National Defence
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DREA CR/98/402

MODELLING AND REFINING STRUCTURAL DETAIL IN A **MAESTRO** MODEL FOR A BOTTOM-UP OR TOP-DOWN ANALYSIS USING THE PC VERSION OF **MAESTRO/DSA**

by
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CONTRACTOR REPORT

Prepared for

Defence Research Establishment Atlantic

Centre de Recherches pour la Défense Atlantique

Canada

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Accepted by :
Layton Gilroy - Contract Scientific Authority

October 1997

W7707-6-3561
Contract Number

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Abstract

The report describes the process for modelling and refining structural detail of a ship, for which a MAESTRO model has been created, in preparation for a bottom-up or a top-down detail stress analysis. The detail can be modelled by either locally refining the MAESTRO model, using the program MAESTRO/DSA, or by creating the model separately with a mesh generator such as HYPERMESH. The processing of the results to display them in graphic form suitable for the documentation program LaTeX is also illustrated.

Résumé

Le présent rapport décrit le processus de modélisation et d'affinage du détail structural d'un navire pour lequel un modéle MAESTRO a été créé, en vue de préparer une analyse ascendante ou descendante des contraintes de détail. Le détail peut être modélisé localement par affinage du modéle MAESTRO, en utilisant le modéle MAESTRO/DSA ou en créant le modéle sparment avec un générateur de maillage comme HYPERMESH. Le traitement des résultats en vue de leur affichage sous une forme graphique compatible avec le programme de documentation LaTeX est également illustré.

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1 Introduction

The computer code MAESTRO[1] has been developed for the finite element analysis of the global structural behaviour of ship hulls. When used for such an analysis, details such as stress concentrations around openings and other geometries which require fine grids cannot be assessed. MAESTRO can, however, provide boundary conditions for fine mesh models of structural details generated for a general purpose finite element code. There are two types of detail analyses that can be performed in conjunction with a MAESTRO global analysis to obtain detail stresses at various locations of a ship structure. One method is top-down analysis where a MAESTRO global analysis of a ship structure is carried out and then a detail of the ship structure is refined using the program MAESTRO/DSA[2]. An option to this method is to generate an external finite element model of the detail as a VAST[3] geometry file, using a mesh generator such as HYPERMESH[4] and read it in through MAESTRO/DSA and append it to the MAESTRO ship model. In the case where an externally generated model is used the MAESTRO elements it replaces must be deleted first.

The second method is the bottom-up or superelement method. This procedure can achieve the same purpose as top-down by two processes. One is to refine the detail area in place on the MAESTRO model, in which case a superelement is created automatically and is inserted into the MAESTRO model equilibrium equations in the form of statically condensed stiffness matrices. The second process involves the removal of the portion of the MAESTRO model which is replaced with an externally generated detail model of the portion removed. The externally generated detail is treated as a superelement in the same manner as the internally generated detail model.

In both the top-down and bottom-up methods the Master and Slave nodes are identified to account for incompatibility at the boundaries. The type of analysis to be carried out, either top-down or bottom-up, is chosen and the DSA (Detail Stress Analysis) file is created. The file is then used by MAESTRO in conjuction with VAST to obtain the stresses in the detail structure.

This report describes the procedure followed in producing a DSA file for a bottom-up and a top-down analysis using a laptop computer. The processing of results to display them in graphic form suitable for a document preparation system, such as LaTeX[5], is also described as well as the process of transfering graphic files to a Silicon Graphics workstation for enhanced display of the models and the analytical results.

2 Bottom-up Procedure Using an Externally Generated Model

An external model was created using the mesh generating program HYPERMESH. With the model created the following procedure is used to merge the detail model with the MAESTRO model and produce a DSA file.

With Windows 95[6] loaded on the laptop PC.:

Click On: START

Click On: PROGRAMS

Click On: MS-DOS Prompt

To load the program MAESTRO/DSA, connect to its folder directory

cd \maestrod\v71aug26

The run command is RUNMG

2.1 MAESTRO Graphics Mode to Localize the Area to be Detailed

The following is the procedure for removing a portion of a MAESTRO model in preparation for adding an externally generated detailed model of the portion removed. The program is run in the MAESTRO Graphics mode to proceed. This can be confirmed by checking the lower right hand area of the screen where MG> MODE = Menu should be displayed. If it is not, a Click on the alternative display DSA> MODE = MENU will restore it.

Click On: FILE

Enter MAESTRO Job Name, in this case CPF71

Click On: OK

Click On: NO to ARE PLC/PLE/PLN FILES Available?

The model is automatically plotted as a wire model as shown in Figure 1

Click On: PLOT

Click On: PLOT FILL HIDE to plot as a panel fill model.

The panel fill model is shown in Figure 2
Remove the superstructure to expose the area where structure is to be refined.

Click On: Erase/Restore

Click On: SUBSTRUCTURE/MODULE

Click On: OK to table

Click On: 3 then OK in this case to remove superstructure

Click On: PLOT then FILL HIDE

Click On: Choose -Y axis at bottom of screen

Click On: Erase/Restore then BOX cursor OK

Window the portion of the hull in which detail is to be inserted by creating. a four point box around it.

Click On: -Z view

Click On: OK in BOX Menu

Window the portion of the deck and bulkheads to be retained for eventual deletion by forming a four point box around it. Use as many boxes as required by clicking on OK for each box

Click On: View V1 for an oblique view

Click On: -RH to rotate about horizontal axis as required to expose structure to be deleted.

Click On: Cancel to bring up Erase/Restore

Click On: CURSOR

Indicate the individual MAESTRO elements to be removed by locating their centroids with the cursor.The portion of the MAESTRO model to be deleted is shown in Figure 3.

After the model to be deleted has been identified as the remaining structure switch to DSA mode.

Click On: MG> MODE=MENU to obtain DSA> MODE=MENU

2.2 Detail Stress Analysis Mode

The deletion of the portion of the structure, to be replaced by the externally generated detail, is carried out as follows.

Click On: Generate/Modify, then ELEMENTS, then DELETE, to remove the portion of the deck, identified in the previous procedure, by windowing the whole of the remaining MAESTRO structure with a box of four points located with the cursor.

Click On: Single to bring up box then OK

Click On: OK to accept Inside. Then encompass the structure to be deleted with the four point box.

Click On: YES to proceed with BOX OPERATION

Click On: OPTIONS then DISPLAY

Click On: DELETE displays the structure deleted

To restore the complete MAESTRO model, proceed as follows.

Click On: DSA/MODE=MENU to bring MG/MODE=MENU

Click On: Erase/Restore then INITIALIZE

Click On: Fill to display MAESTRO model.

Click On: MG/MODE=MENU

Click On: Options, then DISPLAY then UNDELETE to display undeleted portion of the MAESTRO model

Click On: DELETE to display deleted portion.

Read in the externally generated detail model.

Click On: FILES

Click On: DSA and enter externally created model file name.

Click On: READ

Click On: GEOMETRY and ELEMENT File

Enter the file name (in this, case BIGMF) which is the VAST geometry file for the detail structure that has been created externally.

Click On: NO to append to existing model.

The detail model is displayed for inspection as shown in Figure 4 with the axes properly oriented (although it is initially plotted inverted).

To append the model to the full structure, proceed as follows:

Click On: FILES

Click On: DSA

Click On: READ

Click On: GEOMETRY and ELEMENT File

Click On: YES to append to existing model.

The detail model is displayed inserted into the MAESTRO model, in place of the deleted structure, as shown in Figure 5.

Restore the entire structure in preparation for the generation of master nodes and slave nodes.

Click On: DSA> MODE=MENU to obtain MG> MODE=MENU

Click On: Erase/Restore

Click On: SUBSTRUCTURE/MODULE

Click On: 3 then OK to restore superstructure

Click On: MG> MODE=MENU to obtain DSA> MODE=MENU

2.3 Generating Master Nodes and Slave Nodes at the Interface

The master and slave nodes required for the boundary conditions are generated as follows:

Click On: Erase/Restore

Click On: MAESTRO

Click On: ERASE to remove MAESTRO model to leave only the refined detail model.

Click On: Generate/Modify then NODES

Click On: MASTER

Click On: use COINCIDENT MAESTRO NODES YES

The tolerance for the location of coincident master nodes is requested. The selection of the tolerance is important as too fine a tolerance, especially for externally generated detail, may result in some coincident nodes being missed. After the master nodes have been identified then proceed with slave nodes.

Click On: SLAVE, Line, then OK

Figure 6 shows the master and slave nodes located on the detail model.

2.4 Creating a Detail Stress Analysis DSA File

After slave nodes have been identified, return to screen display.

Click On: INTERFACE

Click On: MAESTRO/DSA

Click On: SUPERELEMENT ANALYSIS

Click On: CREATE DSA Files

Click On: FILES

Click On: EXIT

2.5 Running the DSA Analysis

The DSA file for the analysis has been created and MAESTRO can be run with the option to carry out a detailed stress analysis selected. The command to run the analysis are:

Click On: START then PROGRAMS

Click On: MS DOS Prompts

Connect to the MAESTRO/DSA file

```
c:Windows>cd \maestrod\v71aug26

c:\maestrod\v71aug26>maestro cpf71/dsa
```

The MAESTRO analysis automatically runs with the superelement in place and the displacements required for the designated master nodes are generated. The detail stress analysis portion of the run begins on the completion of the MAESTRO run. The progress of the stages of the analysis is displayed on the screen.

3 Top-down Procedure Using an Externally Generated Model

The top-down procedure when using an externally generated detail model is essentially the same procedure as for bottom-up. Starting initially in the MG/MODE, the region in the MAESTRO model to be replaced is isolated using the Ersae/Restore option. The mode is then switched to the DSA/MODE and the region is deleted by using Generate/Modify as in the bottom-up procedure. The DSA file is created in the same way as for bottom-up,as described in subsection 2.4, except that TOP-DOWN ANALYSIS is chosen in place of SUPERELEMENT ANALYSIS. The procedure for running the analysis is identical to that described for bottom-up in subsection 2.5.

4 Generating a Refined Model in the MAESTRO Model

The analysis of the stresses in a hull detail is most often accomplished by refining the local detail in place with DSA. It is carried out as follows.

4.1 Refining MAESTRO Elements in the MAESTRO Model

Click On: File and enter the MAESTRO file name e.g. cpf71

It may be desirable to chose No to ‘ ARE PLC/PLE/PLN FILES’ Available in order to renumber the NODES which may be required if previous operations have been carried out. In any case a wire plot will be displayed to confirm the presence of the model.

Click On: DSA mode

Click On: Erase/Restore to define region to be refined.

Click On: Box then OK to Cursor and separate out the region

Click On: On/Off then switch ON Stiffener Display

Click On: Fill to display model with stiffeners.

Click On: Generate/Modify

Click On: Refine

If beams are present the general 3D beam element is the simplest to apply. The plated beams often require considerable planning at beam to beam intersections. The process for refining the general beam elements is as follows.

Click On: Element

Click On: Line to refine beams.

Click On: MAESTRO beam with cursor and accept or change the number of beams

Click On: Cancel to return to elements.

Click On: Stiffened Panel. The number in the first line defaults to 2 elements between stiffeners, the second line defaults to 5 elements accross.

Click On: The MAESTRO elements to be refined.

Click On: The space to the right of the plot to return to the menu.

An example of refinement of the local structure of a ship structure is shown in Figure 7.

Click On: Cancel

Click On: Nodes

Click On: Master nodes

After defining master nodes, then

Click On: Slave nodes

After defining Master and Slave nodes, equivalence and compress the elements by

Click On: Regular nodes

Click On: Equivalence

Click On: Compress

Click On: Interface

Click On: MAESTRO/DSA

Click On: Either TOP DOWN Analysis or SUPERELEMENT analysis

Enter DSA file name

Click On: Files

Click On: Exit

4.2 Using the Mesh Option

When refining a detail on a MAESTRO ship model it is often found that the MAESTRO element geometry is too crude to properly represent the detail required to model the stress field present on the ship. In such a situation, refining alone will not be sufficient. Such a case is shown in Figure 8, which is a large opening in the ship deck extracted from the MAESTRO model. The corners of the opening are approximated by triangular MAESTRO elements, when in fact they are made up of radii with a coaming . In this case, the majority of the model is refined using REFINE from the menu activated by clicking on Generate/Modify. The refinement of the deck region of the large opening is shown in Figure 9, using stiffened plates with the corner plates untouched. The refinement of the bulkheads of the large opening is shown in Figure 10. The beams are refined as regular beams using line elements. The corners are refined using the MESH option.

In preparation for meshing, a properties file had to be created as the meshed elements are new elements and do not use the MAESTRO element data. The properties file was created as follows:

Click On: Files

Click On: PROPERTY

Select: New

Enter: Property file name

Click On: OK

Click On: Generate/Modify

Click On: PROPERTIES

Click On: UNITS

Click On: MATERIAL and enter the required properties.

Click On: PLATE and enter the required properties.

Click On: STIFFENER and enter the required properties. Repeat as many times as there are different stiffeners.

Click On: BEAMS if defined by crossection dimensions.

Click On: SECTION if the beams are to defined with section properties

The return to the Generate/Modify menu is achieved by canceling the displayed menus until the main Generate/Modify menu is displayed. Prior to meshing, reference was made to pages 35 and 44 of VAST GRAPHICS SYSTEM user manual[7].

Click On: Delete then Cursor then the MAESTRO elements in the corner to be deleted.

An enlarged view of the corner of the large opening with the MAESTRO corner fillet element and beams removed is shown in Figure 11.

Click On: MESH

Click On: PLATE then Click on plate type until the Triangular Plate is obtained. Select meshing proportions consistent with ajacent elements, in this case 6 3 4 for 3 nodes along one side and 4 along the other and 6 along the hypotenuse. Change straight to radius.

Click On: the element nodes locating the hypotenuse by first starting with the side with 4 elements. Then locate the third node as the orientation point.

Click On: the Radius of the RADIUS OPTION window and enter the radius required. The Chord option draws a curve through the chosen points, as shown in Figure 12,while the Tangent option may not.

Click On: OK unless biasing of the nodes is required.

A gridded triangle is formed which can be accepted or rejected. If accepted the meshed triangle is drawn as shown in Figure 13. An enlarged view of the mesh is shown in Figure 14. Frequently in the case where a tangent radius is chosen the triangular plate nodes do not exactly match the adjacent plate nodes. This can be corrected by selecting NODES from the main GENERATE/MODIFY menu and then REGULAR followed by EQUIVALENCE. The node to be moved is clicked on first followed by the node it is to be matched with.

The next step, if a compound radius is required, would be to add two curved triangular elements to represent the radii at the corner. In this case a single radius is used and a collar representing the coaming around the opening is created. The collar is located in the MESH menu of GENERATE/MODIFY. The collar is formed with two elements whose height dimensions WT and WB as shown in Figure 14.8-2 of Reference 6. The default grid is defined by Netel in the element form display eg: 5 2 2 which indicates 5 elements along the length 2 above and 2 below the deck. This is changed in this case to 6 1 1 to suit the surrounding plate mesh. The collar thickness is defined by the plate property number. The ends of the collar are located with the cursor, as is the third point which is the orientation point as shown in the referenced figure. If a curved collar is required, then the FORM must be changed to Radius and a value entered after clicking on OK. A curve will be drawn for inspection which can be accepted. If rejected another radius can be tried. When accepted the gridded collar is drawn and any mismatch of the nodes with the adjacent plate can be corrected by using the equivalencing option. The curved collar is shown attached to the fillet in Figure 15. The addition of straight portions is shown in Figure 16. The attachment of straight portions to the curved portion is much more difficult to achieve when the Tangent radius option is used.

5 Hardcopying the Screen Graphics

A hard copy can be made of any of the screen displays by clicking on H/C on the top the screen buttons. A Postscript file will be created after entering the file name at the prompt at the bottom of the screen. The file name must contain the suffix .eps so that it will be compatible with the screen previewing program Ghostscript[8], and the Silicon Graphics workstations should the file be transferred there.

5.1 Previewing Hardcopy Files

The hardcopy in the form of a Postscript file can be previewed before printing by exiting MAESTRO/DSA and continuing as follows;

Click On: START

Click On: Programs

Click On: GS Tools

Click On: GSview 32

Click On: FILE button

Click On: Open

Double Click On: desired .eps (encapsulated Postscript) graphics file to preview the file.

Click On: FILE then select File to view another file or Exit to end previewing.

5.2 View Orientation

The orientation of the preview graphics is controlled by the graphics driver located in folder gssgks as cgi.cfg. The orientation is normally landscape which can be changed to portrait by editing cgi.cfg using the VI editor in Windows 95.

Click On: START

Click On: PROGRAM to MS-DOS Prompts

Enter the following commands after the Windows prompt indicating the C drive is in use. The subdirectory is drivers and the file name of the postscript control program is cgi.cfg.

C:\WINDOWS>cd\gssgks\drivers

Check for the existence of the file

C:\gssgks\drivers>dir *.cfg

To edit with VI

C:\gssgks\drivers>vi cgi.cfg

The orientation can be changed to either portrait or landscape.

CTRL Z ends the editing

5.3 Transfering a Graphics File from the Laptop to a Silicon Graphics System

After a hardcopy of a graphics file has been created it can be transfrered to a Silicon Graphics workstation as a .eps(encapsulated Postscript)file for further viewing and or processing by a document preparation system such as LaTeX. The method for transferring the file is as follows.

Click On: START then PROGRAMS

Click On: MS-DOS Prompt

Go to windows for file transfer protocol.

C:Windows>ftp.exe

ftp>open

(to)palantir (the name of the Silcon Graphics station)

User(————)smith

Password:

Connect to laptop folder containing the eps file

ftp>lcd c:\maestrod\v71aug26

Switch to binary to transfer files

ftp>binary

Connect to Silcon Graphics directory

ftp>cd /remote/greatwhite/big1/hydro/smith/models

Place file in directory

ftp> put don1.eps

5.4 Preparing DSA Generated Graphics Files for LaTeX Processing

A hardcopy file generated by MAESTRO/DSA is in Postscript format. It can be previewed on the Silicon Graphics workstation for confirmation after transferring from a PC computer. If it was generated using portrait as the orientation, the picture will appear distorted when viewed because the aspect ratio is incorrect. This distortion can be corrected in the LaTeX specification for the figure with a special statement found on page 6 of the DVIPS: A TEX Driver.

\special{psfile=filename.ps[key=value]}

key options are:

hoffset = The horizontal offset(default 0)

voffset = The vertical offset(default 0)

hsize = The horizontal clipping size(default 612)

vsize = The vertical clipping size(default)

hscale = The horizontal scaling factor(default 100)

vscale = The vertical scaling factor(default 100)

angle = The rotation(default)

clip = Enable clipping to the bounding box

An example of the use of the special feature is shown in the following LaTeX figure specification.

```
\begin{figure}
\special{psfile=stress1.eps hoffset=-50 voffset=-500 hscale=90 vscale=60}
\vspace{7.0in}
\caption{ }
\label{f9}
\end{figure}
```

An example of the element stresses plotted with and without the use of the special statement is shown in the following figures, where Figure 17 shows the graphics without the use of the special feature and Figure 18 shows the graphics with its use.

6 Comments

The Laptop version of MAESTRO/DSA is shown to be capable of refining structural detail in a MAESTRO model to obtain the detail stresses at a local area of a global model. The two methods of modeling the detail are demonstrated. One is by refinement using the capabilities within the program and the other is by generating a refined model externally. Both methods of modelling the detail work satisfactorily, as do the element and node creation routines. The top-down analysis works very well, however, the bottom-up analysis gives unreliable results, the reason for which has not been determined.

Other problems encountered with the program were as follows;

(a)Externally Generated Model: The externally generated model, when initially read into MAESTRO/DSA, is plotted inverted when not appended to the MAESTRO model.

(b)Meshing: To fit elements to a fillet radius, such as found in a deck opening, is an important requirement. A radius can be guaranteed to fit between the selected nodes without equivalencing the nodes of the adjacent elements with the use of the cursor if the Chord option is used when defining the radius. This is seldom the case if the Tangent option is chosen. The same applies when fitting a collar element to represent the coaming along the fillet radius.

(c)Hardcopy: This option can not produce a portrait view of the screen image without distortion. It requires the use of a special LaTeX feature to produce suitable report quality figures. The hard copy of the screen image showing fringe plots of the stresses did not remove all of redundant background, although it did so when copying an element stress plot. The hard copy of the beam stresses did not respond to the strut width setting. The option to plot beams failed to reproduce the beams as displayed in the screen image because they were plotted first and were then obscured by the elements which were plotted last. The master and slave nodes, although they appeared on the screen image, were not plotted on the hardcopy of the image.

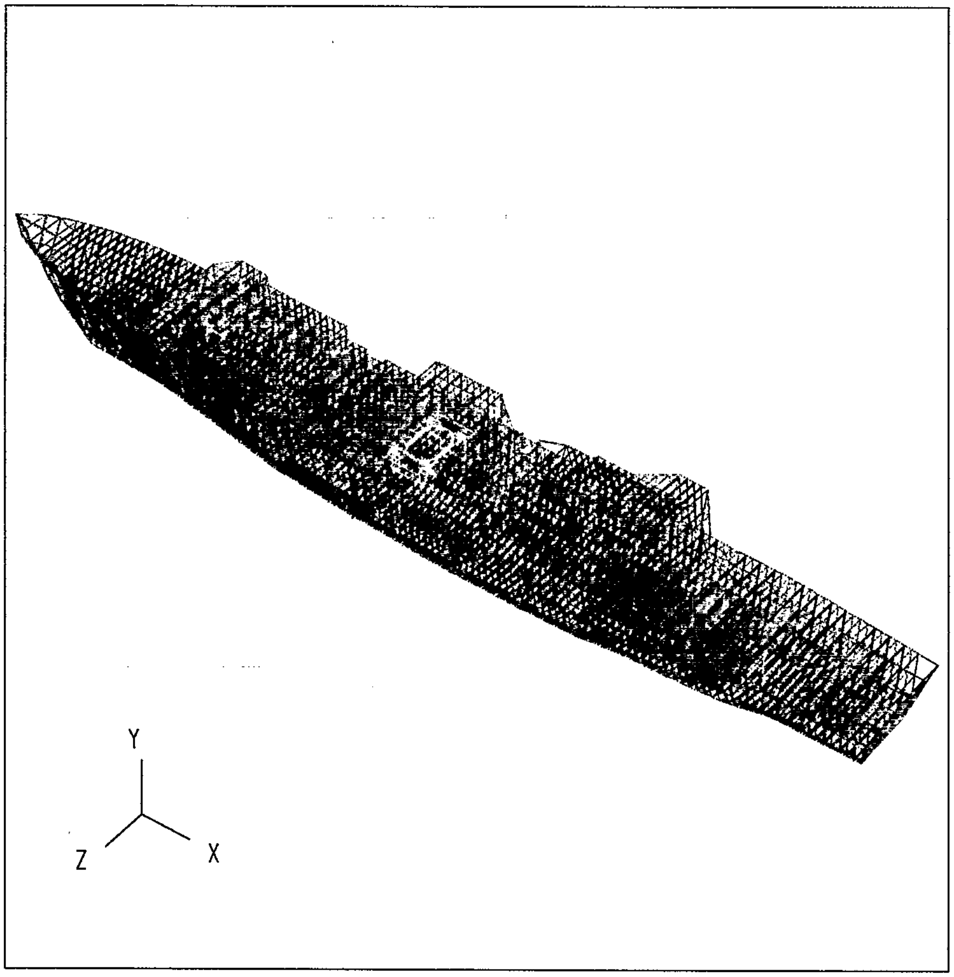

Figure 1: Wire Drawing of MAESTRO Ship model

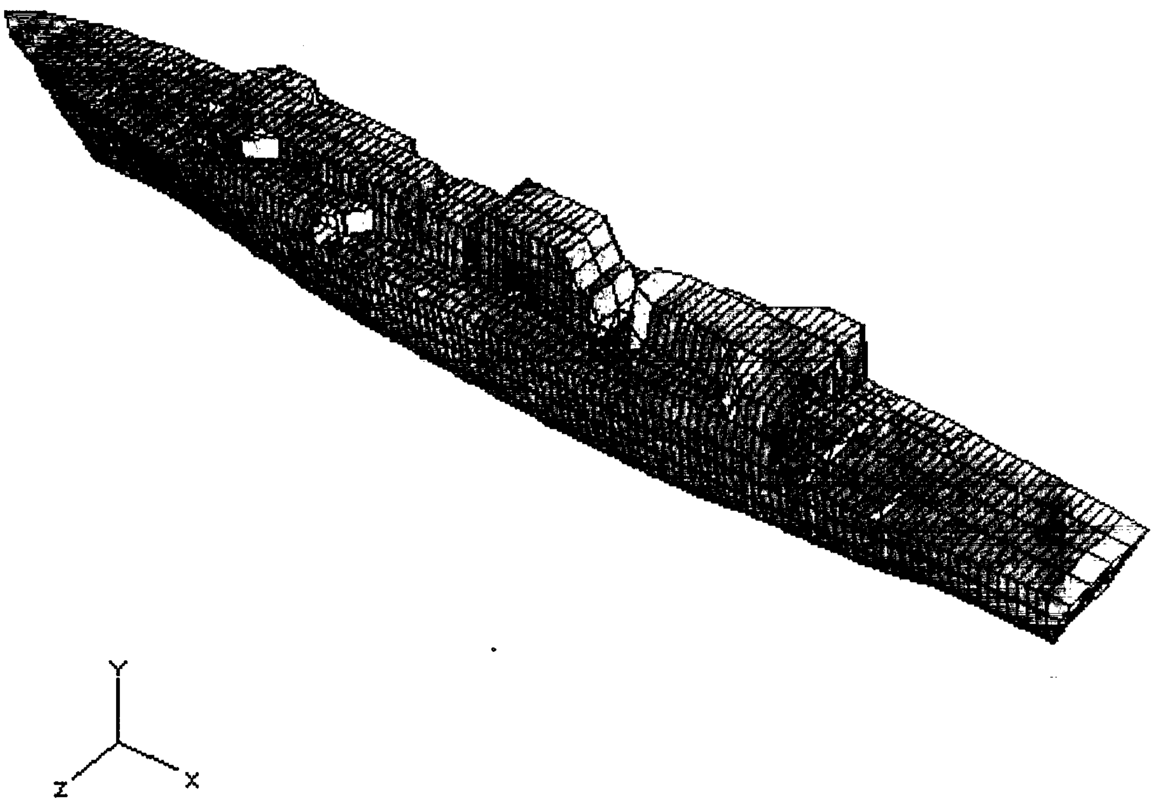

Figure 2: Panel Fill Plot of the Model

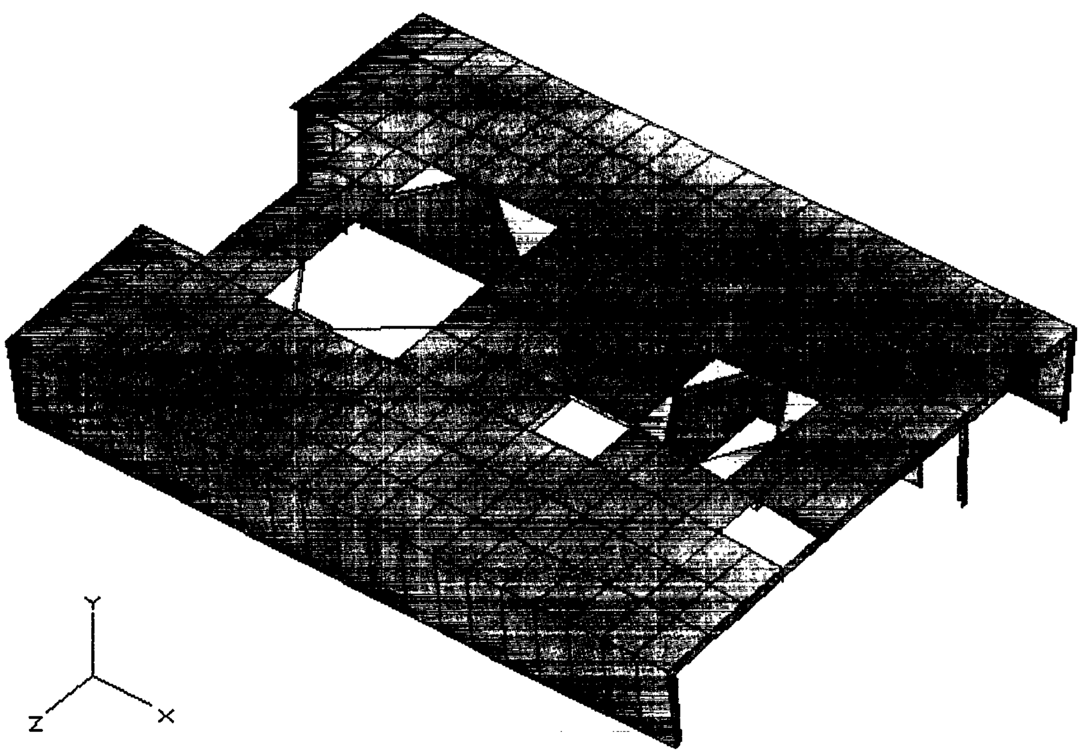

Figure 3: The Portion of the MAESTRO Model to be Deleted

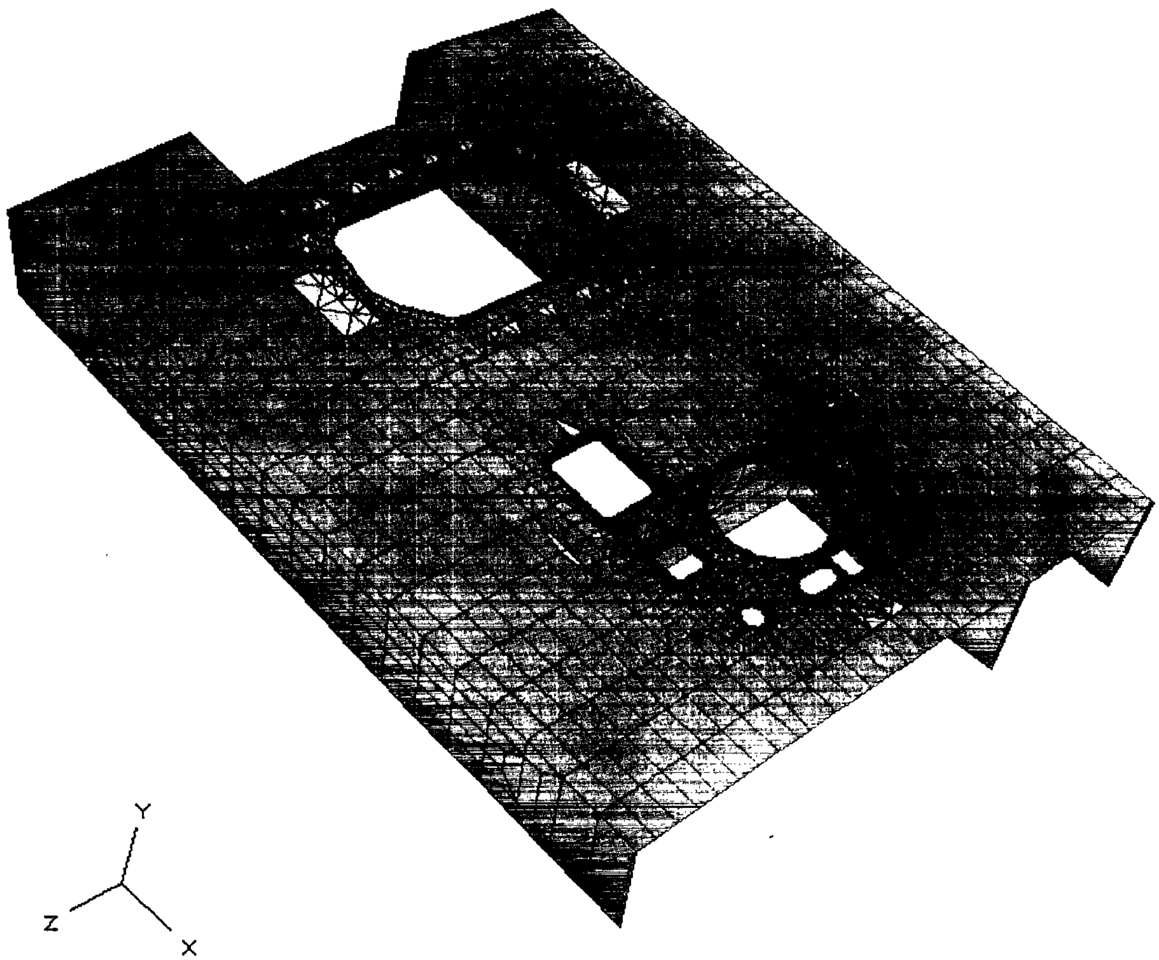

Figure 4: The Externally Generated Detail Model Displayed for Inspection

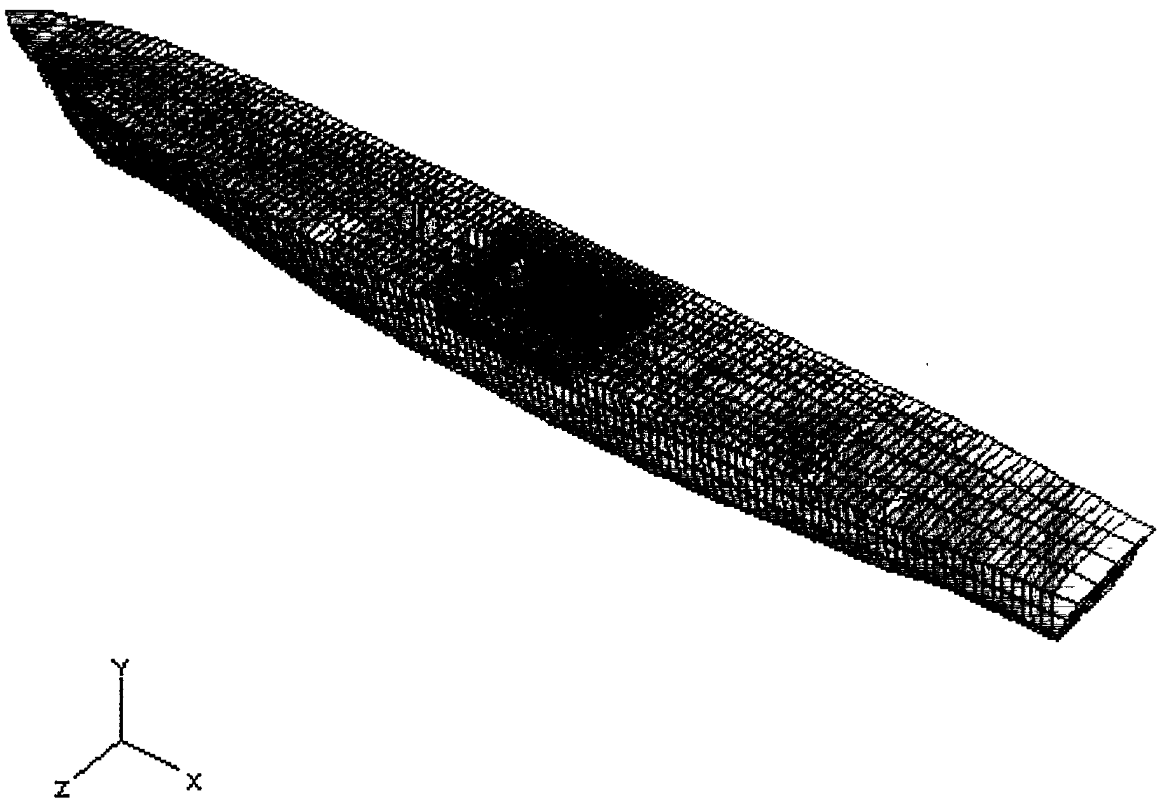

Figure 5: The Detail Model Inserted Into the MAESTRO Model

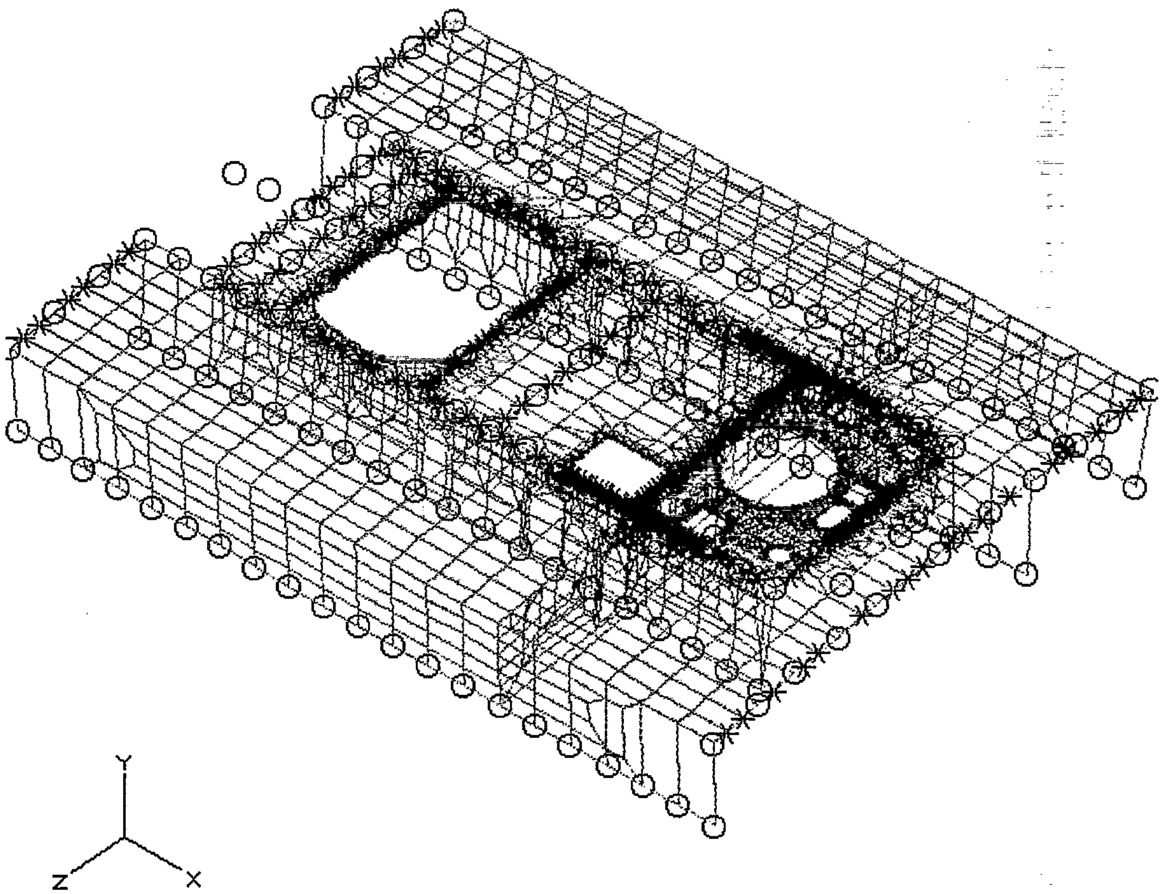

Figure 6: Master and Slave Nodes Applied to the Detail Model

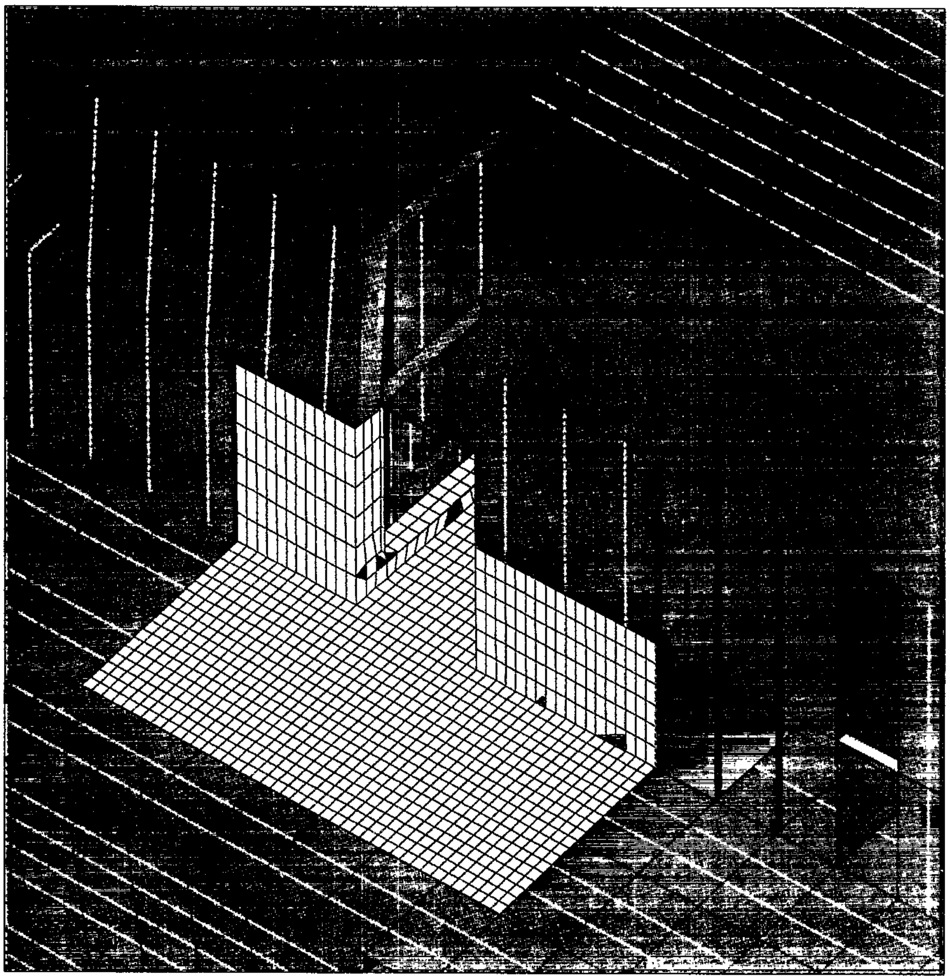

Figure 7: An Example of Refinement of the Local Structure of a Ship

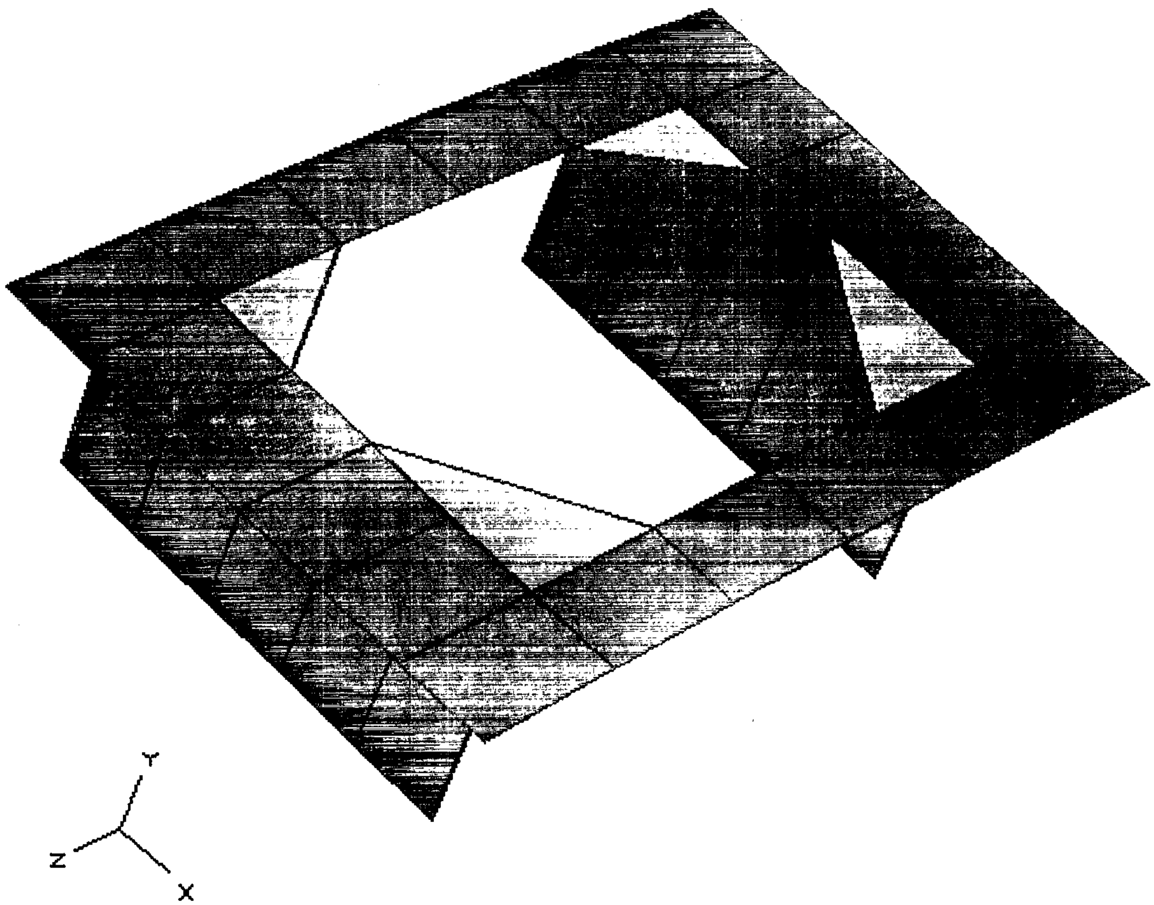

Figure 8: A Model of a Large Deck Opening Extracted from the MAESTRO Model

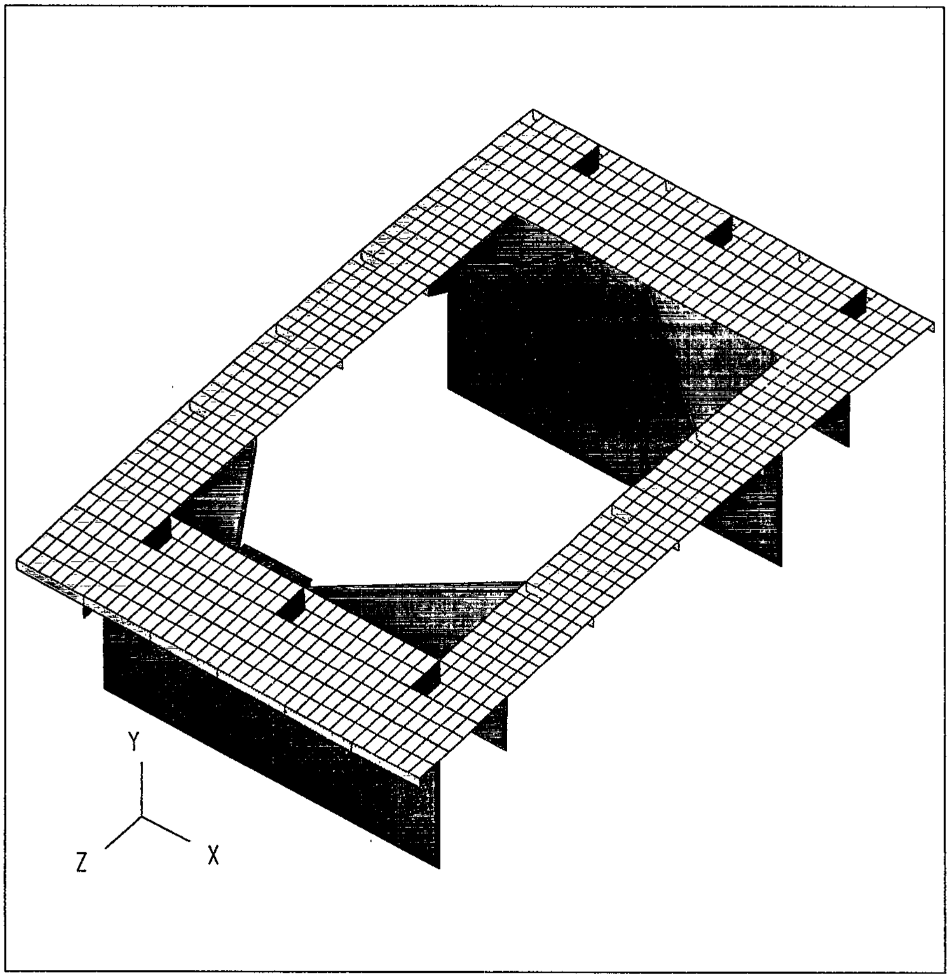

Figure 9: Refinement of the Deck Region of the Large Opening

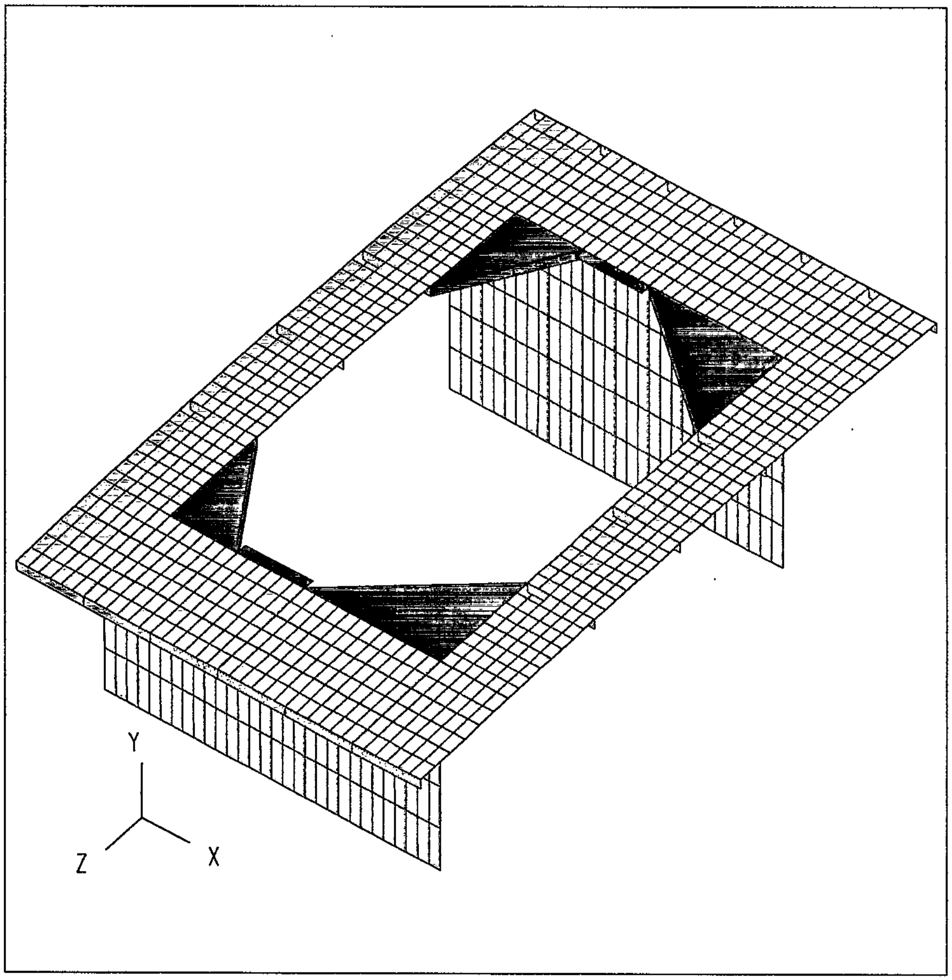

Figure 10: Refinement of the Bulkheads of the Model of the Large Opening

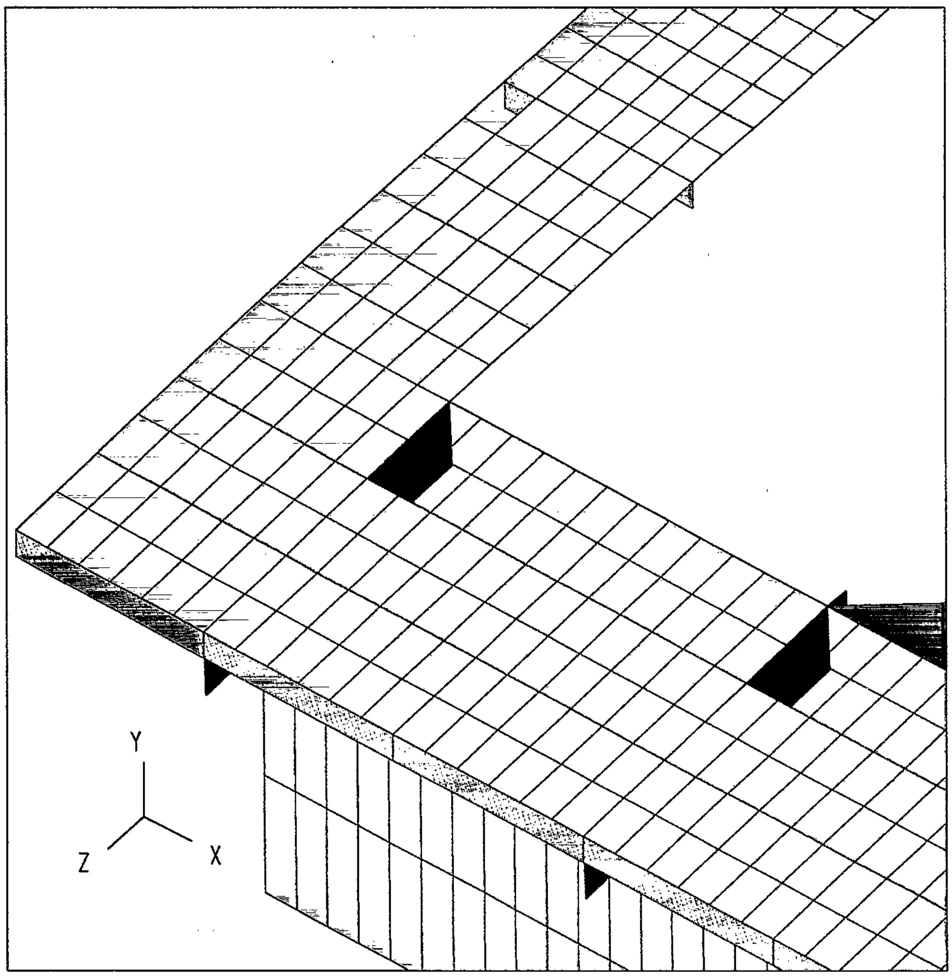

Figure 11: An Enlarged View of the Corner of the Large Opening with the Corner Plate and Beam Removed

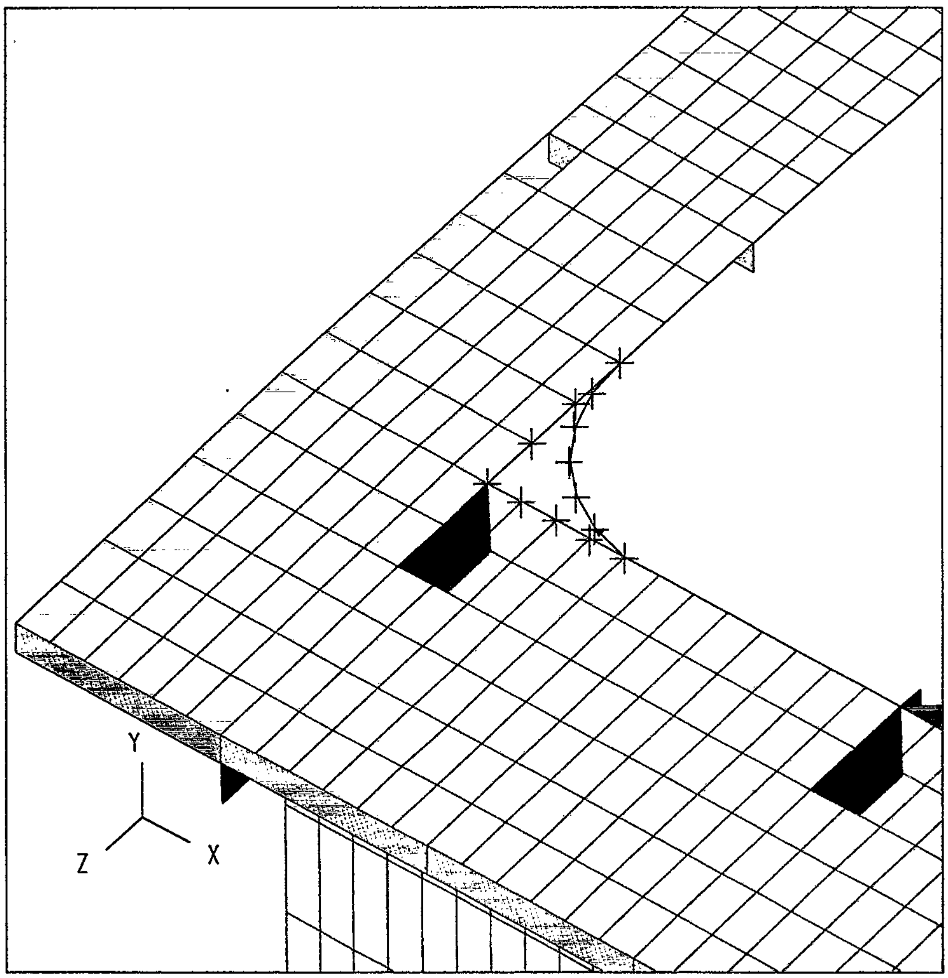

Figure 12: The Chord Option Curve Drawn Through the Chosen Points

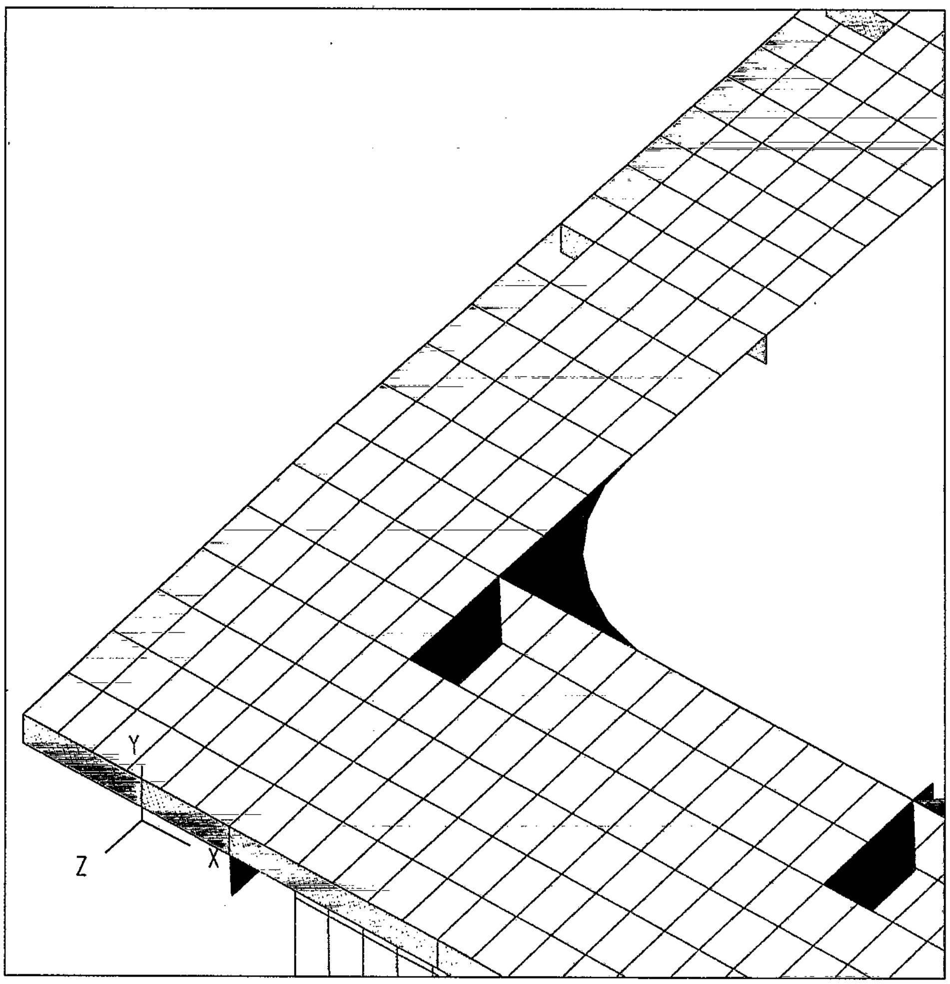

Figure 13: The Meshed Triangle in the Corner of the Large Opening

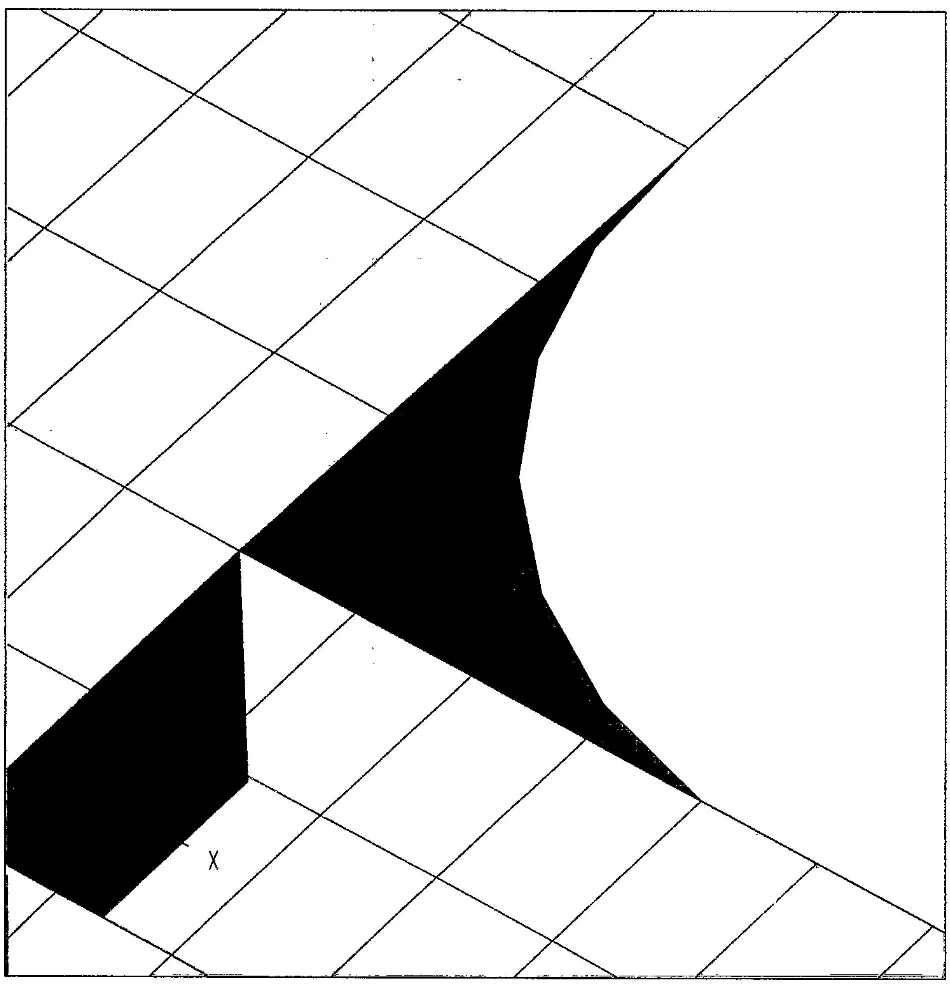

Figure 14: An Enlarged View of the Meshed Triangle

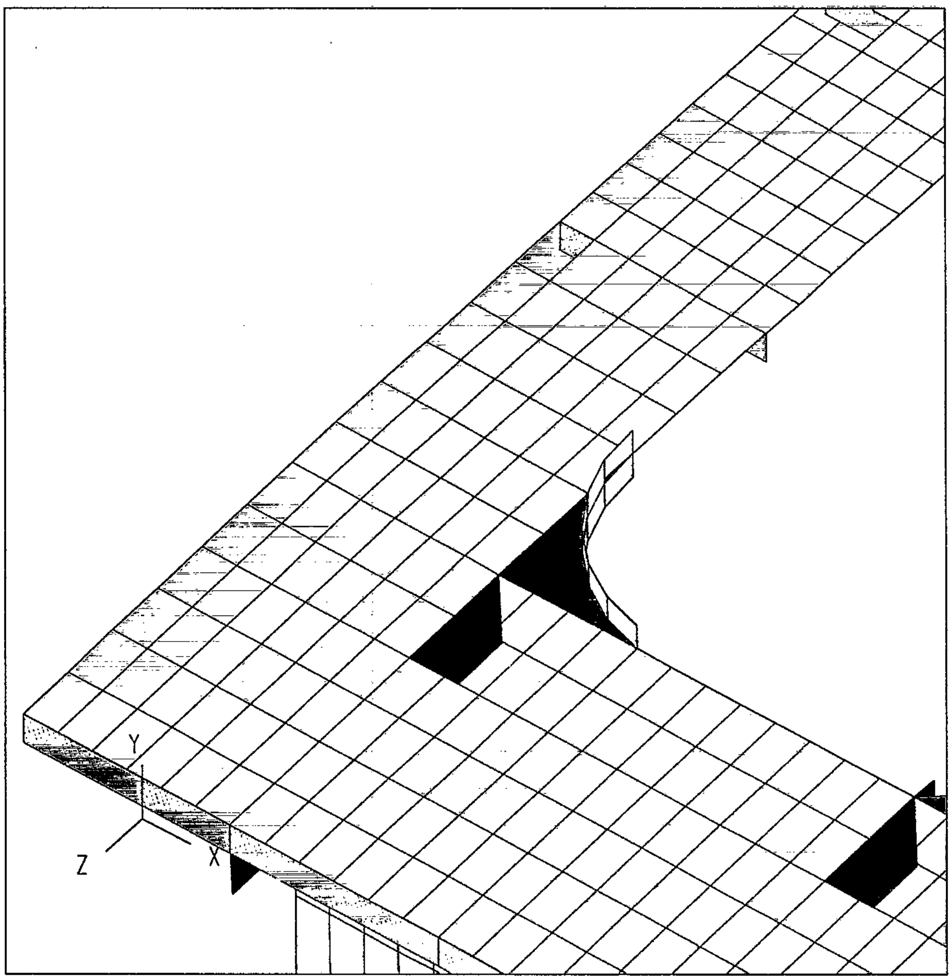

Figure 15: The Curved Collar Attached to the Meshed Triangle

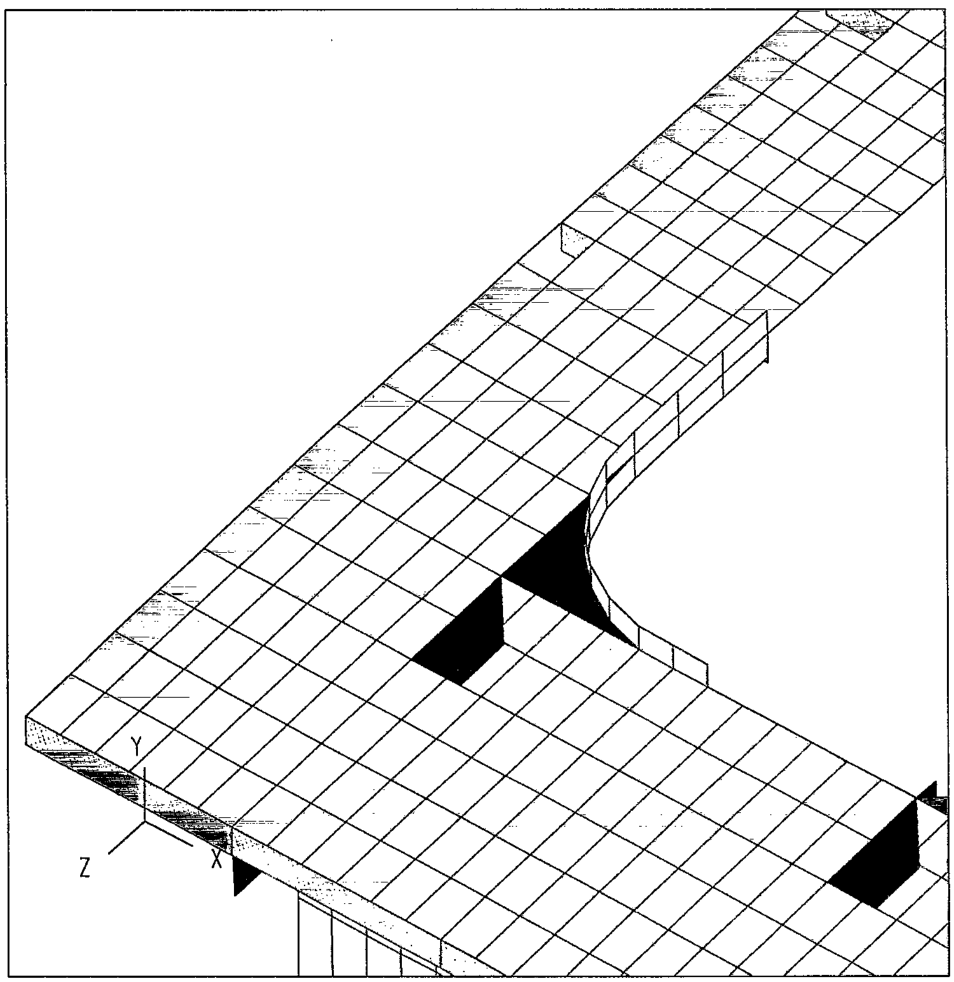

Figure 16: The Curved Collar with Straight Portions Attached

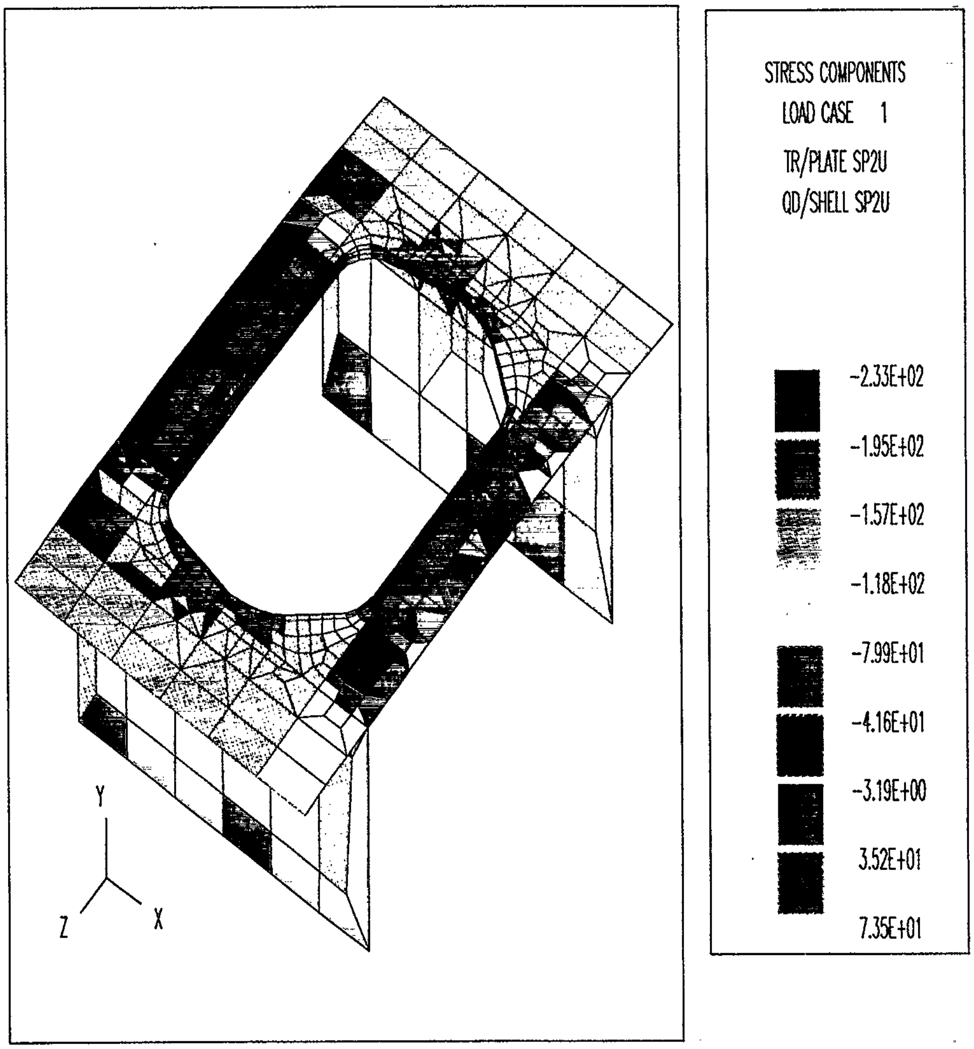

Figure 17: Element Stresses Plotted After Latex Processing without the use of the Special Feature

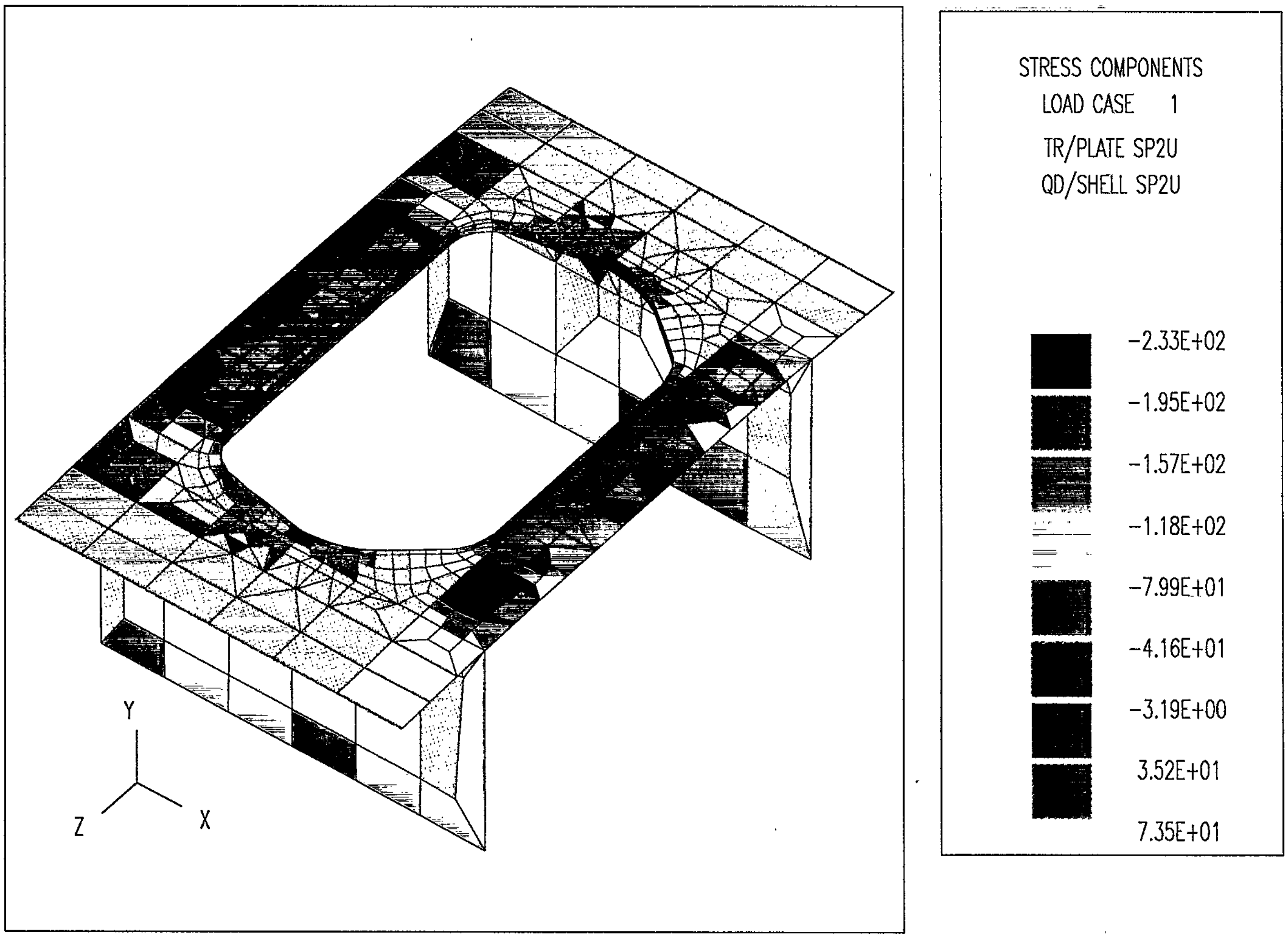

Figure 18: Element Stresses Plotted After Latex Processing with the Use of the Special Feature

References

[1] "MAESTRO,-Method for Analysis Evaluation and Structural Optimization, User's Manual Version 6.0,", distributed by Ross McNatt Naval Architects, Annapolis, MD., July 1992.

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[4] "HyperMesh 2.0 Documentation"Altair Computing Inc., Troy, Michigan.

[5] Lamport Leslie,"Latex User's Guide and Reference Manual" Addison Wesley Publishing Co., Reading, Mass., April,1986.

[6] "Microsoft Windows 95" Microsoft Corporation, Redmond, Washington, 1995.

[7] "VAST GRAPHICS SYSTEM -VG-" Martec Ltd., Halifax, Nova Scotia, March 1996.

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7 Laptop Specification

The Laptop computer used in the analysis had the following specification

MULTIMEDIA NOTEBOOK Model 85

Central Processor	120 Mhz Pentium
RAM	24 MB
VGA RAM	1 MB
Hard Drive	1.2 GIG
3.5 Floppy Drive	1.44 MB
CD-ROM	4X Speed
PC Card Slots	type II and type III
Ethernet Card	3COM Etherlink III 3C589C LAN PC

SOFTWARE

Windows 95

Ghostscript

Maestro

Maestro/DSA for DOS Version 71

GKS Graphics System

8 DSA File

A typical DSA file for suprelement analysis created by MAESTRO/DSA is shown below

```
MAVEVAS  3     don    1        don = file name for the created files
MAESTRO                                  3 = number of letters in prefix
 SE      |                    |          1 = code for Maestro
 SE      | list of MAESTRO    |          1 = superelement
 SE      | elements deleted   |              analysis
 SE      | where superelements |         2 = only generate
           will fit                          the superelement
                                         3 = stress recovery
```

A typical DSA file for top-down analysis

```
MAEVAS   4  neil   4   1
MAESTRO
PRESCRIBED DISPLACEMENTS   -1    2
LC    1
8.OM WAVE, SAG AND HORIZ CORRECTION
    1 -0.53938164E+02 -0.11708205E+03 -0.10004120E+01
       0.13252186E-03 -0.55373755E-04 -0.82660967E-03
    4 -0.53743038E+02 -0.11732638E+03 -0.49293923E+00
       0.41686534E-03  0.26068112E-04 -0.81398454E-03
```

```
 7 -0.53374020E+02 -0.11737679E+03 -0.37201625E+00
    0.58673213E-04  0.13978501E-03 -0.80943649E-03
10 -0.52898952E+02 -0.11749815E+03 -0.36968574E+00
   -0.36042857E-04  0.54389442E-04  0.39366216E-04
11 -0.54523613E+02 -0.11782254E+03 -0.10801766E+01
    0.49130415E-03  0.39949059E-03 -0.50284766E-03
          |                |                |

LC    2
8.0M WAVE, HOG AND HORIZ CORRECTION
 1 -0.14490368E+01  0.11860401E+03  0.41130793E+00
   -0.65364706E-03  0.33972072E-04  0.61284652E-03
 4 -0.15585902E+01  0.11971218E+03 -0.77930227E-01
   -0.41333679E-03 -0.27129530E-04  0.70788147E-03
 7 -0.19260654E+01  0.11977243E+03 -0.18246761E+00
   -0.17746368E-03 -0.12925698E-03  0.64403581E-03
10 -0.23804166E+01  0.11995909E+03 -0.18673787E+00
   -0.16360631E-04 -0.48573776E-04 -0.20149683E-03
11 -0.91056573E+00  0.11912961E+03  0.48744330E+00
   -0.44808740E-03 -0.36280282E-03  0.27723025E-03
14 -0.77296960E+00  0.12040355E+03  0.16627207E+00
   -0.79554861E-03 -0.52258442E-03  0.19819010E-03
17 -0.19581997E+01  0.12054018E+03 -0.23847967E-01
   -0.21438014E-03  0.67287829E-03  0.66593126E-03
20 -0.24528770E+01  0.12059032E+03 -0.14515410E+00
```

	-0.44545606E-04	-0.51934898E-04	0.11440367E-02
|		|	|

48	0.19956732E+01	0.12023772E+03	0.55965502E-01
	-0.12979197E-03	0.43529345E-03	0.25769553E-03
2	-0.14855574E+01	0.11897343E+03	0.24821611E+00
	-0.57353755E-03	0.13603317E-04	0.64452726E-03
3	-0.15220770E+01	0.11934284E+03	0.85128777E-01
	-0.49343018E-03	-0.67648757E-05	0.67620713E-03
0	0.00000000E+00	0.00000000E+00	0.00000000E+00
	0.00000000E+00	0.00000000E+00	0.00000000E+00

ENDMAEVAS

9 MAESTRO.DAT File

An example of a MAESTRO.DAT file This file is explained line by line and item by item in the MAESTRO Data Preparation Manual. The dollar sign indicates a comment.

```
"EX1.DAT - EXAMPLE NO. 1; DESTROYER ESCORT HULL"
$ JOB INFORMATION
ANALYSIS  1  1
$ STRUCTURE PARAMETERS
2   2    2   3
UNITS  Newtons  MM  "COST UNITS"  TONNES
CRITERIA  DEFAULT  1.50  1.25
$ MATERIAL PROPERTIES
MAT  1  210000.  0.3   400.  500.  400.  7.85E-06  7.85E-09
MAT  2  210000.  0.3   250.  400.  250.  7.85E-06  7.85E-09
$ SUBSTRUCTURE IDENTIFIER
SUBS  1
0.0       0.0        0.0
$ MODULE INDENTIFIER
MODULE   1
$ DATA GROUP 1 - GENERAL INFORMATION
2  1   ,  17  4  ,  4
2500.  , , ,   999.   0.5
$ DATA GROUP 2 - END POINTS
```

```
0.0          0.
644.     -2500.
1260.    -4700.
2500.    -5500.
3000.    -5500.
4300.    -5500.
6700.    -5500.
6700.        0.
6700.    -2900.
4300.        0.
4300.    -2900.
END
$ DATA GROUP 3 - ADDITIONAL NODES
NODE   1  5000.    2000.   -2500.
NODE   2  5000.    2000.   -4200.
NODE   3  3500.    2000.   -2500.
NODE   4  3500.    2000.   -4200.
$ DATA GROUP 4A - STRAKES
BOTTOM        1    1    2    1  1  2  ,  LSH
BOTTOM        2    2    3    1  1  2  ,  LSH
SIDE          3    3    4    1  1  2  ,  LSH
SIDE          4    4    5    2  2  ,  ,  LSH
SIDE          5    5    6    2  ,  ,  ,  LSH
SIDE          6    6    7    1  1  ,  ,  LSH
```

```
DECK          7    8    9    1  1  ,  ,  LSH  ,-T
DECK          8    9    7    1  1  ,  ,  LSH  ,-T
OTHER         9   10   11    2  2  ,  ,  ,  ,-T
OTHER        10   11    6    2  ,  ,  ,  ,  ,-T
END
$ DATA GROUP 4B - GIRDERS
GIRDER  1  1  1,,0.    1.0
+       2  1  1,,15.   1.0
+       3  2  1,,35.8  1.0
+       5  4  2,,90.   1.0
+       7  7  1,,180.  0.5
+       8  7  1,,180.  0.5
+       9  9  2,,180.  0.5,,1
+      10  9  2,,180.  0.5
END
$ DATA GROUP 5 SUPERELEMENTS
SUPER 1 "TRANSVERSE BULKHEAD AT SECTION 0"
SECTION  0
$ Additional Nodes
$        X         Y        Z
NODE   1001      3000.   -4700.
NODE   1002      2500.   -4700.
NODE   1003      2500.   -2900.
NODE   1004      2500.       0.
```

```
END

$ ELEMENTS COMPRISING SUPERELEMENTS

ELEM     1      2      1   1004  1003   2    9.
ELEM     2      3      2   1003  1002   2    9.
ELEM     3      3   1002      4     ,   2    9.
ELEM     4      4   1002   1001     5   2    9.
ELEM     5      5   1001      6     ,   2    9.
ELEM     6   1001     11      6     ,   2    9.
ELEM     7   1002   1003   1001     ,   2    9.
ELEM     8   1001   1003     11     ,   2    9.
ELEM     9   1003   1004     10    11   2    9.
ELEM    10     11     10      8     9   2    9.
ELEM    11      6     11      9     7   2    9.
END
ENDSUP
$GROUP VI(A) - PILLAR
STRUT  2  1.2
TUBE   1   1   10  1  1  6.  125.  ,  0.5
$GROUP VI(B) - TRIANGLES
2  2 -1  0 -3  0  2  10.
2  2 -3  0  2  1  2  10.
3  2 -2  0 -4  0  2  10.
3  2 -4  0  3  1  2  10.
$GROUP VII(A) - ADDL. BEAMS
```

```
   1  0  1004  0  2  HI
1004  0    10  0  2  HI
  10  0     8  0  2  HI
  11  0     9  0  2  HI
   5  0  1001  0  2  HI
   6  0  1001  0  2  HI
  11  0  1001  0  2  HI
1001  0  1002  0  2  HI
   4  0  1002  0  2  HI
1002  0  1003  0  2  HI
1003  0  1004  0  2  HI
   3  0  1002  0  2  HI
   2  0  1003  0  2  HI
1003  0    11  0  2  HI
  10  1     8  1  2  LO
  11  2     9  2  2  -T
   1  1     2  1  2  T  1 ! SUBSTITUTE FOR STRAKE 1 FRAME UNDER PILLAR
$GROUP VII(B) - ADDL. PANELS
10  1  11  1  9  1  8  1  2  OL  ,  9  1
11  1  11  2  9  2  9  1  2  OL  ,  9  2
-3  0  -1  0 -2  0 -4  0  2  OL
 2  2   3  2 -2  0 -1  0  2  OL
!  GROUP VIII
$GROUP IX - STIFFENED PANEL SCANTLINGS
```

```
5   0   12.   170.   6.   100.   10.
5   0   12.   150.   6.   100.    9.
2   1   12.   150.   6.   100.    9.
0   1   10.   100.   6.    82.    7.
1   0   10.   100.   6.    82.    7.
3   0   12.   110.   6.    90.    8.
6   0   12.   110.   6.    90.    8.
5   0   12.   110.   6.    90.    8.
3   0    8.   100.   6.    82.    7.   0  0  1
3   0    8.   100.   6.    82.    7.
$GROUP X - GIRDER SCANTLINGS
500.    6.   200.   20.   0
350.   12.   180.   16.   0
300.   12.   180.   16.   0
250.   12.   180.   16.   0
400.    6.   120.   16.   0
400.   12.   180.   16.   0
400.    6.   120.   16.   0
400.   12.   240.   16.   0
$GROUP XI - FRAME SCANTLINGS
400.    8.   250.    8.
350.    8.   250.    8.
300.    8.   125.    8.
300.    8.   100.    8.
```

```
300.    8.   100.    8.
300.    8.   100.    8.
300.    8.   125.    8.
300.    8.   125.    8.
250.    8.   125.    8.
250.    8.   125.    8.
$GROUP XII(A) - ADDL. BEAM SCANTLINGS
250.  3.  62.5  6.  10.  300.
250.  3.  62.5  6.  10.  300.
250.  3.  62.5  6.  10.  300.
250.  3.  62.5  6.  10.  300.
250.  3.  62.5  6.  10.  300.
250.  3.  62.5  6.  10.  300.
250.  3.  62.5  6.  10.  300.
250.  3.  62.5  6.  10.  300.
250.  3.  62.5  6.  10.  300.
250.  3.  62.5  6.  10.  300.
250.  3.  62.5  6.  10.  300.
250.  3.  62.5  6.  10.  300.
250.  3.  62.5  6.  10.  300.
250.  3.  62.5  6.  10.  300.
250.  3.  62.5  6.   6.  300.
250.  6.  125.  6.   6.  300.
500. 10.  300.  15. 12.  300. ! SUBSTITUTE FOR STRAKE 1 FRAME UNDER PILLAR
```

```
$GROUP XII(A) - ADDL. PANEL SCANTLINGS
3  6.  100.  6.  50.  12.
3  6.  100.  6.  50.  12.
0 10.
0 10.
$BRT  1  1  1  1  400.  400.  8.  60.  15.
$BRT  5 10  6  1  200.  200.  8.  40.  12.
$BRT  6  8  7  1  200.  200.  8.  40.  12.
END
$GROUP XV - MODIFICATIONS TO THE STRUCTURAL MODEL
TITLE     "OPENING FOR UPTAKE"
GIRDER    9    2
PANEL     9    2
FRAME     9    2
NODE      10   2
END
$ BOUNDARY CONDITIONS
BOUND  1  1  1  1
RESTRAINT    1    1    1    2    100001
+            1    1    2    2    100011
+            1    1    3    2    100011
+            1    1    4    2    100011
+            1    1    5    2    100011
+            1    1    6    2    100011
```

```
+              1    1    7    2    110011
+              1    1    8    2    100001
+              1    1    9    2    100011
+              1    1   11    2    100011
END
LOADSET 1  "STATIC LOADS (STEEL, OUTFIT, MACH'Y, SUPERSTRCT. & BOUYANCY)"
Y  1.0  1
IMMERSION  3600.
7  4  0  1.0
$$ENGINE AND MACHINERY WEIGHTS
1    1         0.      -8000.
2    1         0.     -16000.
1    2         0.      -4000.
2    2         0.      -8000.
$$SUPERSTRUCTURE LOAD
9    0         0.     -4600.
9    1         0.     -4600.
9    2         0.     -4600.
PRES     1        .999
PRES     7        .022
PRES     8        .022
PRES     9        .011   1
PRES    10        .011
PRES     A        .100   1
```

```
PRES    A    .200  2
PRES    A    .300  3
PRES    A    .400  4
PRES    T    .500  1
PRES    T    .600  2
PRES    T    .700  3
PRES    T    .800  4
WEIGHT
3.6   3.6
LOADSET 2  "UNDERWATER EXPLOSION AND STRUCTURAL INERTIA FORCES"
Y  1.0  1
4  0  0  0.4
$$Balancing shear force: -0.17 MN, divided into 4 equal parts
4   0    0.   -42500.
5   0    0.   -42500.
6   0    0.   -42500.
7   0    0.   -42500.
QUASISTATIC  5000.0  -7800.  0.0  0.3   3.75E-04
QST  1  2  3
END
LOADSET 3  "HOGGING WAVE"
Y  1.0
IMMERSION  3600.  ,,  WAVEONLY   2500.   90000.  20.   0.
0  0  0
```

```
LOADSET 4 "SAGGING WAVE"
Y  1.0
IMMERSION  3600.  ,,  WAVEONLY   2500.   90000.  -160.   0.
0  0  0
END
CASE 1 "STATIC LOADS + EXPLOSION + HOGGING WAVE"
1.0 1 2 3
-1.65E+11    0.0    -3.65E+05
CASE 2 "STATIC LOADS + EXPLOSION + SAGGING WAVE"
1.0 1 2 4
 1.50E+11    0.0    18.10E+05
ENDLOADS
DESPRESS   0.024  -0.024
STRAKES  7  8
END
PERMANENT  6.
CONCENTRATED  40000.   100.   100.
STRAKES  7  8  9  10
END
```

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Modelling and Refining Structural Detail in a MAESTRO Model for a Bottom-Up or Top-Down Analysis Using the PC Version of MAESTRO/DSA

4. AUTHORS (Last name, first name, middle initial. If military, show rank, e.g. Doe, Maj. John E.)

D.R. Smith

5. DATE OF PUBLICATION (month and year of publication of document) October 1997	6a. NO OF PAGES (total containing information Include Annexes, Appendices, etc). 52 (approx.)	6b. NO. OF REFS (total cited in document) 8

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The report describes the process for modelling and refining structural detail of a ship, for which a MAESTRO model has been created, in preparation for a bottom-up or top-down detail stress analysis. The detail can be modelled by either locally refining the MAESTRO model, using the program MAESTRO/DSA, or by creating the model separately with a mesh generator such as HYPERMESH. The processing of the results to display them in graphic form suitable for the documentation program LATEX is also illustrated.

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finite element
model
MAESTRO
mesh refinement
bottom-up
top-down
detail stress analysis
DSA

#509064