INTRODUCTION TO THE GRASP SYSTEM

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ABSTRACT

This paper describes the GRASP (GRaphical Analysis Structural Processor) system currently under development at The MacNeal-Schwendler Corporation. The specific capabilities of this new interactive pre- and post-processing system, designed to provide interactive support for MSC/NASTRAN, are discussed and illustrated with examples taken from a typical engineering analysis.

INTRODUCTION

The GRASP system provides extensive interactive pre- and post-processing capabilities for MSC/NASTRAN. The development effort has been time-phased so that the first release of GRASP will primarily encompass post-processing functions that include:

- Deformed and Modal Plots
- Element Stress Contours
- Output Scanning
- X-Y Plots
- Key-Frame Animation

Additionally, models can be created using the capabilities of MSGMESH and modified with an editor.

GRASP DESIGN

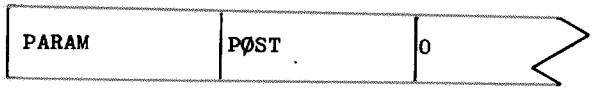
GRASP has been designed as a modular system that performs specific Tasks for the user. A Task is a single operation such as DISPLAYing a structural model, RECOVERing MSC/NASTRAN solution results or EDITing a data file. User input to GRASP is through a simple, yet powerful, command language. Commands are translated by the TASK MONITOR. This monitor then activates the appropriate TASK CONTROLLER for subsequent interactive processing. The first release of GRASP supports the following Task Controllers:

- EDIT - To create and modify Bulk Data Decks
- MESH - To generate a model with MSGMESH
- CONFIGURE - To define the user's graphic device/terminal
- DISPLAY - To support graphic display activity including deformed shapes and contours
- RECOVER - To post-process solution results for output scanning and X-Y Plots
- VIEW - To support graphics display using MSGMESH fields

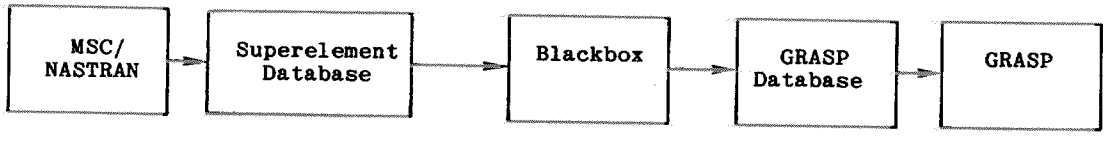
Subsequent releases of GRASP will include fully interactive model generation capability. Human engineering factors have been enhanced by the inclusion of extensive HELP and error diagnosis facilities.

COMMUNICATIONS WITH MSC/NASTRAN

If the user desires to recover solution data from MSC/NASTRAN for post-processing, he enters an additional PARAM Bulk Data card to his deck. The format of this card is:



This card activates a sequence of conditional database store (DBSTORE) modules that place solution results on the Superelement database. A secondary job step follows the MSC/NASTRAN execution. This "Blackbox" creates a direct access GRASP database that will be used for interactive processing. The sequence of operations is illustrated below:



ILLUSTRATIVE EXAMPLE

The remainder of this paper will be devoted to presenting detailed examples of many of the features of GRASP as applied to an engineering problem.

Creating Models

In the Phase 1 release of GRASP, Finite Element models may be created by using the two Task Controllers EDIT and MESH. The EDIT Controller allows the user to input MSGMESH Bulk Data cards into a data file residing on the host computer. The editor allows functions that include:

- Free Field Input of MSC/NASTRAN Data
- Deletion, Insertion and Modification of Data
- Simple Replication of Data
- Insertion of Executive and Case Control Cards

After creating the MSGMESH Bulk Data, as well as any other input required, the user leaves EDIT and executes the MESH controller.

The MESH Controller within GRASP works just as it does in MSC/NASTRAN. It creates the specified element fields, meshes them, creates loads and constraints, etc. Having created the model, the user may now execute MSC/NASTRAN.

Executing MSC/NASTRAN

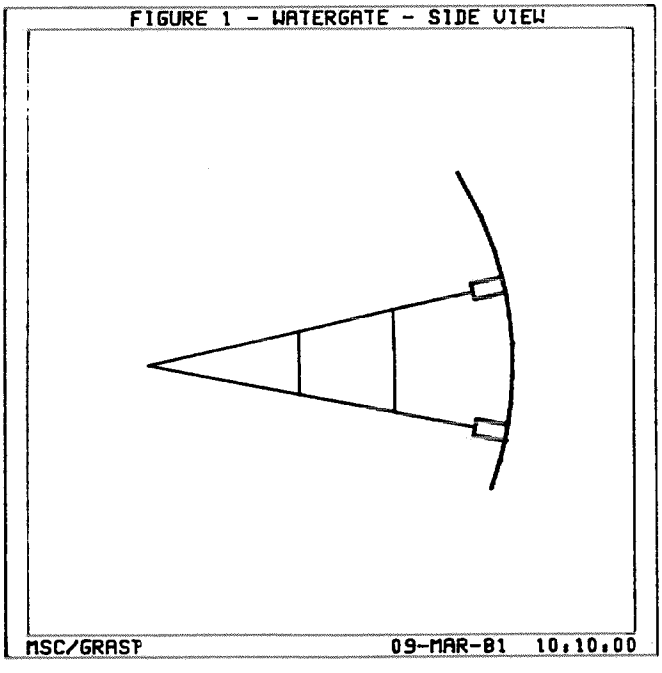
GRASP has the capability, on some computer systems, of directly submitting the MSC/NASTRAN run to the background of the host system. The user is then informed when execution is complete and the solution results available.

Displaying the Model

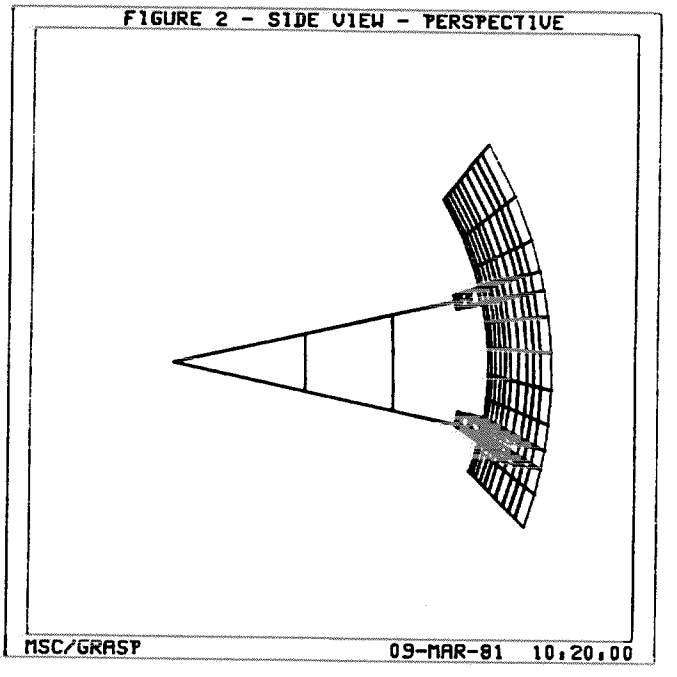
Once the model has been created it may be displayed by the user. Numerous graphic functions are available. These include:

- Viewing Functions
  - Perspective Projection
  - Orthographic Projection
  - Shrunken Elements
  - Hidden Surface Removal
  - Three-Dimensional Clipping
  - Color and Shading
- Modeling Functions
  - Element ID Numbers
  - Grid Point ID Numbers
  - Set ID Numbers
  - Arbitrary Set Definition
- Manipulation Functions
  - Rotation in the Viewing, Basic or Set Coordinate Systems
  - Translation, as above
  - Scaling, as above
  - Arbitrary Zooming

The engineering example to be discussed here is a simple mechanical watergate. Such gates are typically used to control the flow of water through canals and in conjunction with dam projects. An orthographic projection of the side view of such a gate is shown in Figure 1. Clearly seen are the gate itself, the heavy box beams used to stiffen the gate and the arms used to raise and lower the gate to control the flow of water.



The additional clarity that may be gained by the perspective projection is vividly seen in Figure 2 for the same side view.



Creating Graphic Scenes

GRASP allows the user to create complex graphic SCENES from his data by defining arbitrary sets of elements and manipulating such sets in space. Sets are specified in a manner consistant with MSC/NASTRAN with the command:

SET *id* *element-list*

A scene may then be "composed" using any or all of the SETs that have been defined using the command:

SCENE *set-list*

Manipulating Graphics Scenes

Having composed a scene, the user is free to manipulate it in space in any of three coordinate systems:

- The Viewing System (V)
- The Basic System (B)
- A Particular Set System (S)

The scene may be translated, rotated or scaled in any of the coordinate directions with the commands:

TRANSLATE	*set-list*	*coordinate-list*
ROTATE	*set-list*	*angle-list*
SCALE	*set-list*	*scale-factor-list*

Turning to our watergate example, four sets are created:

```
SET 1 1000 THRU 1120 (Gate)
SET 2 1200 THRU 1599 (Stiffeners)
SET 3 2000 THRU 3100 (Box Beams)
SET 4 4000 THRU 4100 (Lifting Arm)
```

These sets are then translated with the commands:

```
TRAN 2 XV  300
TRAN 3 XV -300
TRAN 4 XV -500
```

The resulting exploded view of the model is shown in Figure 3.

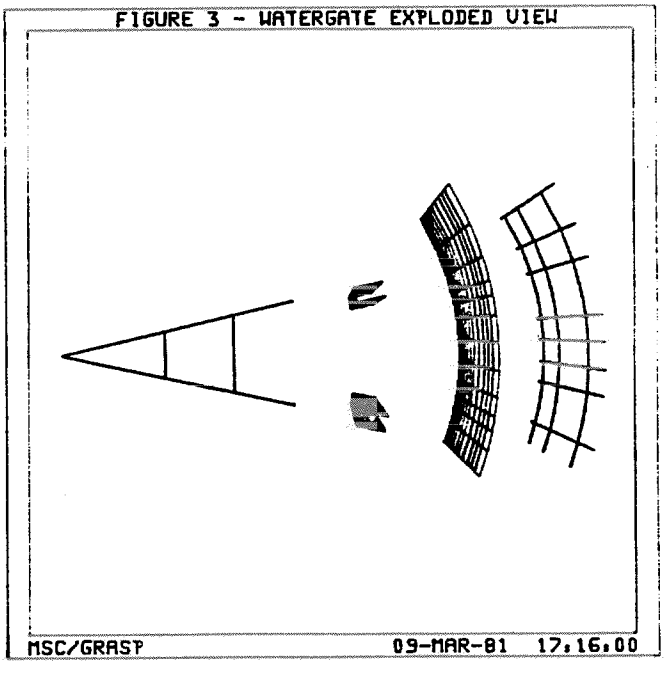


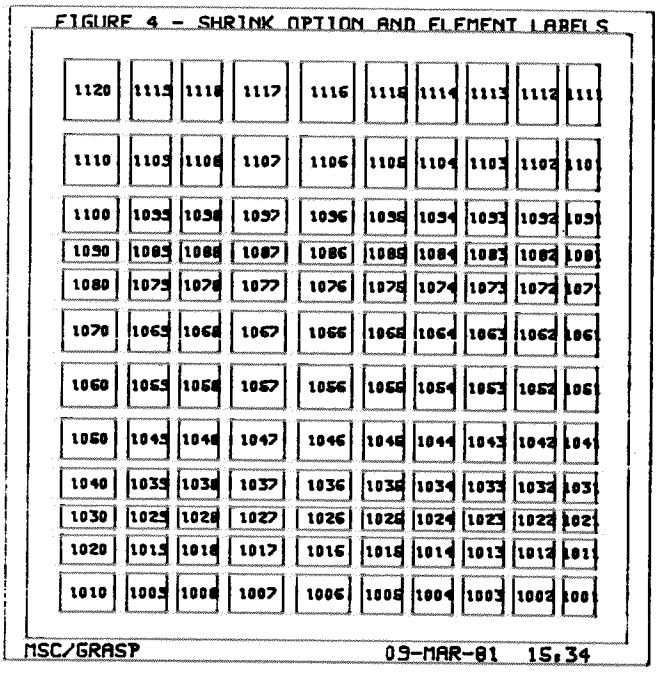
FIGURE 3 - WATERGATE EXPLODED VIEW

Identifying Parts of the Model

By composing a new Scene that contains only SET 1 (the gate) the individual elements may be identified. The shrunken element option aids in this process while showing the analyst that no "holes" exist in the model. The commands:

```
SCENE 1
OPTION ELABEL, SHRINK
SHRINK .3
GO
```

result in the illustration shown in Figure 4. GRID labels can be added as easily.



Clarifying the Model

Through the years techniques have been used to clarify the confusion evident in some graphic displays. One technique used is the outline. Although the concept of an outline of a globally planar surface is well-defined, this is not the case for three-dimensional solids or two-dimensional warped surfaces in three-dimensional space. A better approach, and the one used by GRASP, is to remove hidden surfaces. This technique results in very realistic renderings of structures. Selecting the HIDDEN option and a Scene composed of the gate and its supporting box beams, Figures 5a and 5b are created.

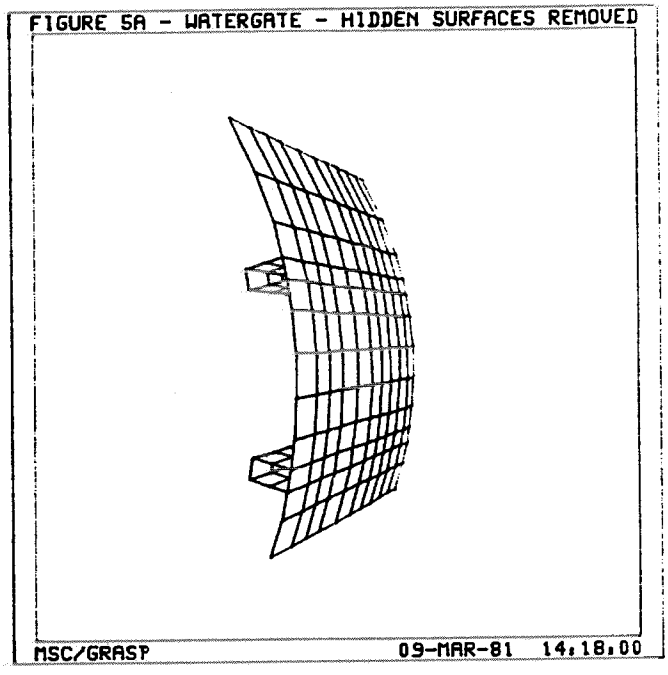


FIGURE 5A - WATERGATE - HIDDEN SURFACES REMOVED
MSC/GRASP
09-MAR-81 14:18:00

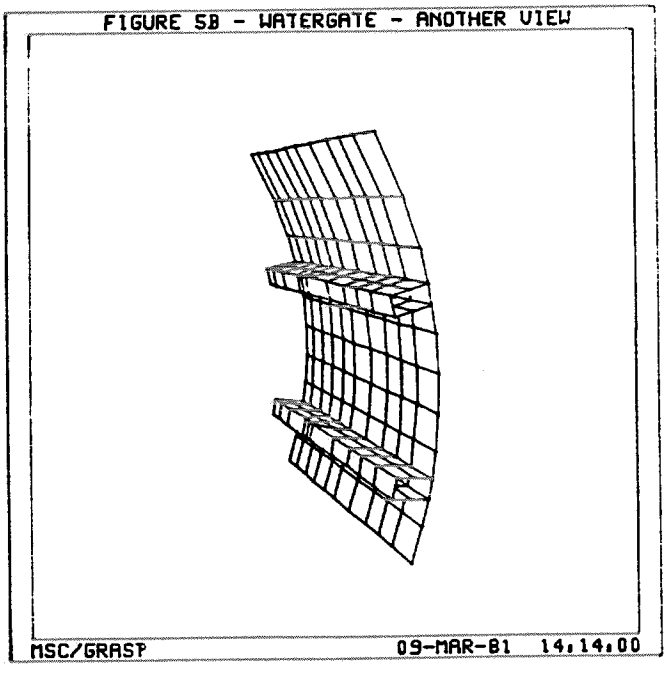
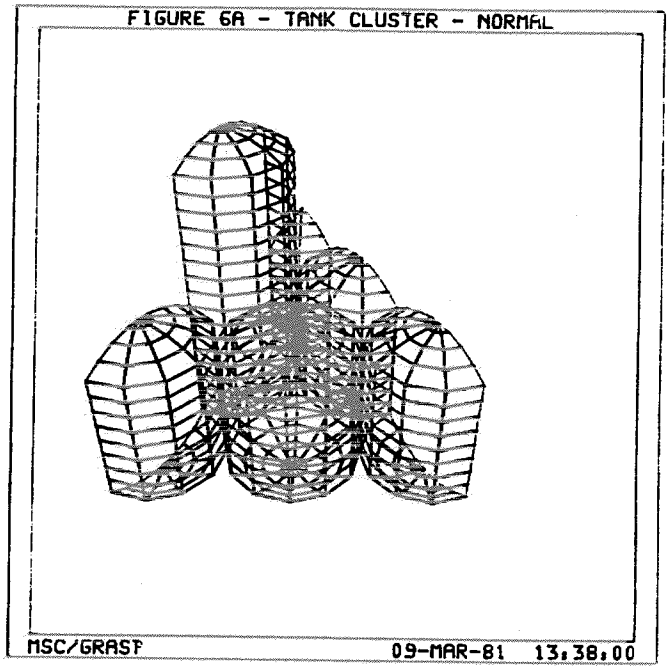
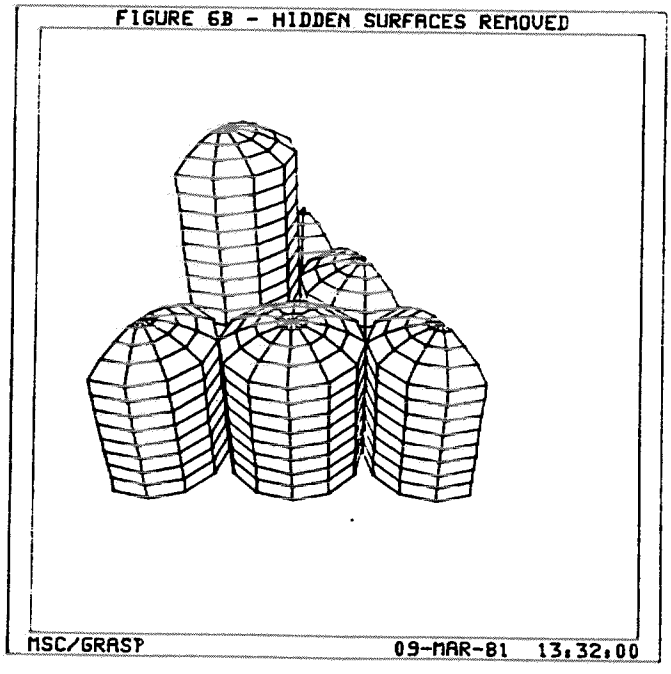


FIGURE 5B - WATERGATE - ANOTHER VIEW
MSC/GRASP
09-MAR-81 14:14:00

More stunning examples, such as the 1/6 model of a cluster of tanks, shown in Figures 6a and 6b, are convincing evidence for the importance of this feature.





Recovering Solution Results

Once the model has been correctly generated, the user executes MSC/NASTRAN to solve his structure. GRASP may then be used to post-process the solution results either as deformed, or modal plots; contour plots of any single output evaluated at the grid points of the model; selected scans of output data items; or X-Y plots that are typically used in transient and frequency response analyses.

Deformed Shapes

GRASP will plot the deformed shape for any Scene that has been composed by the user. Any subcase, mode, time step or frequency may be selected. This is done with the command:

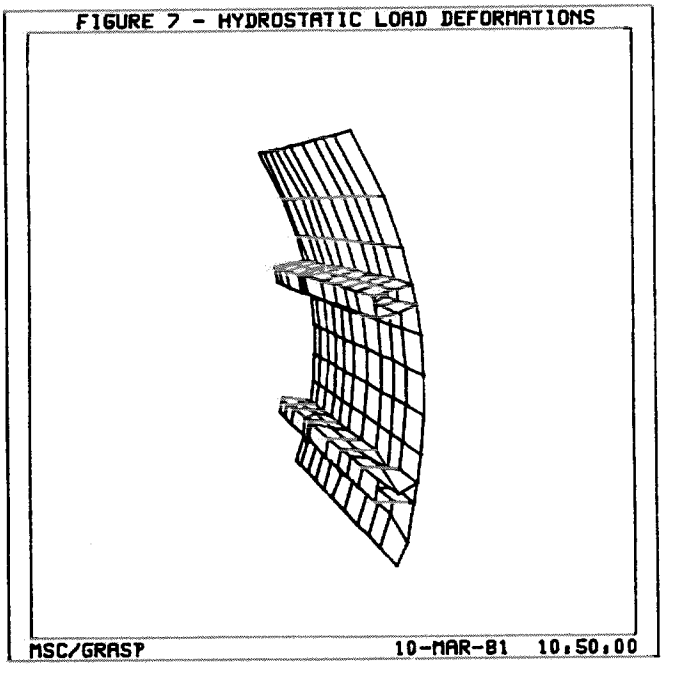
DEFORM *subcase-id* *scale-factor-list* *option-list*

The *scale-factor-list* allows the user to scale the displacement values by any factor independently in the three coordinate directions. If these factors are not selected, the default value of 10% of the largest physical dimension of the model is used. The *option-list* allows the user to underlay the undeformed shape (UNDEFORM) and determine the type of line that will be used (SOLID, DASHED). The displacement of the gate of the example problem (for a simple hydrostatic load), shown in Figure 7, was obtained by the command:

DEFORM 1

where the default values were used for scaling and options.

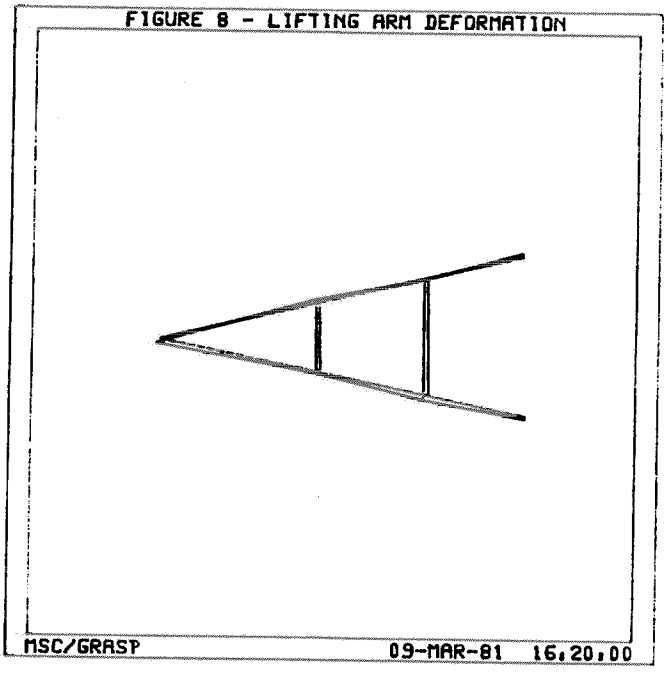
FIGURE 7 - HYDROSTATIC LOAD DEFORMATIONS



To see the effects of this load on the lifting arm, a Scene is created and deformed shape requested:

```
SCENE 4
DEFORM 1    ALL 300. UNDEF DASH
```

where the displacement have been scaled by 300 and the undeformed shape is underlayed with dashed lines. This is shown in Figure 8.



Contour Plots

Any MSC/NASTRAN output item that is calculated for grid points may be contoured over the surfaces of the model. This includes:

- Grid Point Quantities
  - Displacement Components
  - Velocity Components
  - Acceleration Components
  - Constraint Force Components
  - Applied Load Components
- Elements
  - Stress Components
  - Force Components

The user may select the range of the output item and the number of contour levels, to a maximum of 25, that will be drawn in the range. This is done with the command:

CONTOUR *subcase* *levels* *item* *range* *options*

Available *options* include placing labels on the contour lines and printing a table of the contour values. Note that contours may be drawn only when the HIDDEN option is used to avoid confusion. Figure 9 shows a contour plot on the surface of a portion of the gate.

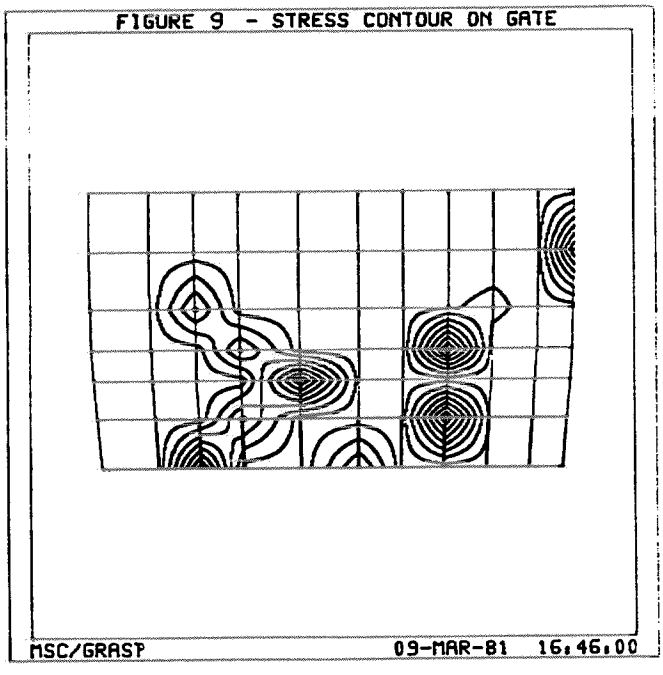


FIGURE 9 - STRESS CONTOUR ON GATE

Output Scanning and Reporting

All MSC/NASTRAN output, both at grid points and elements, may be selectively reported by using the RECOVER Controller. There are five hierarchies of data definition for tables of output:

- Row
- Column
- Page
- Chapter
- Book

The user is free to specify the particular sort order of data by entering the quantities he wishes to display at a given level. The available classes of output are:

- Grid or Element List
- Time or Frequency List
- Subcase List
- Item List
- Superelement List

The table below shows a typical report where rows have been defined as grid points; columns as output items; and pages as subcase ID's. Notice that, unlike MSC/NASTRAN, output types, here displacements and loads, may be mixed.

GRASP RECOVERY MODULE OUTPUT

SUBCASE 1

	ITEM LIST		
GRID	DT1	DR2	PT3
11	1.3121E-02	1.8886E-03	-1.4700E+03
12	1.1924E-02	7.9978E-04	-4.6200E+03
13	1.0532E-02	2.8893E-03	-2.1000E+02
14	8.9710E-03	1.8594E-04	-2.9400E+03
15	7.3659E-03	-1.9565E-03	-1.6800E+03

SUBCASE 2

	ITEM LIST		
GRID	DT1	DR2	PT3
11	-9.7064E-03	1.1467E-03	-1.0500E+03
12	-1.2320E-02	6.5642E-04	-3.3000E+03
13	-1.3658E-02	2.1507E-03	-1.5000E+02
14	-1.4282E-02	1.3396E-04	-2.1000E+03
15	-1.3843E-02	-1.4748E-03	-1.2000E+03

The next table illustrates the capability to create any sort desired by the user. Here, rows are defined as subcases; columns as grid ID's; and pages as output items.

GRASP RECOVERY MODULE OUTPUT

ITEM LIST DT1

SUBCASE	GRID 11	13	15
1	1.3121E-02	1.0532E-02	7.3659E-03
2	-9.7064E-03	-1.3658E-02	-1.3843E-02
3	2.3912E-02	7.6577E-03	-9.2494E-03

ITEM LIST DR2

SUBCASE	GRID 11	13	15
1	1.8886E-03	2.8893E-03	-1.9565E-03
2	1.1467E-03	2.1507E-03	-1.4748E-03
3	1.2711E-03	2.0854E-03	-1.4750E-03

GRASP RECOVERY MODULE OUTPUT

ITEM LIST PT3

SUBCASE	GRID 11	13	15
1	-1.4700E+03	-2.1000E+02	-1.6800E+03
2	-1.0500E+03	-1.5000E+02	-1.2000E+03
3	-1.0500E+03	-1.5000E+02	-1.2000E+03

The output scanning capability provides maximum flexibility for textual output presentation.

X-Y Plots

RECOVER also controls the creation of X-Y Plots of solution results. As with output scanning, there are five hierarchies of data definition:

- Abscissa Parameter
- Ordinate Parameter
- Page
- Chapter
- Book

This allows many plots to be specified in a single plot command. GRASP also supports multiple plots on each frame.

SUMMARY

This paper has presented some of the Phase 1 GRASP capabilities to be released soon by The MacNeal-Schwendler Corporation. The system has been designed to provide interactive pre- and post-processing functions for MSC/NASTRAN and to improve the effectiveness of the structural engineer.