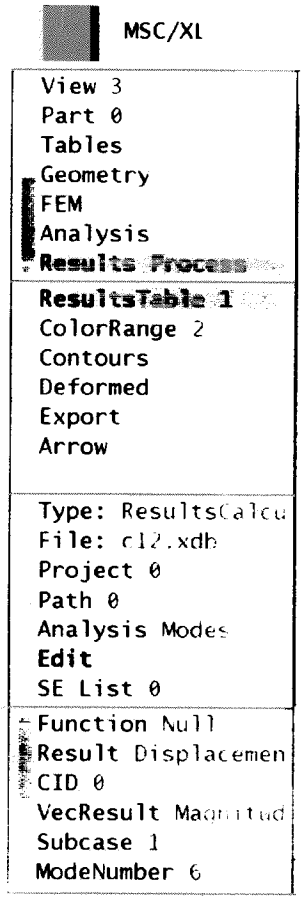

Figure 2: ResultsCalculator

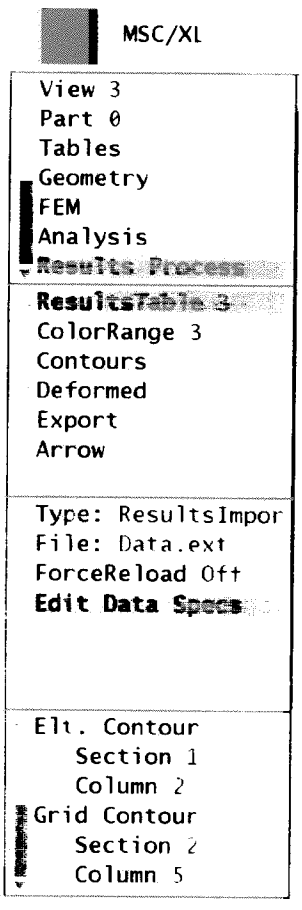

Figure 3: ResultsImport

Structural Plots

After a Results Table is associated with a file containing results data, structural plots may be produced. The user controls the content of the structural plot by editing the Results Table settings. He may select from the available results quantities and subcases available on the results database file, or he may select different sections or columns to read from the import file. MSC/XL Version 2 provides three varieties of structural plots: Deformed plots, Contour plots (line, fringe and fill color), and Arrow plots.

A model's deformed shape may be displayed alone or superimposed over the undeformed model. Figure 4 shows the deformed shape of a model superimposed on the undeformed shape. Also visible in the Deformation menu, is the deformation scale factor computed by MSC/XL. This value may be overridden manually by the user to

control the degree of deformation displayed. The Deformation menu also provides the QuickEditRT option. This option allows the user to change the Results Table settings without traversing the cascade menus.

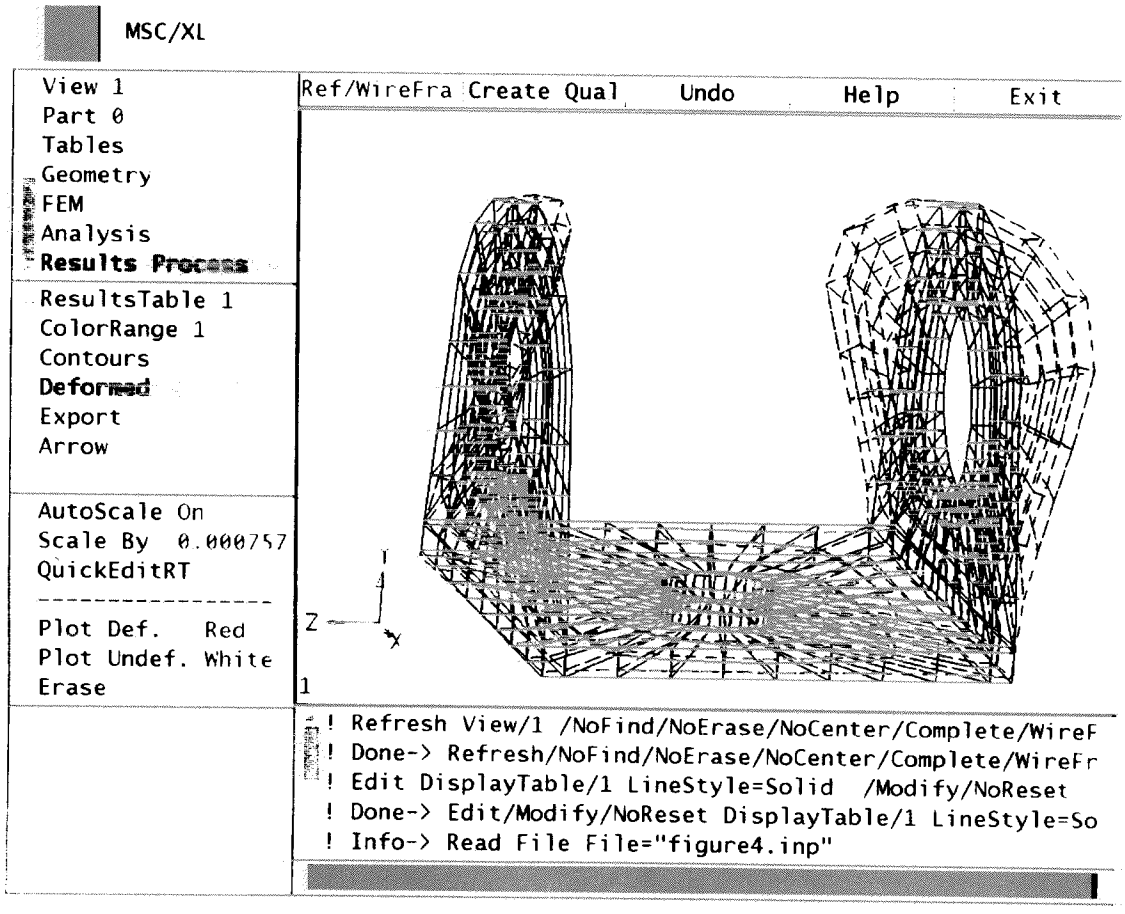

Figure 4: Deformed plot

Line contour, fringe contour plots, and fill color plots may be generated easily using either commands or the menus. Figures 5, 6, and 7 show line contour, fringe contour, and fill color plots respectivly. These three plots were generated with a single mouse pick from the menus.

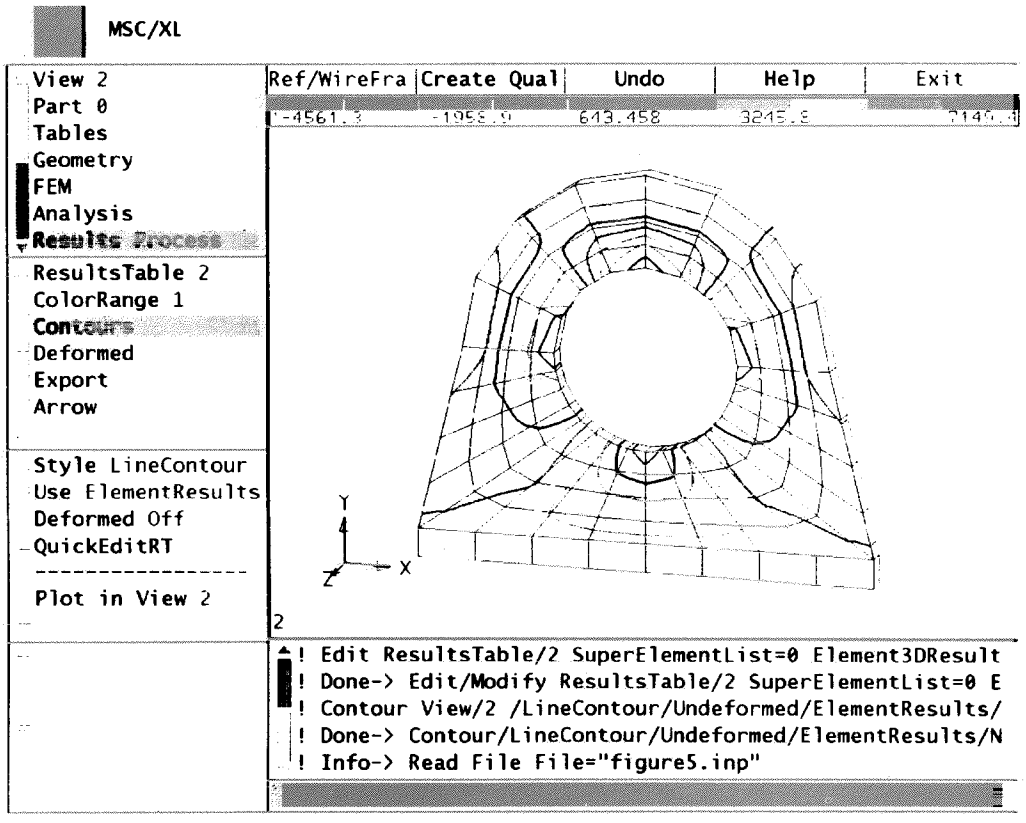

Figure 5: Contour line plot

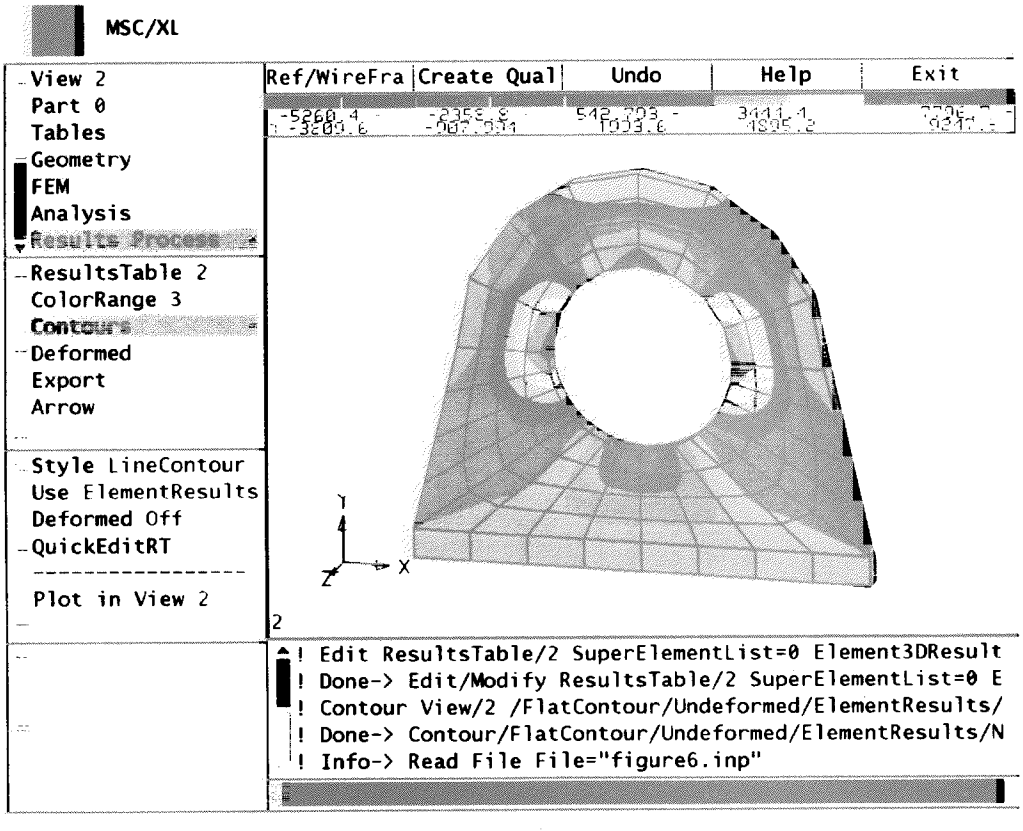

Figure 6: Contour finge plot

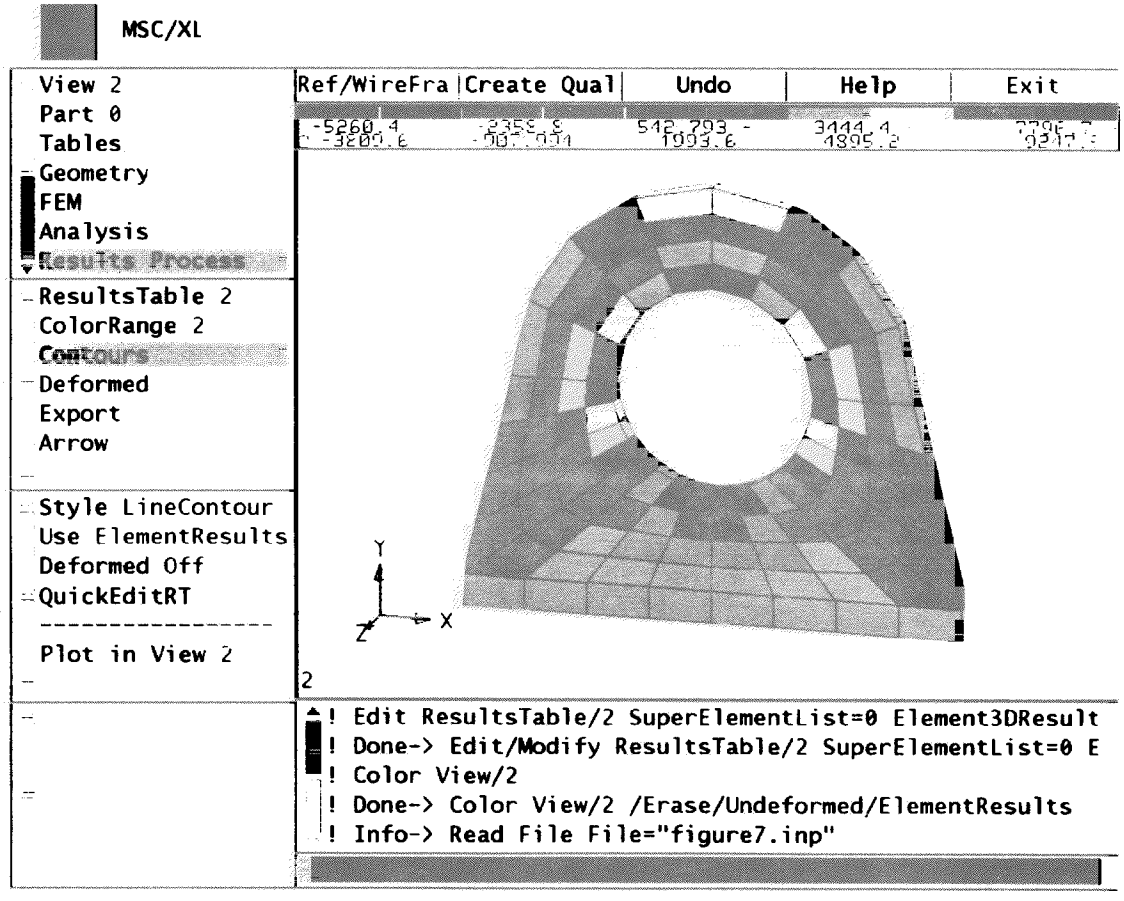

Figure 7: Color fill plot

Color Range Tables

The Color Range Tables, seen in figures 5, 6, and 7, are used to control the color distribution in a contour plot. Color levels may be added or subtracted, and the color for each individual level may be changed to the users preference. In addition, the user may control the range of values by using either the automatic range calculation mode or one of three user-controlled modes. Color Range Tables may be positioned anywhere in the graphics tile in order to enahnce the quality of the display.

Results Table Calculator and Arrow Plots

The operating mode of the Results Table used in all previous figures was ResultsDB. The ResultsDB operating mode will support both deformed and contour plots. The ResultsCalculator mode may be used to produce deformed plots, contour plots and arrow plots. For example, a Results Table with an operating mode of ResultsCalculator may be used to produce a plot of a model's deformation showing directional arrows at the grid points indicating the model's deformed shape.

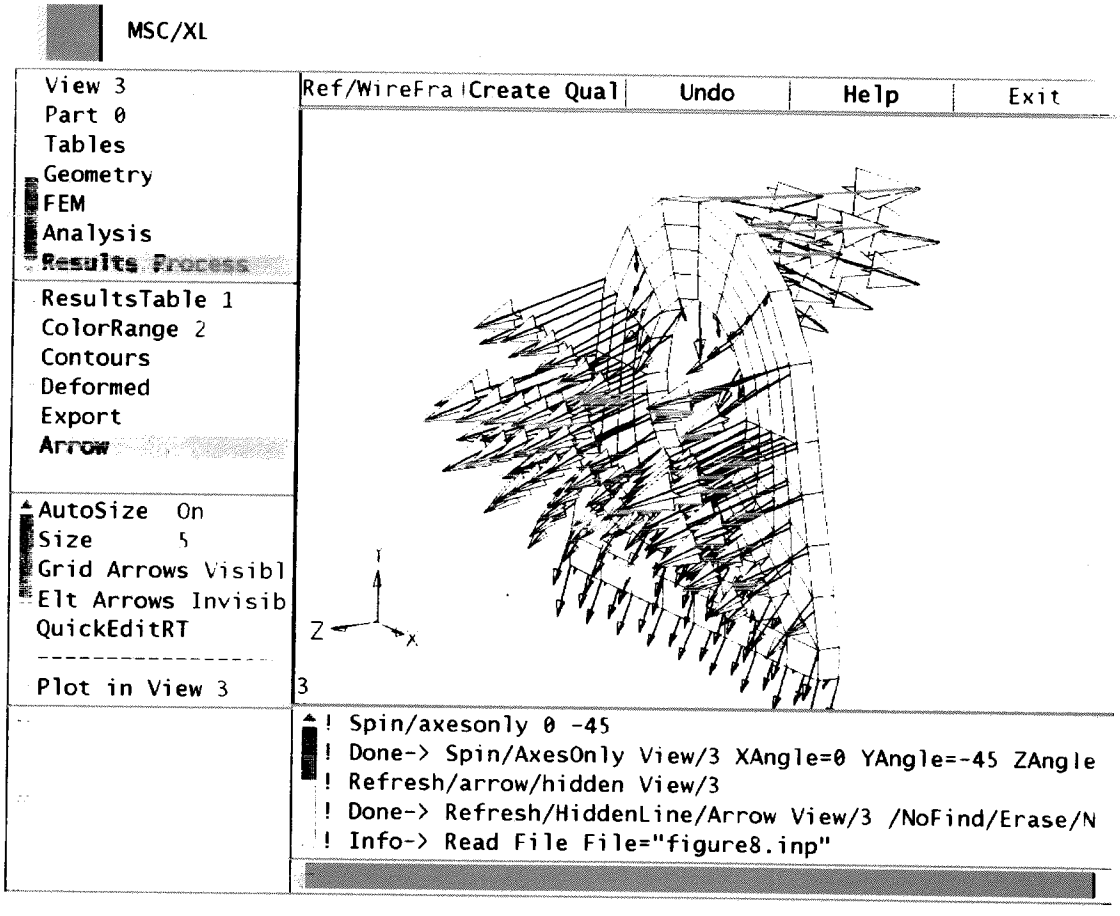

Figure 8: Arrow plot

Figure 8 shows an arrow plot of a model's deformation using the Results Table calculator. The model is displayed using a wireframe rendering mode with arrows at the grid points scaled by the deformation. Figure 9 shows the deformed shape (dashed lines), superimposed on the arrow plot of Figure 8. The tips of the arrows lie on the deformed shape (dashed lines).

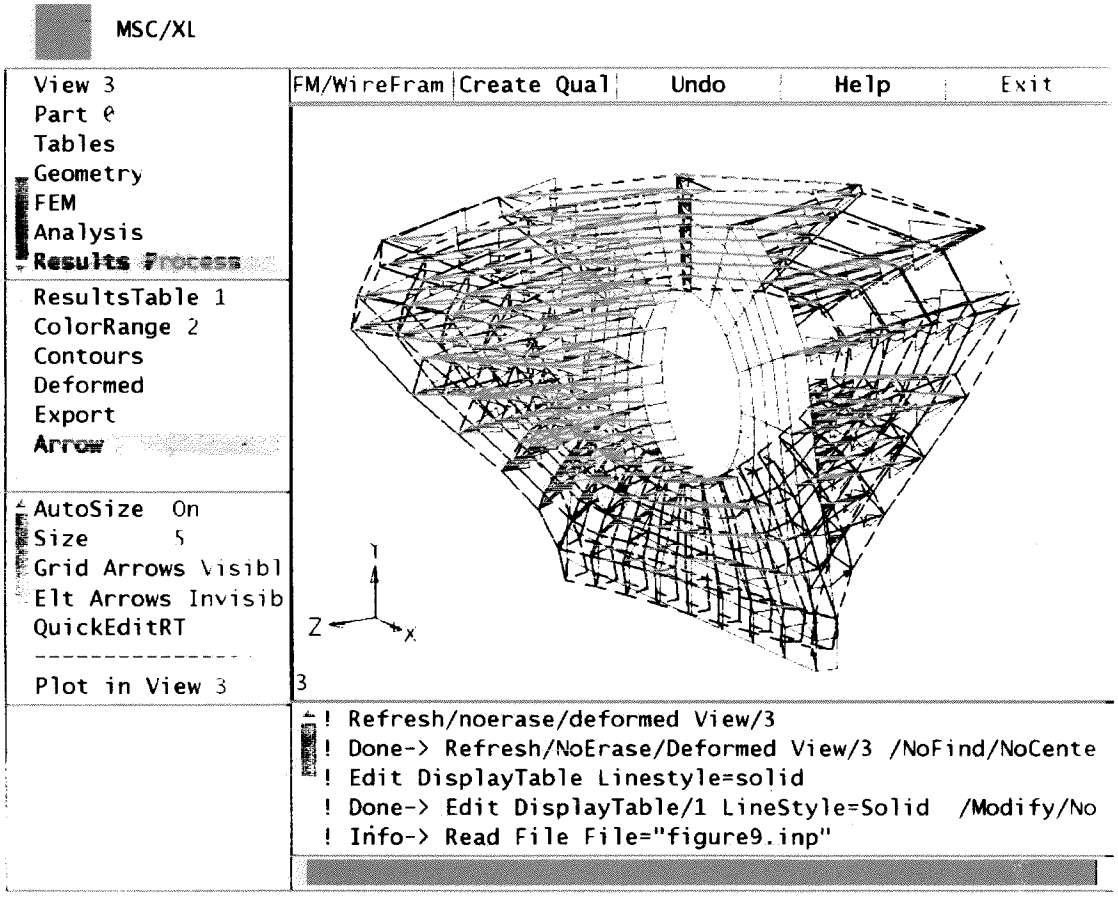

Figure 9: Arrow & Deformed plot

Importing Results

The operating mode of the Results Table called ResultsImport allows the user to access results data for the elements and/or grid points of his model from an external file. This file is known as an import file. Import files may contain data obtained from other FEA codes, data acquired from testing, or data obtained from MSC/XL's own export facility.

The import file has a specific format which MSC/XL requires in order to properly read the results data. Basically the file is composed of sections. Each section contains columns of numbers, and these numbers correspond to the grid point/element ids and the results values to use on those grid points or elements. The user specifies which section and which columns to use for any particular type of structural plot. For example, to generate a deformed plot from an import file, three columns must be

specified: One for X displacement, one for Y, and one for Z. The first column is the grid point id to which the three results values correspond.

Exporting Results data

MSC/XL allows the user to export results data via a Results Table using any of the three operating modes. The file generated is known as the export file. The export file has the same format as the import file. Exporting results will allow the user to access the results data using an external program. The export capability may be useful to users who want to manipulate the data to obtain new results values, typically performing computations not available in the Results Table Calculator. The new data may be easily imported and used in any of the various results processing displays. Exporting results data is easily accomplished using commands or menus. Figure 10 shows the Export menu in the third cascade, where "Write: *Xfile.ext*" will generate the export file *Xfile.ext* containing contour and deformation data for elements and grid points in Parts 0 through 5.

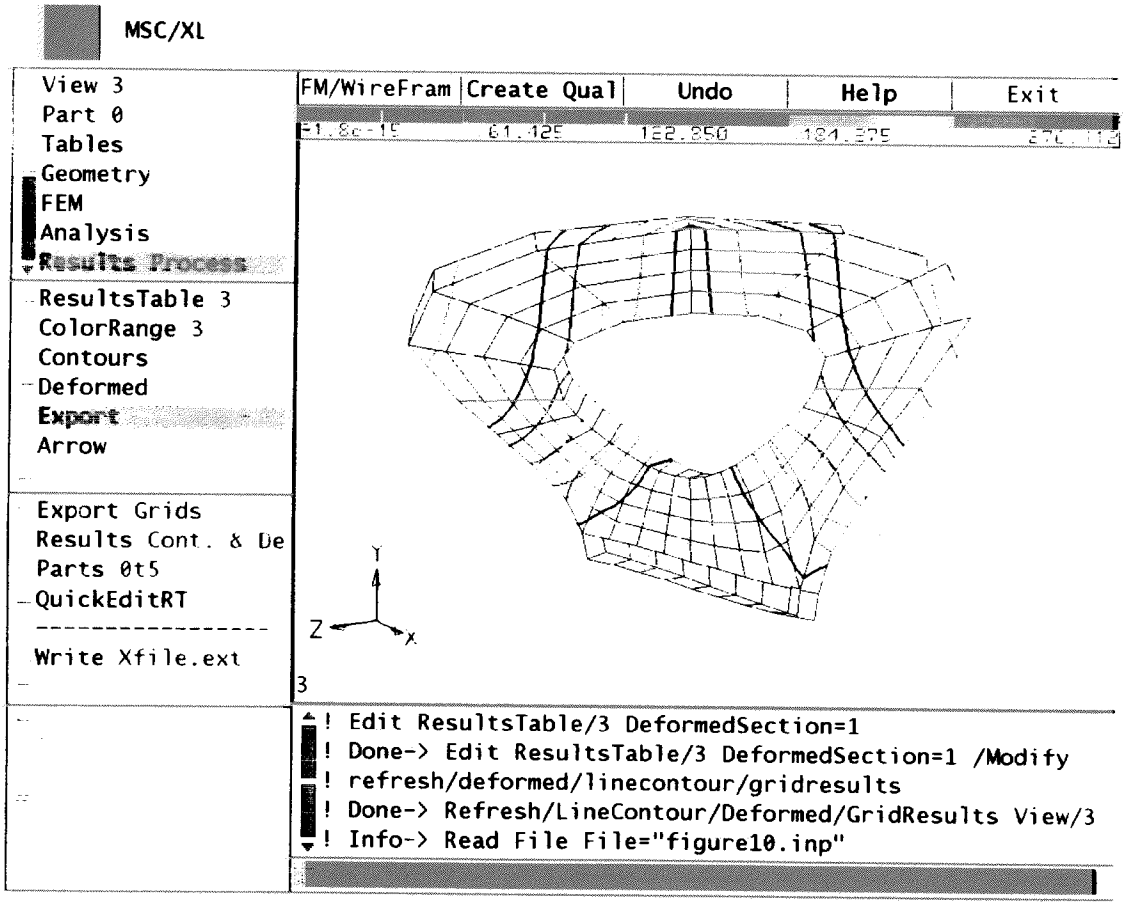

Figure 10: Export Contour & Deformed data

Superelement support and Multiple Results Tables

MSC/XL supports superelements in MSC/NASTRAN results processing. Supporting a multi-superelement analysis can be accomplished using one or more Results Tables. A single Results Table will allow individual control for each superelement. A Results Table will allow selection of different results quantities, subcases, etc. for every element within a superelement. An alternative might be to use multiple Results Tables, perhaps one for each superelement. The use of multiple Results Tables can be accomplished by associating each part of a given superelement id to one Results Table. Using multiple Results Tables may simplify the editing of each Results Table by maintaining a one to one correspondence between superelement identifiers and Results Table identifiers.

Multiple Results Tables may be necessary in certain situations. Suppose that the user has a multi-superelement model. After reviewing the analysis results he decides to restart MSC/NASTRAN and request additional data recovery for superelement number 2. Once the restart run is complete, a new results database will be generated which contains only results data for superelement number 2. At this point multiple Results Tables are necessary to allow superelement number 2 to use the results data contained in the new results database file, and the other superelements to use the results from the original results database file.

The use of multiple Results Tables may be necessary even for single superelement analysis. For example, more than one Results Table is necessary in order to generate accurate contour plots showing grid point stress output where multiple surfaces are used. Suppose the user had a single superelement model with Quad4 elements distributed over two surfaces, surface ids 1 and 2. The default situation would place the entire model into part number 0 and associate part 0 with Results Table number 1. Since there is only one superelement in the Results Table for which a surface selection may be made, only one of the two existing surfaces ids may be selected. In order to produce the proper contour plot, two surfaces must be specified, one for each group of Quad4s. Therefore, the user must partition his model into two parts, associating each to a seperate Results Table. Then the Results Tables, each with one superelement, may be set to different surface ids. An accurate contour plot of grid point stress results may now be generated.

XY Plotting of MSC/NASTRAN Results

The XY Plotting capability in MSC/XL can be used to generate graphs of MSC/NASTRAN results. XY plotting can also be used to create graphs for preprocessing, such as graphs of TABLED1 cards. Six types of graphs are available for MSC/NASTRAN processing. These are SequenceResults, ModelResults, ModelAttributes, XLData, File and GraphData. SequenceResults and ModelResults graph types are used for postprocessing only. ModelAttributes and XLData graph types are useful for preprocessing. File and GraphData are general plotting types that can be used both for pre- and postprocessing. The data associated with a graph can be edited, sorted and exported to external files. All attributes related to graphs and axes such as borders, grid lines, scales and tic marks can be modified easily from the cascading menus as well as from the command line.

Loading Graphs with MSC/NASTRAN Results Data

Results quantities available from MSC/NASTRAN analyses can be plotted in a number of ways. Since the Results Table is the interface to results data, XY plotting of results is tied to the settings of the current Results Table. To make the the process of data acquisition and display quick and easy, MSC/XL provides a set of standard graph types. The user chooses a type of graph depending on the data that is to be plotted.

Results can be plotted for sequences of time steps, frequencies, nonlinear load steps, modes and subcases by selecting the SequenceResults type of graph. The user specifies the sequence to be plotted from the sequences available in the Results Table. For example, Time and Subcase may be the only valid sequences available from a Transient Response analysis. Since XY plotting of results is tied to the settings of the current Results Table, only the valid sequences appear as choices in the menus. The user specifies the id of the grid point or element for which the sequence of results is to be plotted. This id may be specified by simply picking the grid point or element from the view by using the mouse, or by entering the id from the keyboard. Next, the user selects the results quantity to be plotted from the available results in the database. This selection can be made by using the QuickEditRT pop-up form, a handy tool for modifying the settings of the current Results Table.

Figure 11 shows a comparison of displacement in the second coordinate direction of two grid points for a sequence of normal modes. The pop-up form in the cascading menus shows the standard graph types available in MSC/XL. The legend in the top right corner shows the grid point ids associated with each graph.

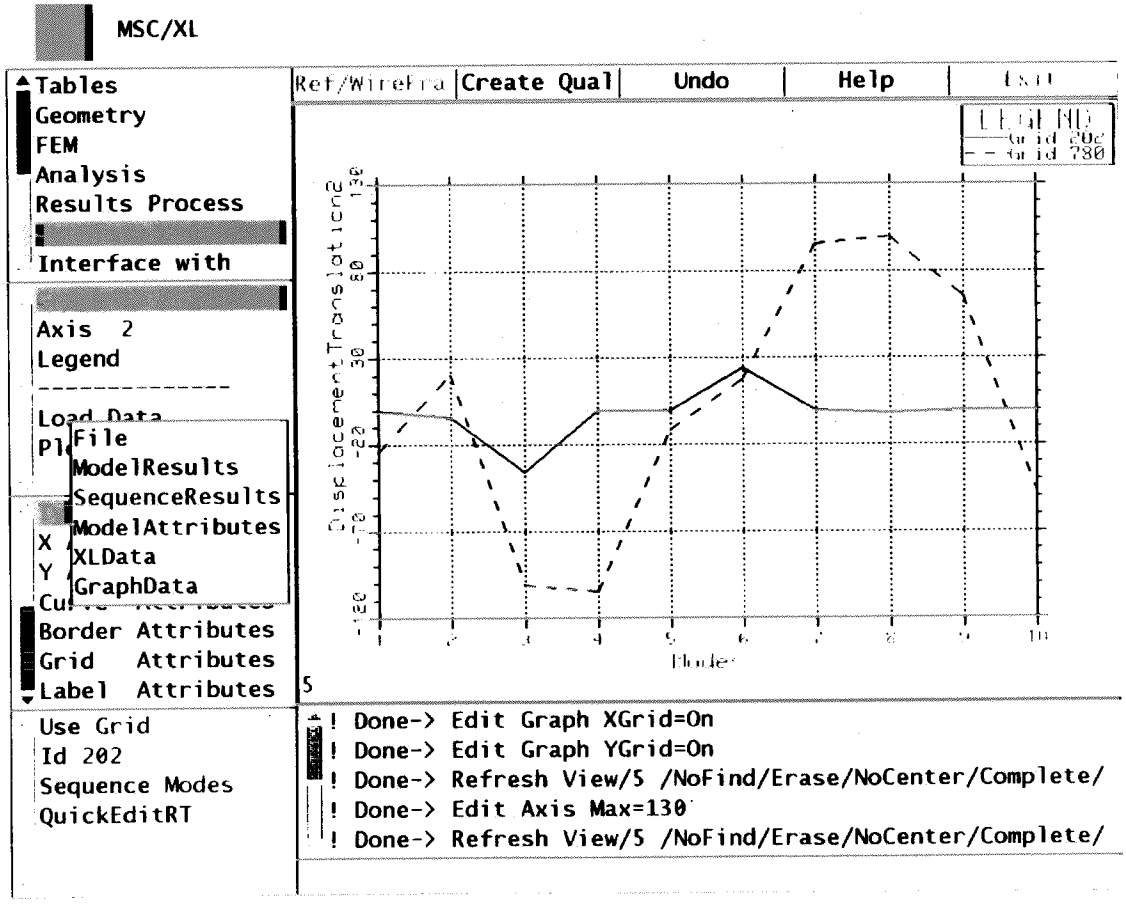

Figure 11: SequenceResults XY Plot

Results can be plotted for a list of grid points or elements by selecting the ModelResults type of graph. The results quantities associated with grid points such as displacement and acceleration can be plotted for a list of grid points. Similarly, the element results quantities such as stresses and forces can be plotted for a list of elements. The user can choose from the results available in the database by using the QuickEditRT pop-up form in the fourth cascading menu, by using the Results Table menu, or by issuing a command. The user specifies an idlist of grid points or elements. This list can be specified by using macros such as ALL, MIN and MAX which are predefined in MSC/XL. The user can also pick the grid points in the view by using the mouse.

Another useful tool for specifying idlists is Groups. The user can collect a list of entities such as grid points and elements into a Group, which is identified by a name. In general, name of a Group can be entered wherever an idlist is to be specified. There are several ways to define a Group. One simple method is to specify a window (rectangular or polygonal) around the entities to be grouped. In conjunction with this window, a logical expression can be specified as an additional criterion. The user can collect entities either inside or outside the window, and specify whether entities on the boundary should be included or not.

Figure 12 shows a plot of Octahedral Shear Stress associated with a list of elements for modes 3 and 4. The QuickEditRT pop-up form at the bottom of the cascading menus shows the current settings of the Results Table.

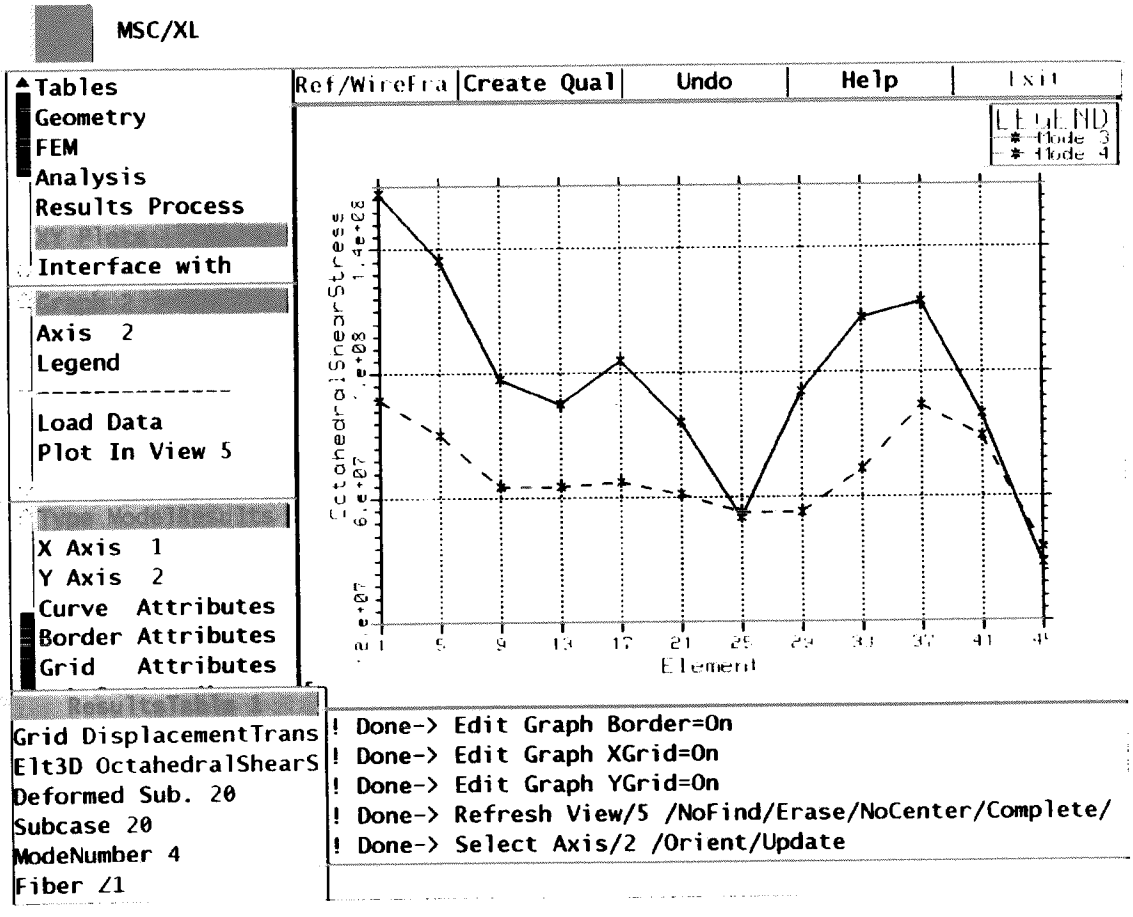

Figure 12: ModelResults XY Plot

XY Plotting of Model Attributes

The XY plotting capability allows the user to plot the variation of model attributes such as PID, MID, grid point location, element thickness etc. The attributes that can be plotted for grid points and elements are listed in the external file XLayout.ddl. This file is the MSC/XL Data Definition Layout file which provides access to the variables associated with various entities. For example, the user can plot the straight line distance of some grid points from the origin of the coordinate system. Such a plot is shown in Figure 13. The attribute has been specified using an MSC/XL Calculator Expression, "(sqrt (x*x + y*y + z*z))".

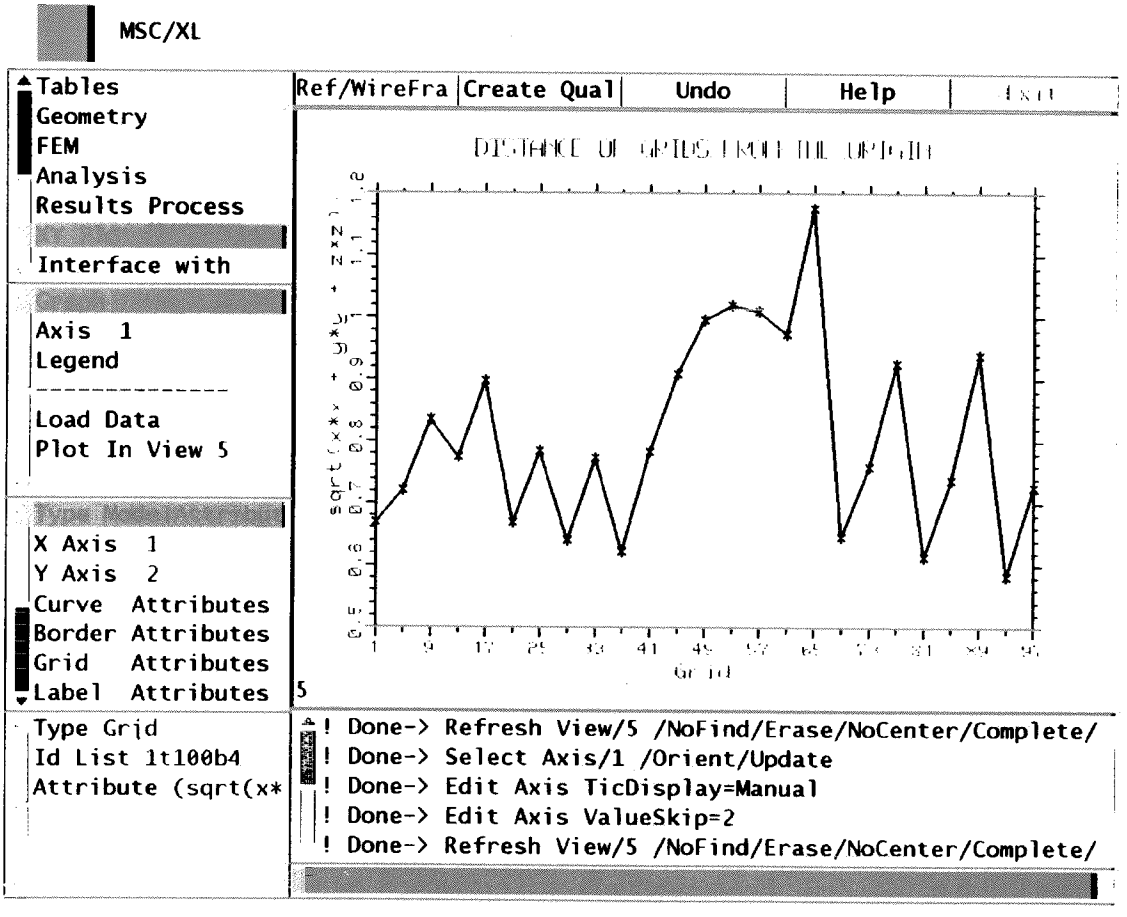

Figure 13: ModelAttributes XY Plot

Import and Export of Data for XY Plotting

Results or analysis data can be imported from external files by using the File type of graph. The format of these external files is similar to the ResultsImport file format

described earlier, except that grid point or element identifiers are not required in the first column. These files can be obtained from previous runs of MSC/NASTRAN or from any other external program. As a result, the user is not limited to the results available on the results database for generating XY plots. In addition, this import of graph data is not done through the Results Table. For example, the user can import test data and compare it with analysis data. This capability can be very valuable to the user.

As shown in Figure 14, the import filename is specified in the fourth cascading menu as *bm2ar2.ext*. The user can select the section of the file and the appropriate columns for X and Y axes of the graph.

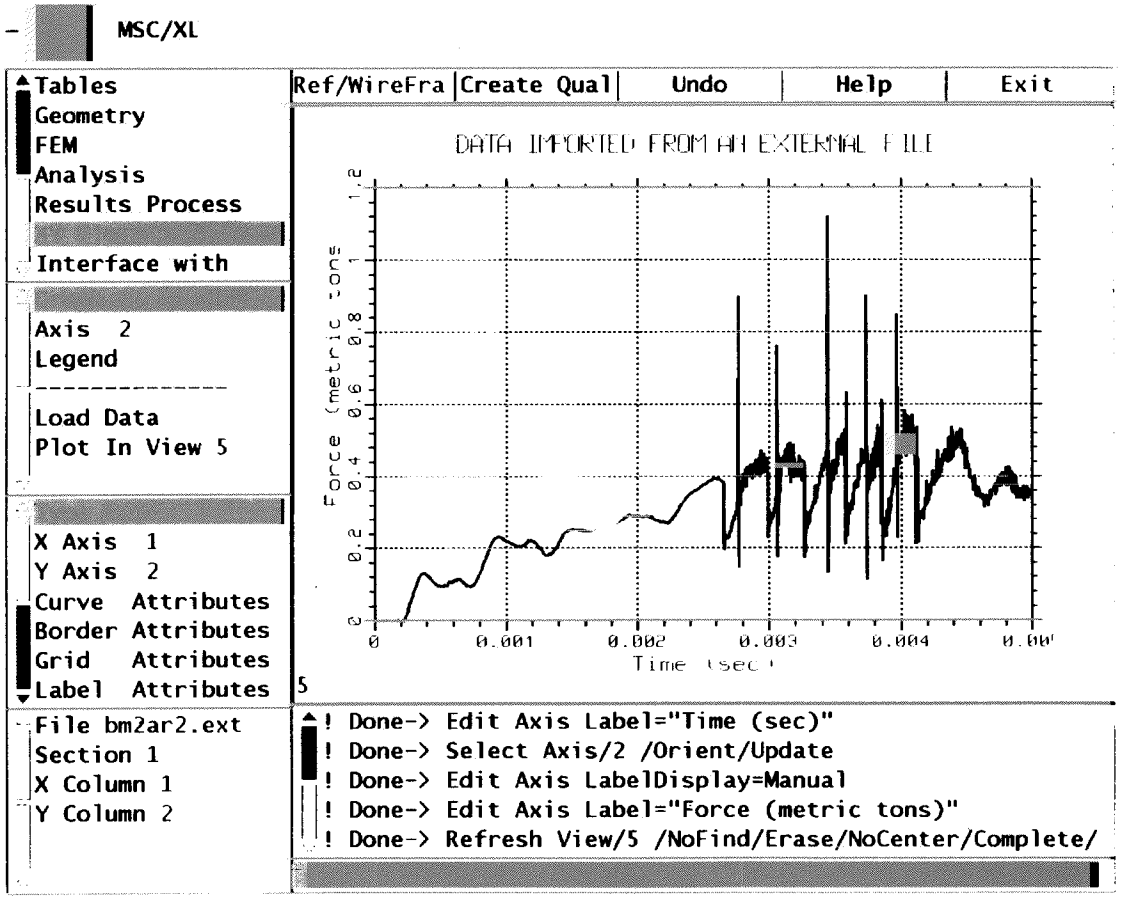

Figure 14: XY Plot of Imported File Data

Graph data can also be exported to external files. This data can be used as input data for an external program, or it can be used for examining a hard copy of the data, and for inclusion in reports. It may also be used for storing data obtained from an MSC/NASTRAN analysis in a format which is ready for import to graphs. The format

of these external files is the same as the format of files for import of graph data. In addition, the user may save data that has been sorted, edited or otherwise modified with the help of various XY plotting tools.

Conversion between Graphs and Table Records

Graphs of table records are a very useful preprocessing tool. These graphs are generated by selecting the XLData type of graph. The user can not only plot the xy pairs contained in a previously defined MSC/NASTRAN TABLED1 card but also generate a graph first, and then ask MSC/XL to create a TABLED1 card from the graph. For example, this type of graph can be used to plot a forcing function before creating a table record for input to MSC/NASTRAN. Figure 15 shows a step funtion described by a TABLED1 card, and a pop-up form showing the TABLED1 entries.

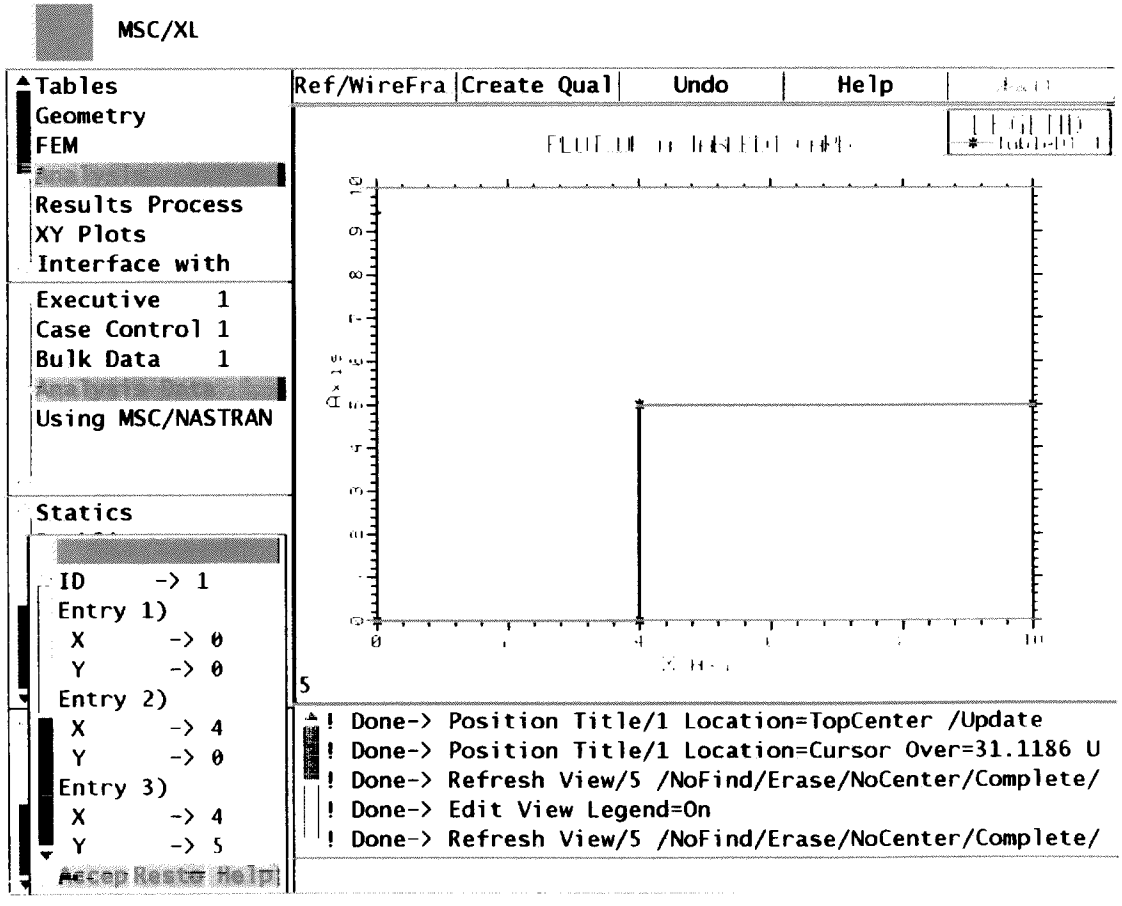

Figure 15: XLData XY Plot

Combination of Graph Data

Data can be extracted from two different graphs to plot a combination graph, by selecting the GraphData type of graph. For example, the user can ask for a plot of the Y axis data from two graphs. This capability can be used to create interaction curves of data from two graphs such as the stress in the first coordinate direction versus the stress in the second coordinate direction.

Editing and Sorting Graph Data

The data associated with a graph can be edited and sorted. Data can be modified, added and deleted interactively by using the XLEdit operation. The XLEdit operation invokes the system editor, allowing the user to edit the graph data. Data can be sorted on the X and Y axes in ascending or descending order. This feature can be used to organize test

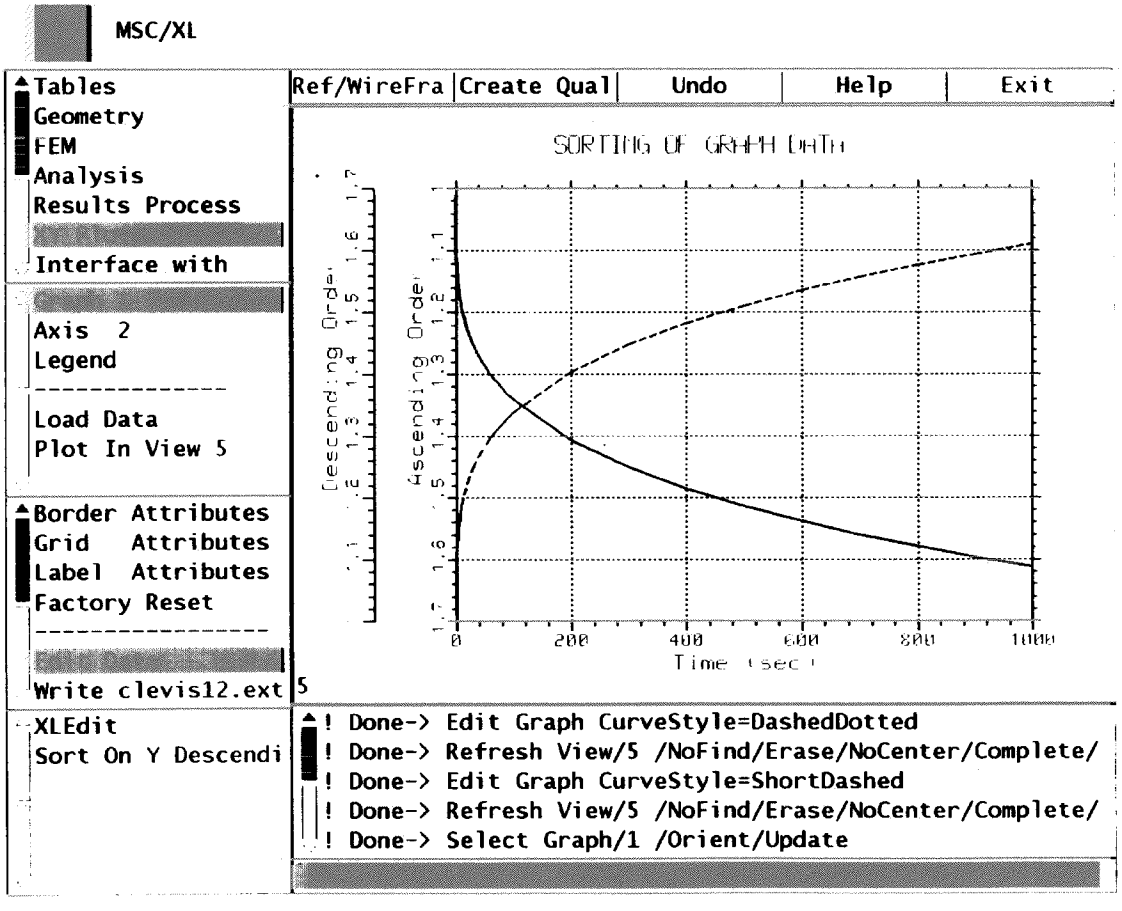

Figure 16: Sorting of Graph Data

and analysis data in a format that is most useful to the user. The edited or sorted data can be exported to an external file as described above, and saved for later use. Figure 16 compares data sorted on the Y axis in ascending and descending order. Note that two Y axes are used to display the ascending and descending order of graph data.

Control of XY Plotting Display Attributes

MSC/XL provides the user with a modern, user-friendly interface for generating XY plots. The user can choose from linear, log and ln scales for axes. The user can control the range of values to be displayed, the intersection of axes, the display of a legend, a border, grid lines, tic-marks, labels and a host of other display attributes. All XY plotting display attributes can be modified from the cascading menus or by issuing commands. The user can display multiple axes and graphs in a view and perform operations like zooming, panning and spinning. In addition, the user can create titles to enhance the readability of the display. Figure 17 shows an example of the display of

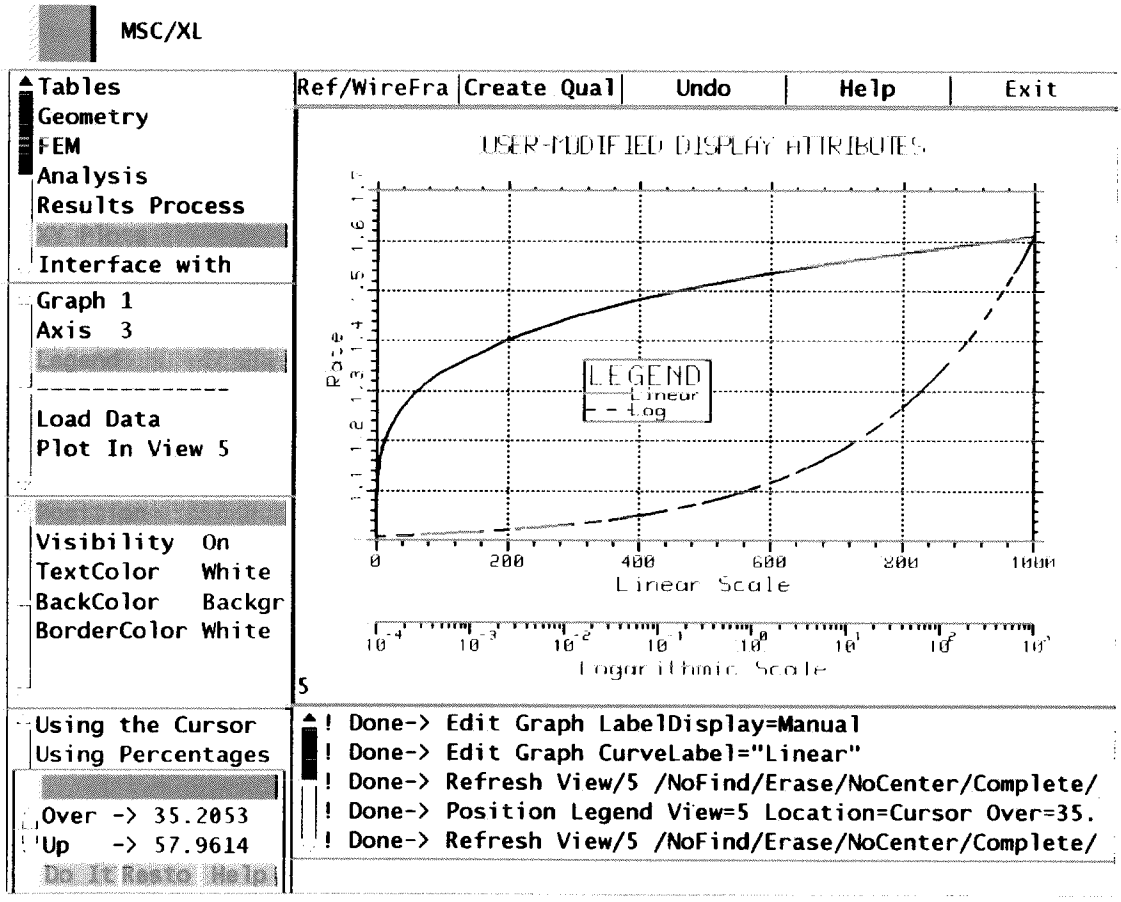

Figure 17: Control of XY Plotting Display Attributes

several graphs in a view, using multiple axes. The legend position and axis labels have been modified by the user. Both graphs display the same data, but one is plotted with a linear X axis, and the other is plotted with a logarithmic X axis. The Position Legend pop-up form in the lower left corner shows the location of the legend, which was positioned by using the cursor.

Appendix

The following list represents all DBC datablocks supported by MSC/XL for MSC/NASTRAN results processing.

Forces

FBARR	FBARRI	FBARMP
FBEMR	FBEMRI	FBEMMP
FCONR	FCONRI	FCONMP
FDMPR	FDMPRI	FDMPMP
FELSR	FELSRI	FELSMP
FGAPR		
FRODR	FRODRI	FRODMP
FTUBR	FTUBRI	FTUBMP
FQD4R	FQD4RI	FQD4MP
FQD8R	FQD8RI	FQD8MP
FQDRR	FQDRRI	FQDRMP
FSHRR	FSHRRI	FSHRMP
FTR3R	FTR3RI	FTR3MP
FTR6R	FTR6RI	FTR6MP

Stresses

SBARR	SBARRI	SBARMP
SBEMR	SBEMRI	SBEMMP
SCONR	SCONRI	SCONMP
SELSR	SELSRI	SELSMP
SGAPR		
SRODR	SRODRI	SRODMP
STUBR	STUBRI	STUBMP
SQD4R	SQD4RI	SQD4MP
SQD8R	SQD8RI	SQD8MP
SQDRR	SQDRRI	SQDRMP
SSHRR	SSHRRI	SSHRMP
STR3R	STR3RI	STR3MP
STR6R	STR6RI	STR6MP
STX6R	STX6RI	STX6MP
SHEXR	SHEXRI	SHEXMP
SPENR	SPENRI	SPENMP
STETR	STETRI	STETMP

Strains

EBARR	EBARRI	EBARMP
EBEMR	EBEMRI	EBEMMP
ECONR	ECONRI	ECONMP
ERODR	ERODRI	ERODMP
ETUBR	ETUBRI	ETUBMP
EQD4R	EQD4RI	EQD4MP
EQD8R	EQD8RI	EQD8MP
EQDRR	EQDRRI	EQDRMP
ESHRR	ESHRRI	ESHRMP
ETR3R	ETR3RI	ETR3MP
ERT6R	ERT6RI	ERT6MP
EHEXR	EHEXRI	EHEXMP
EPENR	EPENRI	EPENMP
ETETR	ETETRI	ETETMP

Grid results

ACCER	ACCERI	ACCEMP
DISPR	DISPRI	DISPMP
VELOR	VELORI	VELOMP
SPCFR	SPCFRI	SPCFMP

GPStresses

SGSPR
SGVPR
SGSVR
SGVVR
SGVAR

StrainEnergy

UBARR
UBEMR
UCONR
UELSR
UGAPR
URODR
UTUBR
UQD4R
UQD8R
UQDRR
USHRR
UTR3R
URT6R
UHEXR
UPENR
UTETR

NLStress

NBEMR
NCONR
NGAPR
NRODR
NTUBR
NQD4R
NTR3R
NHEXR
NPENR
NTETR