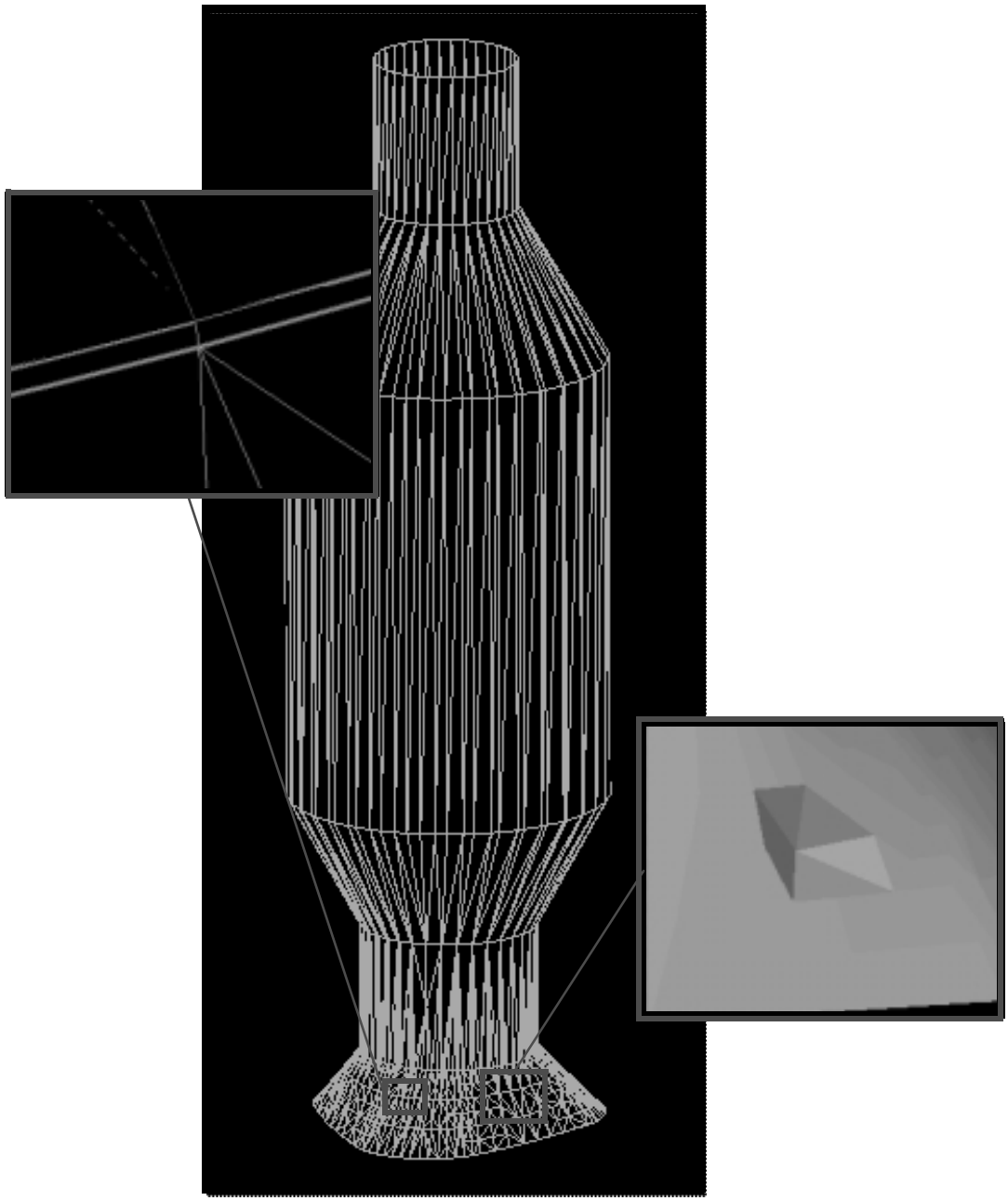
Tutorial 6: MiniCAD

Triangular files sometimes contain deformities or errors which must be corrected before gridding. **GridPro** contains a number of effective tools and utilities that can be used to correct surfaces for grid generation. These tools involve both automatic grid smoothing and techniques in the form of program utilities, and manual tools to segment and merge surfaces, surface filling and moving nodes.

Part I: Surface Correction on Triangles

What You Will Create

You will prepare a deformed surface for grid generation. Surfaces contain deformities such as misaligned nodes and highly skewed cells:



What You Will Learn

- How to change file formats.
- How to determine whether a file needs to be corrected.

- How to Prepare a surface for correction.
- How to Check a surface for gaps.
- Inspecting the surface using the feature tool.
- An introduction to utilities: Using the merge-node utility
- How to use surface correction tools - filling surfaces and moving nodes
- How to reduce the file size by thining and using the segment and merge grid tools.
- About surface correction on quads

Step 1 Change Format

In many cases, before you start the gridding process, you must change the triangular, stereolithography (stl) or quad file into **GridPro** format. The command for changing formats is:

chfmt *file_name* [-f *output_format*] <return>

The **output_format** types can be listed by typing in **chfmt** at the prompt and hitting the return key. If the file you are converting is not in **GridPro** format, all you need to use is this command:

chfmt *file_name* <return>

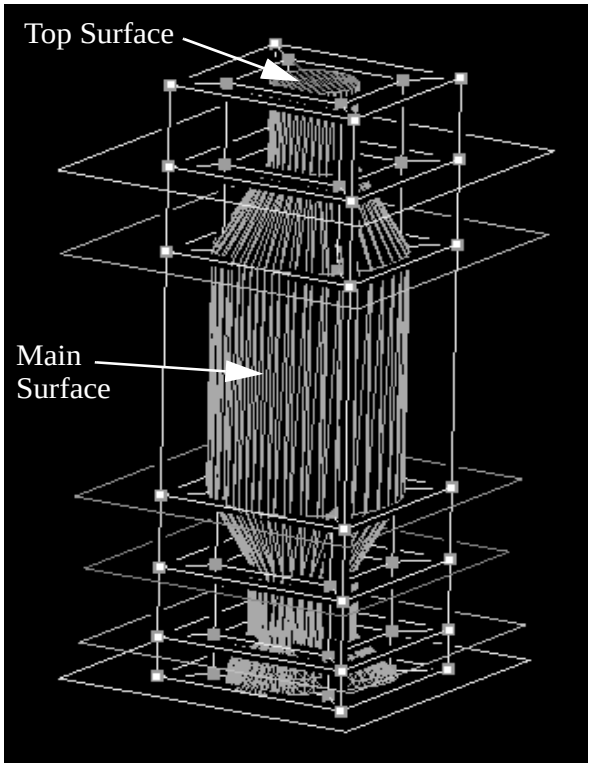
and the output will be automatically converted into **GridPro** format and will be saved as ***file_name.tmp.*** If the file is in **GridPro** format the **chfmt file_name** command will automatically convert the file into **Nastran** format.

If **Gridpro** will not allow you to import the ***file_name.tmp*** some errors have occurred during translation, and in the process fixing the errors it automatically segments the surface and dumps the data into _seg.01, seg.02, seg.03, and seg.04 files. If this problem

occurs, re-import the largest _seg file which will contain all of the relevant data.

Step 2 Encountering Problems

Before creating the grid using an stl or triangular file, you must inspect the surface to ensure that it is smooth and does not contain holes. Let's first look at what will happen when you try to grid a surface that contains imperfections. We will then analyze the problem, make corrections and try to grid the surface again. Go to the **Tutorial 6** directory and double click on the **Tutorial_6.fra** file or start **GridPro** by typing in **az** at the directory prompt and loading in the file by going to the **topo** sub-menu and using **TIL: read**. The file contains the geometry composed of the **main** and **top** surfaces, and the topology. Turn off **Shading** and turn on the **Hidden Line Removal** in the **SYLE** sub-command panel. Also, turn off the **Axis** and **Cut-Plane** in the **SHOW** sub-command panel.



Take a quick look at the surface, and try to start the gridding process by going to the **topo** sub-menu and clicking on **Ggrid: Start**. **GridPro** should say the topology is complete and ask you if you want to start gridding. Hit **ok** and go to the output prompt. The following error will be listed:

```
LOADING SURFACES:
  s0 (2) plane( 0.0932658*Y = 0.0471351 )
  s1 (2) plane( 0.0914557*Y = 0.0418511 )
  s2 (2) plane( 0.0795832*Y = 0.0220462 )
  s3 (2) plane( 0.0839427*Y = 0.0267196 )
  s4 (a) plane( 0.0882464*Y = 0.0189302 )
  s5 (2) plane( -0.0836974*Y = -0.0198242 )
  s6 (a) tria(a) '..GRIDPRO/T6/surf_top':   (nodes=35, cells=33)
    init tree: branchs=4  bs=(m2,M3,avg2.1,lmt=4) depth_max=3
  s7 (a) tria(a) '..GRIDPRO/T6/surf_main_usm': cell-1001 nodes collapsed (too cl
ose)cell-1022 nodes collapsed (too close)  (nodes=868, cells=1626)


found collapsed norm at cell-1000 (542 541 525),exit
```

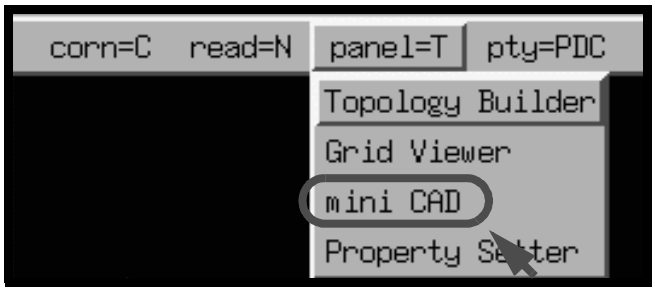
The Grid Generator loaded the plane surfaces without problems but when it began loading the main surface it stopped running. Some of the triangular cells collapsed because of poor surface quality.

Step 3 Preparing the Surface for Inspection

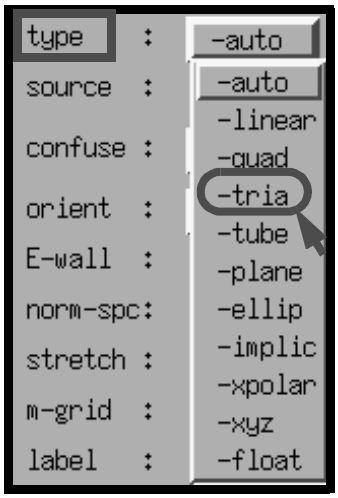
Let's inspect the surface to see what problems we have. Display only the current surface by going to the SURF ALL menu at the bottom of the sub-command panel and clicking 

Also, go to the **SHOW** sub-command panel and turn off the topology by clicking on the **TOPO** button.

Switch to the **mini CAD** panel by going to the **Panel=T** sub-menu and choosing **mini CAD**.



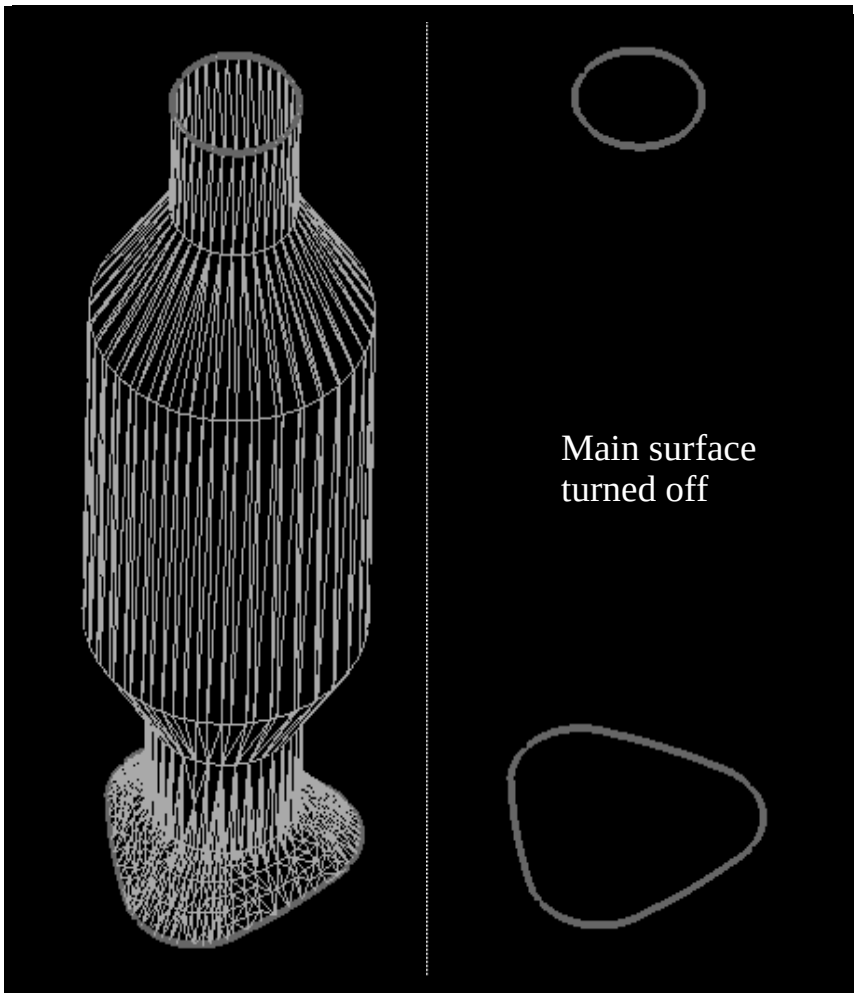
Surfaces can be manipulated only if they are either in **tria** or **quad** format. Make sure that the main surface is in tria format by going to the surf sub-menu and choosing the **surf: reload current** option. Make sure that the main surface is the current surface and is highlighted in light blue. Now in the **type** sub-menu choose **tria** and hit **apply**.



Step 4 Checking for Gaps

It is important to check for gaps to ensure that the surface can be gridded. Go to the **Border/Feature** sub-command panel at the bottom and click on the **border** button.

All borders of gaps in the model will be automatically highlighted in light brown as in the picture below. One way to obtain a quick view of the gaps is to turn off the **SURF** button in the **SHOW** sub-command panel.



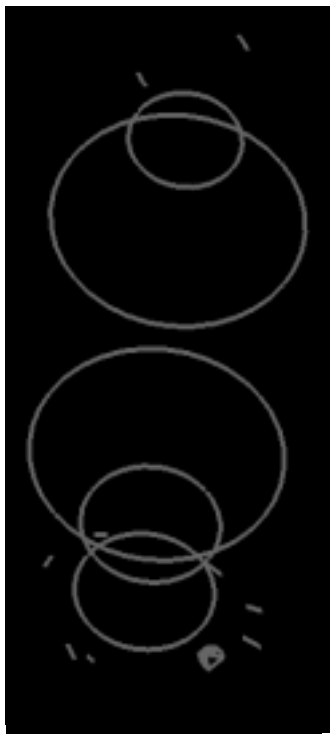
Since the bottom and top of the main surface will be bound by internal surfaces during grid generation, there is no need to fill the gaps. The next step is to check for feature skewness, but first, turn off the border button.

Step 5 Checking Triangle Features

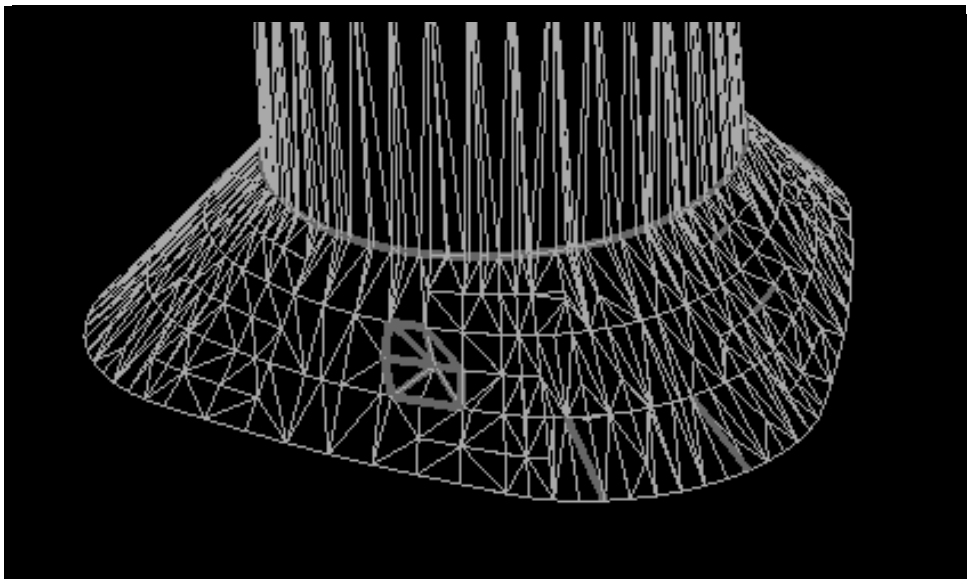
It is important for all triangles to be as smooth as possible. Each triangular cell is composed of 3 points and a surface normal. One way of checking triangle smoothness is to analyze the angles between the normals of adjacent cells. Let's do this procedure by clicking on the **feature** button in the **Border/Feature** sub-command panel

A message listing the angle and problem cell is listed in the upper left hand corner of the screen.

Continue to click on the feature button until the **Feature angle = 11 degrees**. In general, the cell normals on smooth surfaces should not be greater than 10 to 15 degrees. Turn off the main surface and all of the problem cells will be highlighted in light brown as in the picture below. Ignore the highlighted main features of the surface that are defined by a sharp edge. Since we will be placing an internal surface at these points, the skewness issues will be resolved during gridding.



Turn on the surface again, and zoom in on the base where most of the problem surfaces are located.



Since many cells on this surface are unacceptable for grid generation, let’s speed up the surface correction process by using a merge node utility that will help smooth the surface automatically.

Step 5 Introduction to Utilities

Over 30 programs called Utilities exist in GridPro that carry out specific tasks that help the user create optimal grids more efficiently. In this case, we would like to reduce the number of distorted cells by merging nodes which will smooth the surface. The user needs to input the distance and skewness tolerances and the nodes will be automatically merged. The command line is of the format:

mrgn *file_name* [-t *node_distance_tolerance*] [-ts *cell_skewness_tolerance*]

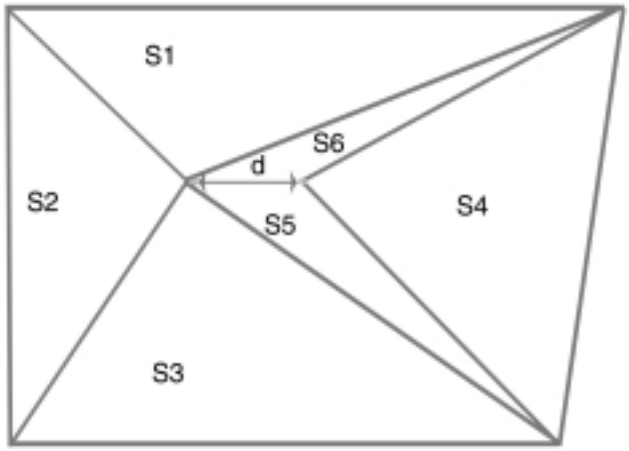
Go to your directory and type in:

```
mrgn surf_main -t 0.01 -ts 0.0001
```

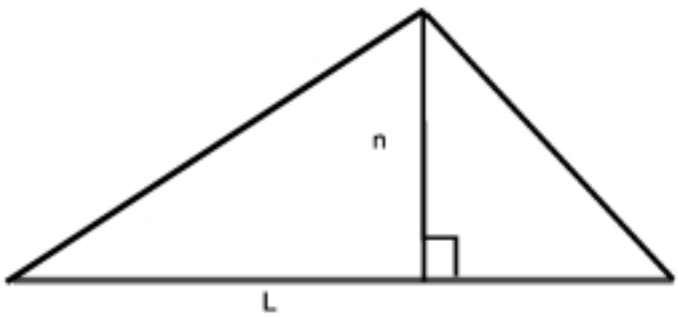
The tolerances depend on your surface correction parameters. In this case we input a tolerance for the distance between nodes as less than 1% of the local grid scale, and a triangle skewness of less than 0.0001.

Defining Node Distance and Skewness Tolerance

To determine which nodes to be merged, GridPro defines the scale of all adjacent cells based on the longest side of the triangle. The code then divides the distance between the nodes (*d*) by the smallest adjacent scale (*Smin*) and will merge the nodes if the result is less than the given tolerance.



In **GridPro** the skewness is determined by n/L. If the skewness is below the tolerance value, **GridPro** will implement a smoothing algorithm on the cells

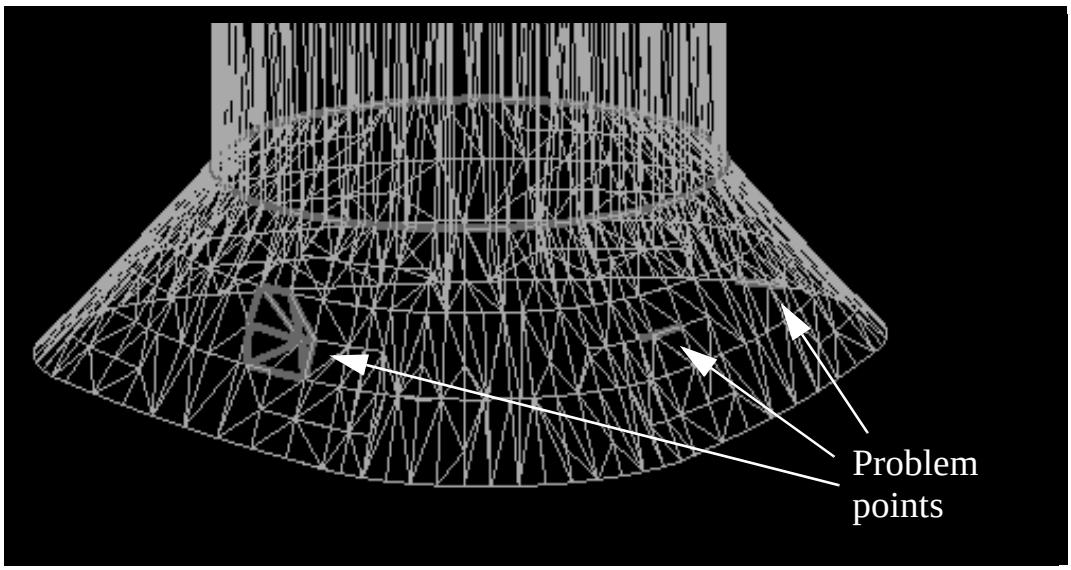


ts = n/L

Hit return and the following information should be output to your prompt.

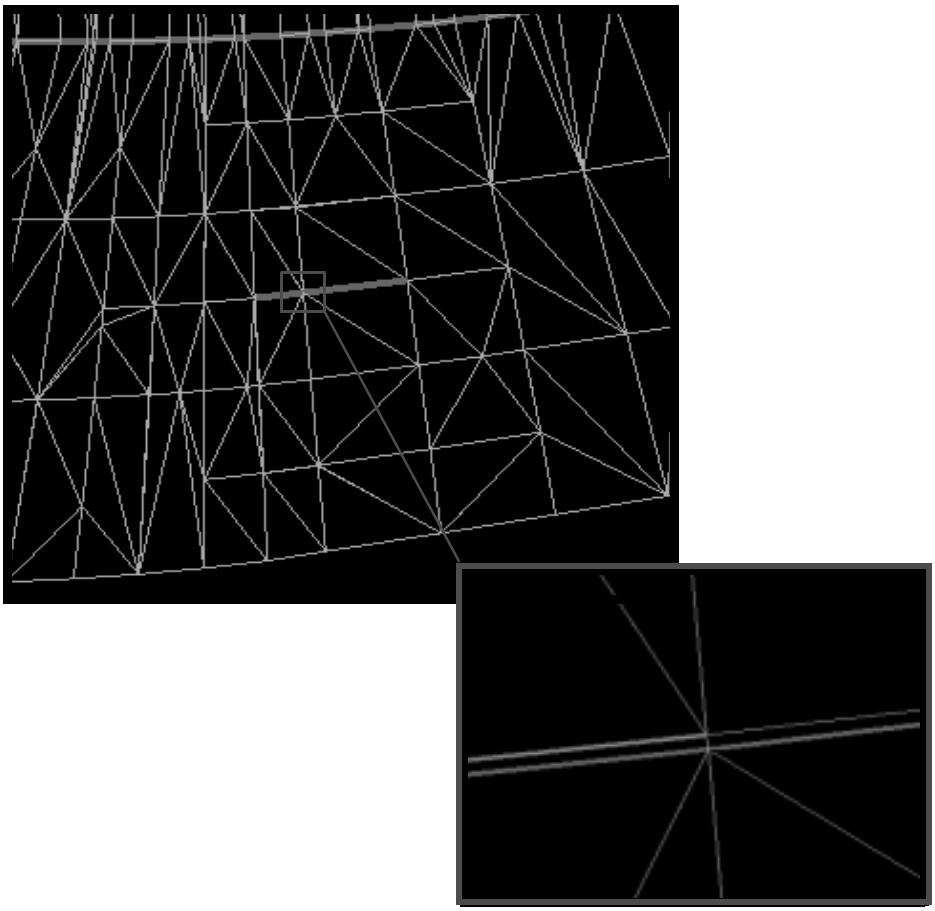
```
  in :'surf_main'        (fmt=TRIA)  (nodes=868,cells=1626)
  out:'surf_main.tmp'

  tolerances: relative=0.01, skewness=0.0001, cell size=-1

  worst skweness=0, cell reduction=10
  comparison count: max=3, average=0.088(868)

  cell scale: min=0, 10%=0.00040523, 50%=0.00246648, max=0.0204744
  7      nodes are reduced: 868 -> 861
  10     cells are reduced: 1626 -> 1616
end
```

Delete the current **surf_main** from the az manager and import the new surface saved as **surf_main.tmp**. Inspect the mesh again and notice that only a few spots remain unsmooth.



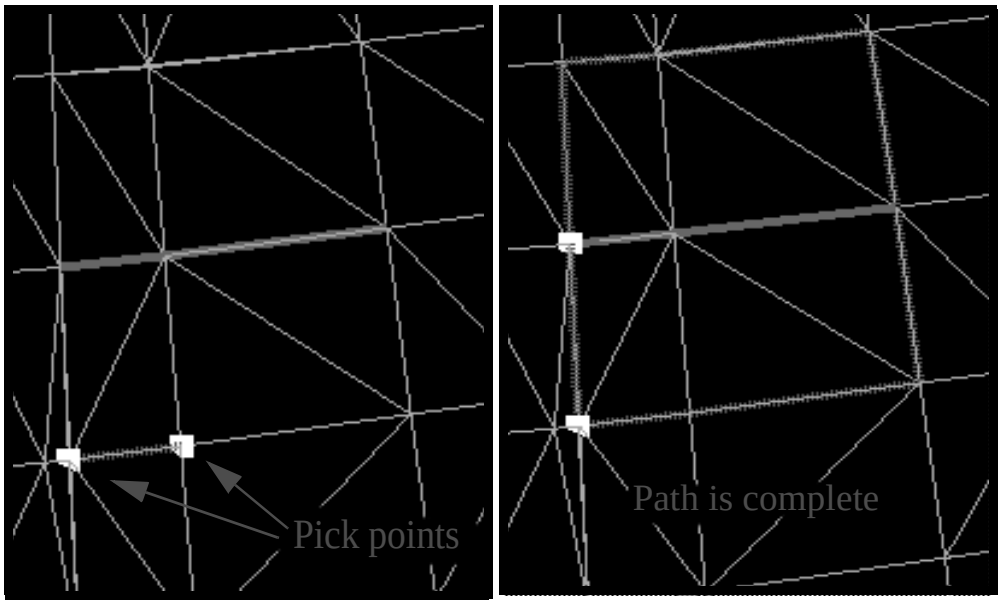
Step 6 Surface Correction Tools: Segmenting and Filling Surface

GridPro allows the user to smooth a surface using the segment and fill functions. The user can also move nodes perpendicular and parallel to a plane normal to a cell. Let's begin the process by correcting the cell in the center of the base. A picture of the problem cell is shown below.



As can be seen from the above picture, a small gap exists between two nodes creating a highly skewed triangle. Zoom in and create a path around the cells by clicking on the 

and on node points on the surface.



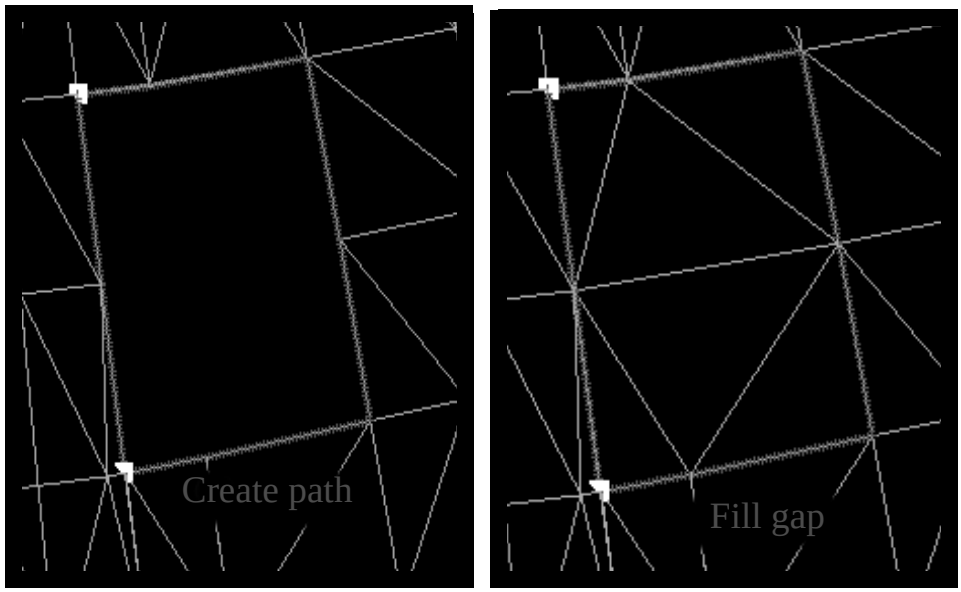
Make sure that the entire path is connected. Now segment the surface by going to the **Cell/Path** sub-command menu and clicking on the **Segm** button.

The segmented surface will be highlighted in yellow. Save the current surface by going to the **Current Piece** sub-command panel and clicking on **Save**.

You can scroll through the current surfaces by clicking on the  button. The name of the file where the surface is saved will appear in the upper left hand corner, in this case it is saved as **_surf.1**. Delete the current surface and load in **_surf.1** as a tria file. Notice that a gap now exists where the surface was segmented. We will fill in the gap and merge it with

the surface. Create a path using the same nodes as you did before and hit the **fill** button in the **Fill/Merge** sub-command panel.

The gap where the path was made will fill with triangles. See pictures below.

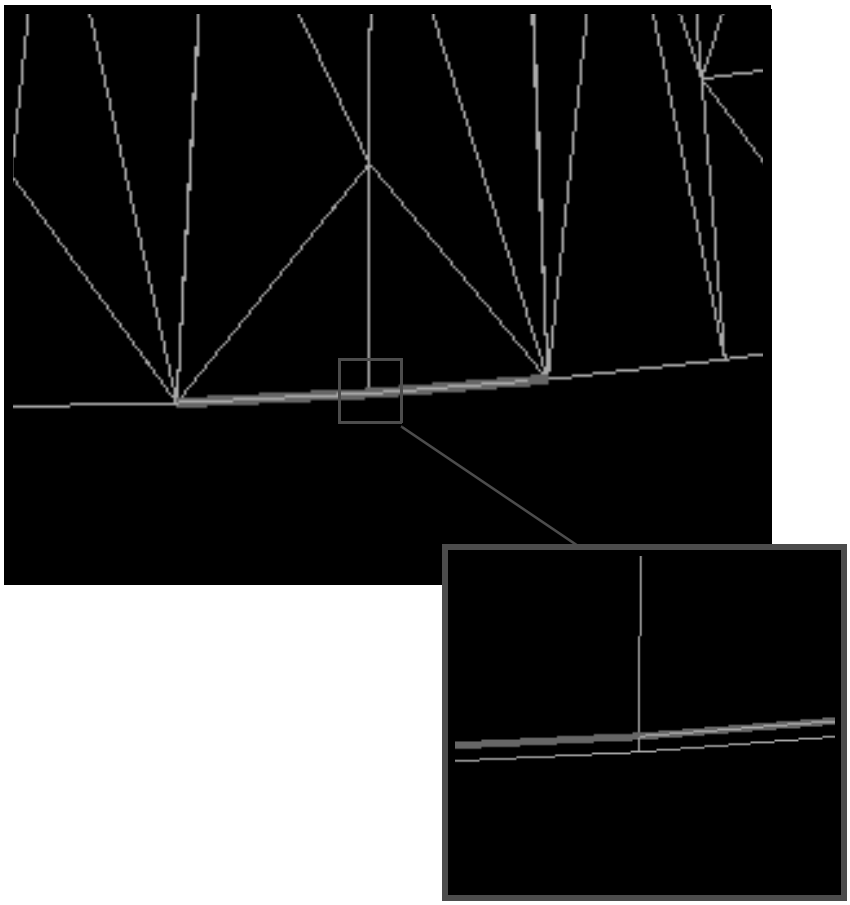


Make sure you merge the new triangles with the surface by clicking the **merge** button as soon as the fill is made. When the surfaces are merged, the red highlight will turn off.

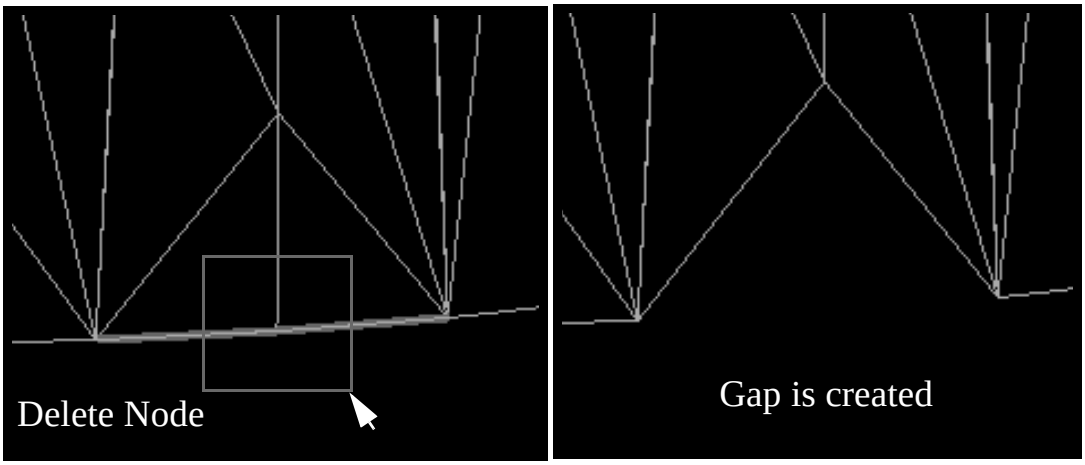
Step 7 Moving Nodes Parallel to Cut-Plane

Another effective method of smoothing surfaces is to move nodes using the **Cut-Plane**. Make sure the 

button is displaying **feature angle = 11 degrees** in the upper left hand corner of the screen. Zoom-in on the cell along the edge of the base and notice that it is also highly skewed.

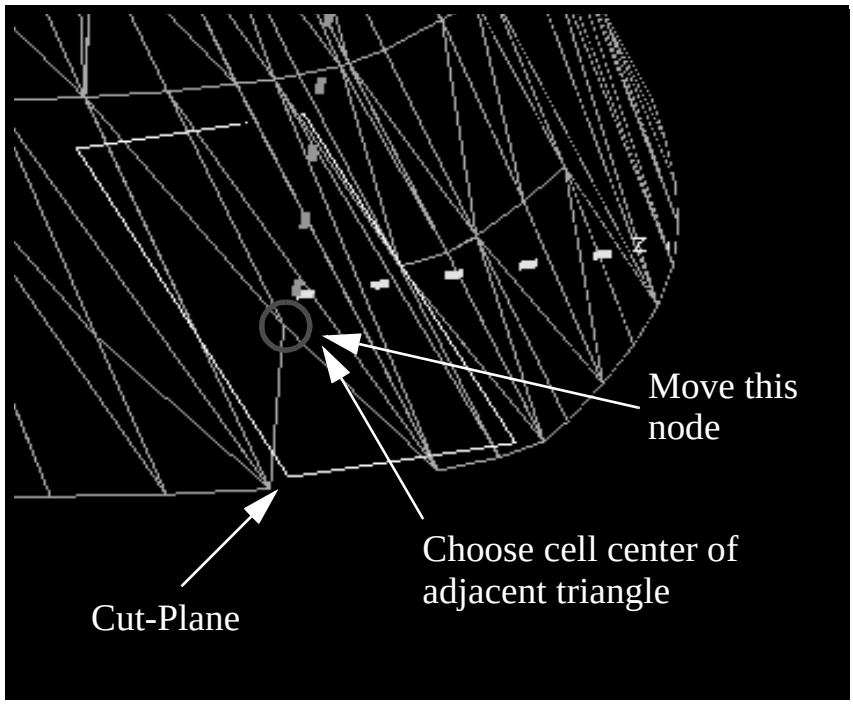


Delete the node by using the **Cell Delete** tool by clicking on the  button and dragging a purple box around the node with the right mouse button. The Cell Delete tool will delete all of the cells that are contained within the purple box and is typically most useful when you want to delete large portions of the surface.



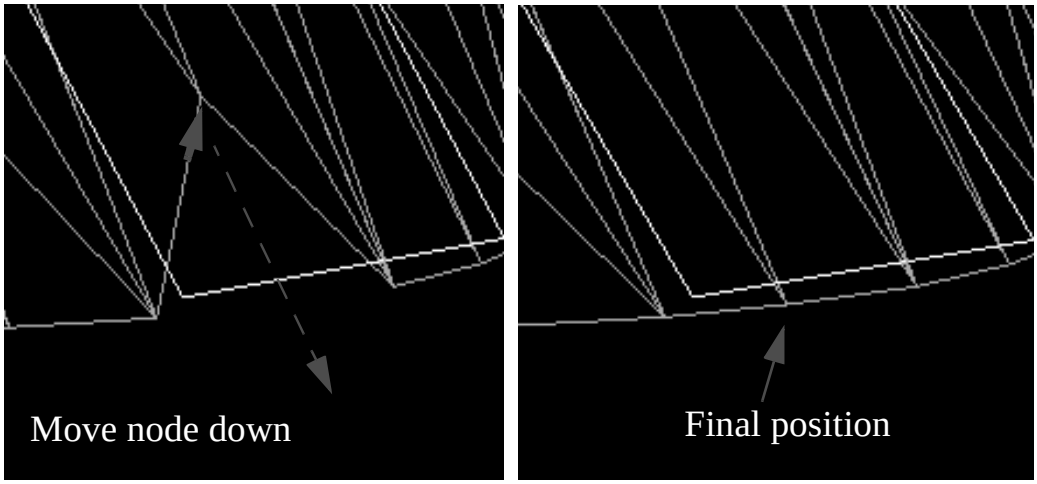
You can remove the light brown line by clicking on the **x** button in the **Border/Feature** sub-command panel. A gap exists along the edge, but since it is open using the fill command will not work. The best method is to move the node downward and align it along the edge. We will accomplish this procedure by aligning the **Cut-Plane** normal along the normal of an adjacent triangle. Go to the **Cut-Plane** sub-command panel and click on  and the position pop-up menu will appear.

Click on the cell center of an adjacent triangle and its coordinates will appear in the pop-up menu, click **apply** and the **Cut-Plane** normal will automatically be snapped along the normal of the chosen triangle.



Go to the **Merge/Fill** sub-command panel and click on the **Move Node** button.

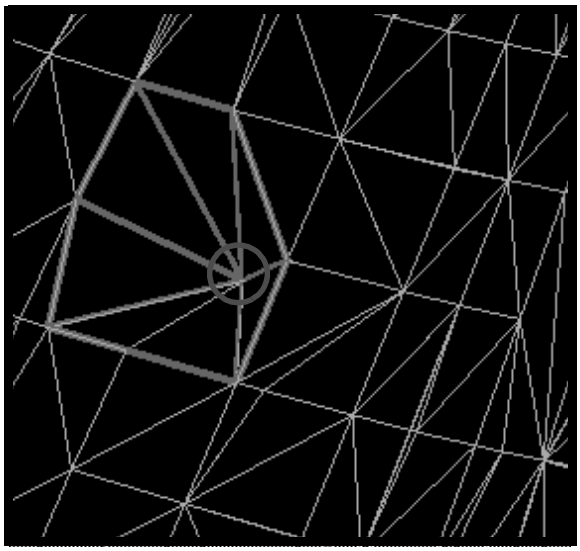
Now place the cursor above the node and the cursor arrow will turn red, at this time, click the left mouse button and drag the node downward. Notice the node remains parallel to the plain.



Make sure you immediately turn the **Move Node** button off after this procedure.

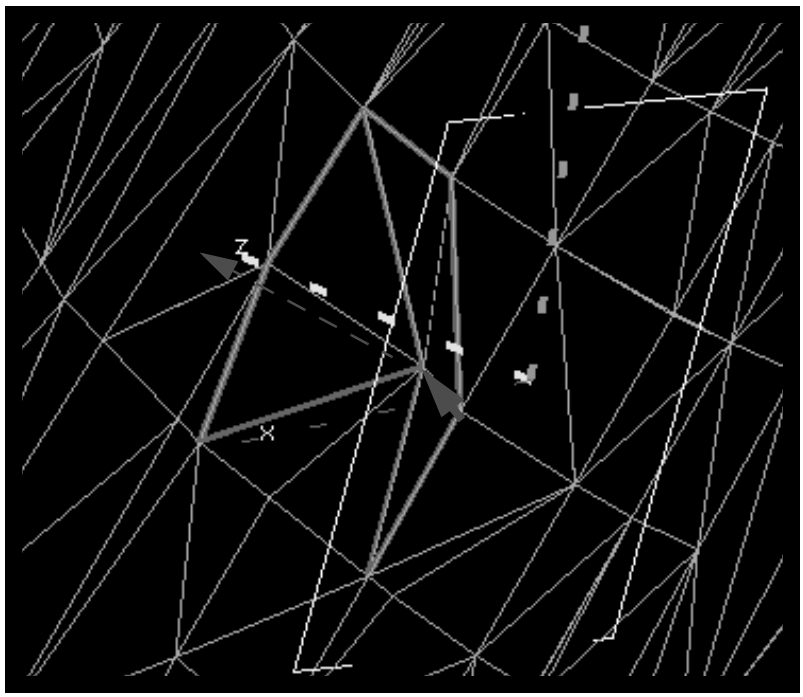
Step 8 Moving Nodes Perpendicular to Cut-Plane

Now that we have smoothed the cell on the edge of the base, one more problem area remains. Make sure the **feature angle = 11 degrees** and rotate the base so that the depressed node is highlighted in light brown as in the picture below.

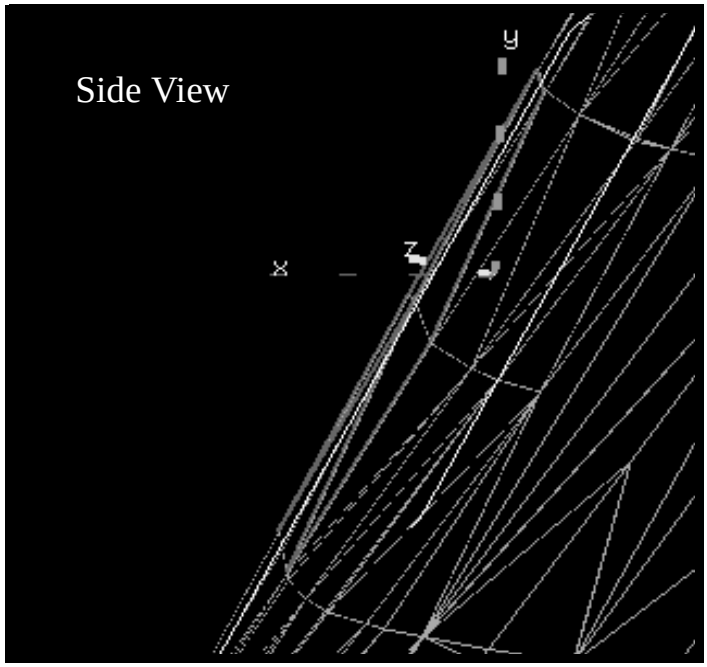


We want to move the node so that it is aligned along the surface. Go to the **Cut-Plane** sub-command panel and click on 

and again the position pop-up menu will appear. Click on the cell center of an adjacent triangle and the **Cut-Plane** normal will automatically be aligned along the normal of the chosen triangle. Click the **Move Node** button on the **Merge/ Fill** sub-command menu and place the cursor above the node you want to move and it will turn red. This time, click the **Right Mouse** button and drag the node perpendicular to the surface. **GridPro** will restrict the movement of the node along the **Cut-Plane** normal.



Make sure that the node is flush with the surface by rotating and looking at a side view. If needed, move the node back and forth so that it is properly aligned.



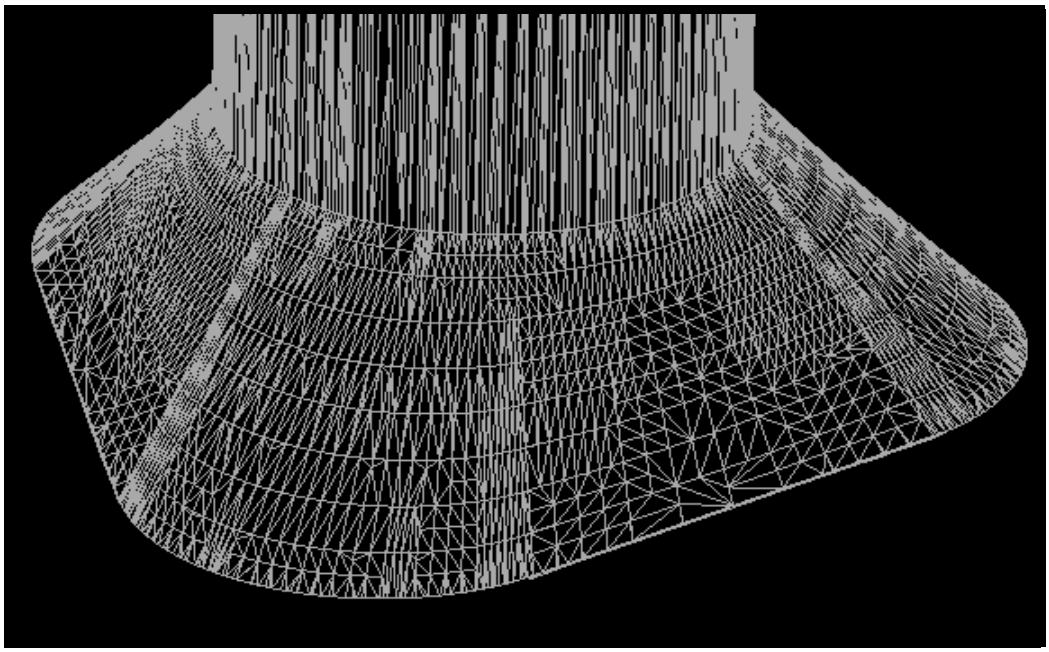
Now that the surface is smoothed, restart the gridding process. Make sure that the topology is properly assigned to all surfaces.

Step 9 Triangle File Thinning Utility

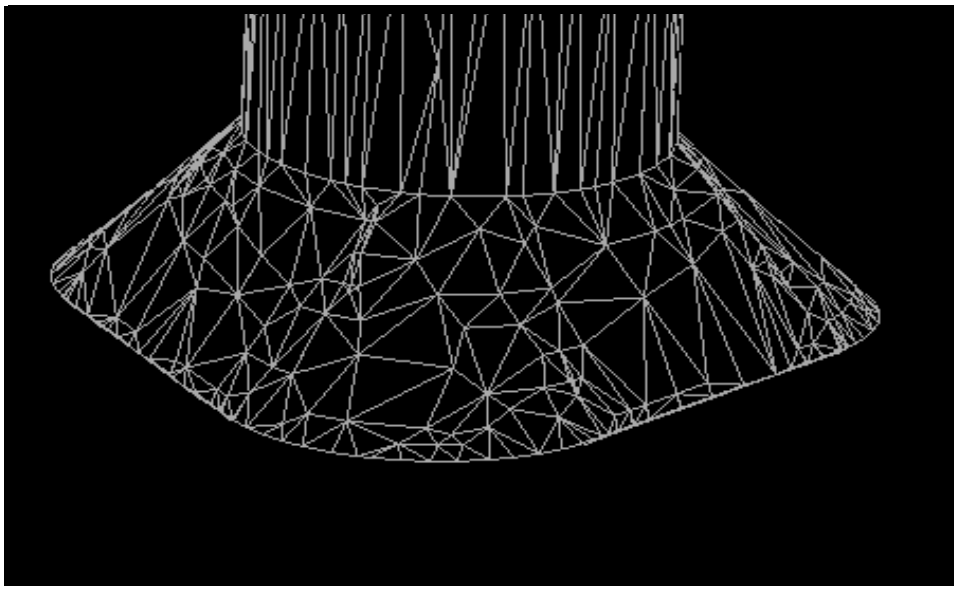
At times you may be working with a file that is too large to manipulate in the az manager. A **GridPro** utility called **thin** allows the user to automatically reduce the number of triangles on a surface while maintaining its resolution. The command is:

`thin` *`file_name`*`.`

Start the az manager and import the file named **surf_dense** and inspect its density, as in the picture below.

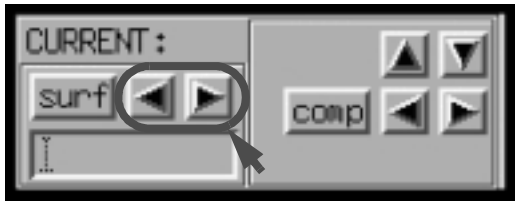


As you can see, the triangular mesh is extremely dense. Now go to the directory and type in `thin surf_dense` at the prompt. The triangles on the surface will be automatically reduced and the file will be saved as `surf_dense.tmp`. Load the file into the az manager and compare it to the denser surface.



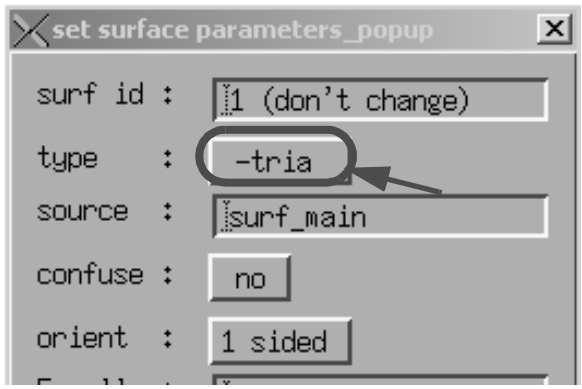
A good way to inspect the two surfaces simultaneously is to, turn on shading, turn **off** the surfaces in the **SURF ALL** sub-command panel

and flip between the surfaces by scrolling through the **Current Surfaces** on the **CURRENT** sub-command panel.

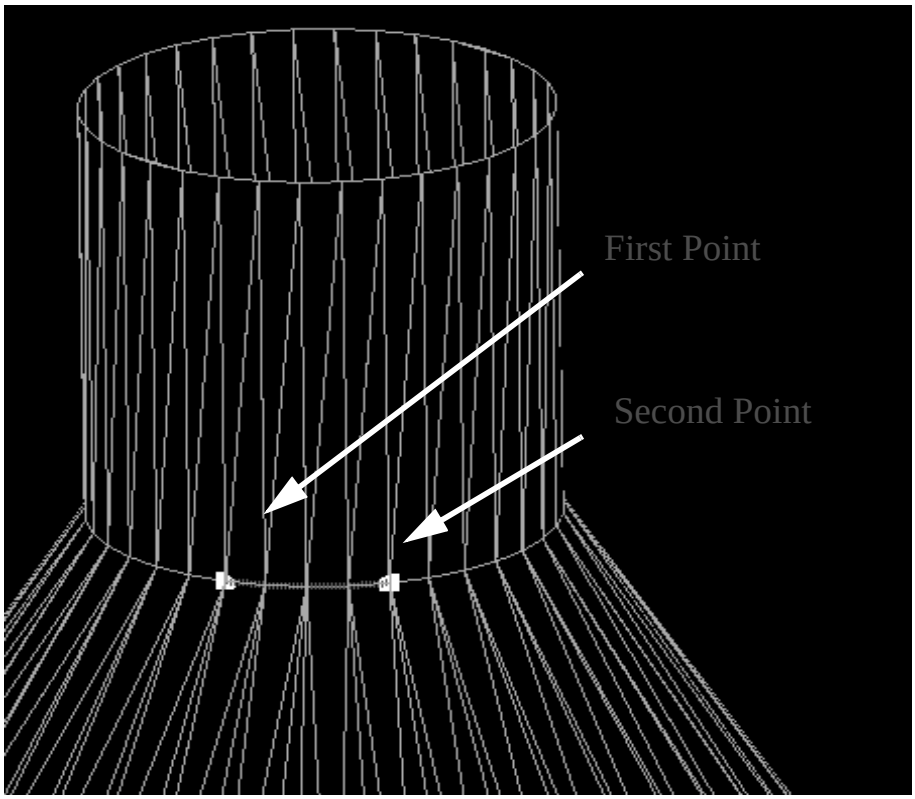


Step 10 Segment and Merging Surfaces

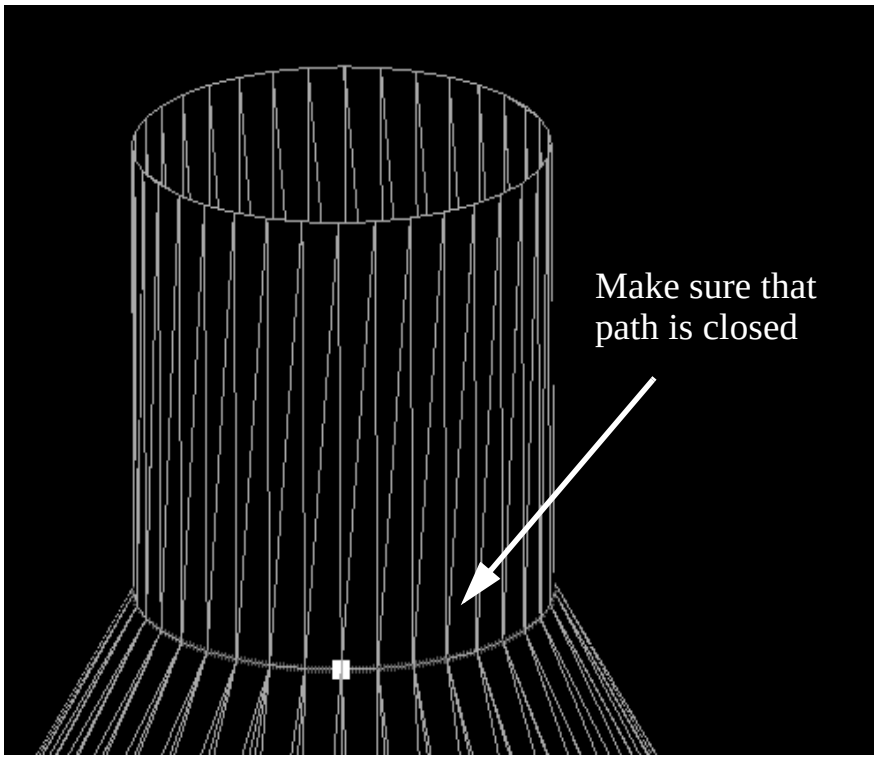
In most cases, in order to grid your model, you must segment the surfaces at the parts which you want to preserve a feature. For example, if you would like to maintain a sharp edge on your grid along a feature you must segment the surfaces along the edge and double assign the topology to the surfaces at that point. Let's practice segmenting a surface. Load the **surf_main** surface by clicking on the **surf/load: file** sub-menu at the top. Load the surface by double clicking on the surface and the **set surface parameters popup** menu will appear. In order to work on any surface within **GridPro**, you must specify its type. In this case it is a triangulation so change the type from **auto** to **tria** in the type menu as in the picture below.



Segment the surface at its main intersections as described below. Start with the first surface at the top by turning on the segmentation path by clicking on the path+ button and two points on the edge of the surface you would like segmented. See the below picture.

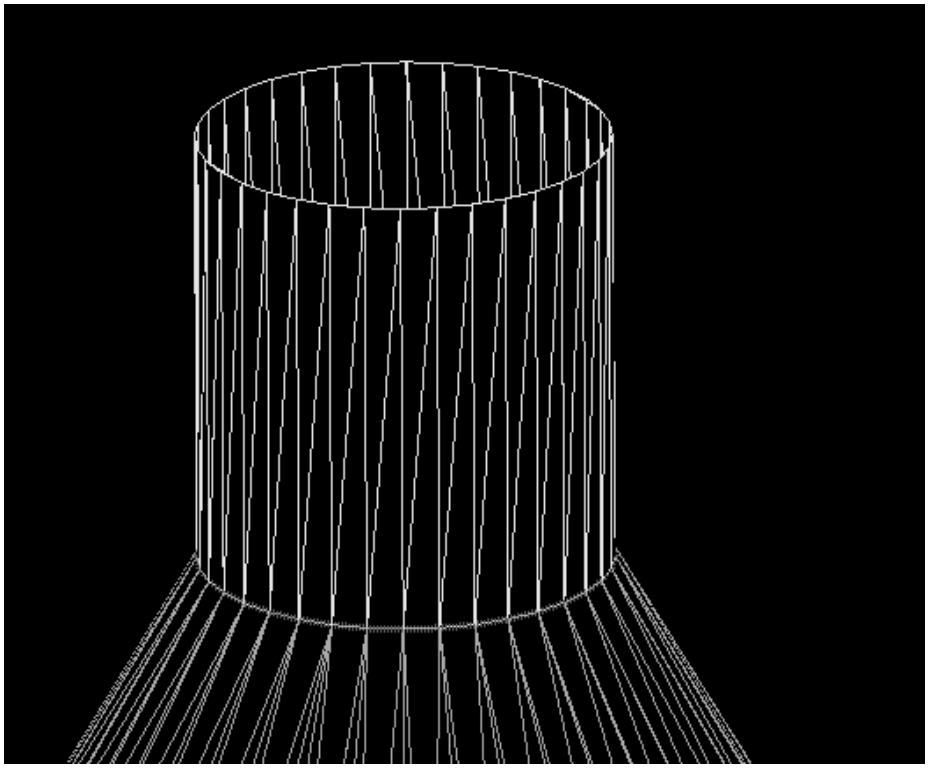


Complete the path around the surface by clicking on the remaining points along the edge. The path must be closed for GridPro to segment the surfaces.

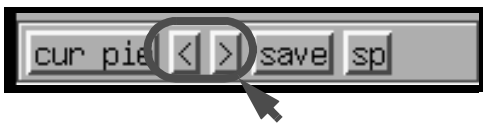


Now click on the **segm** button in the sub-command menu

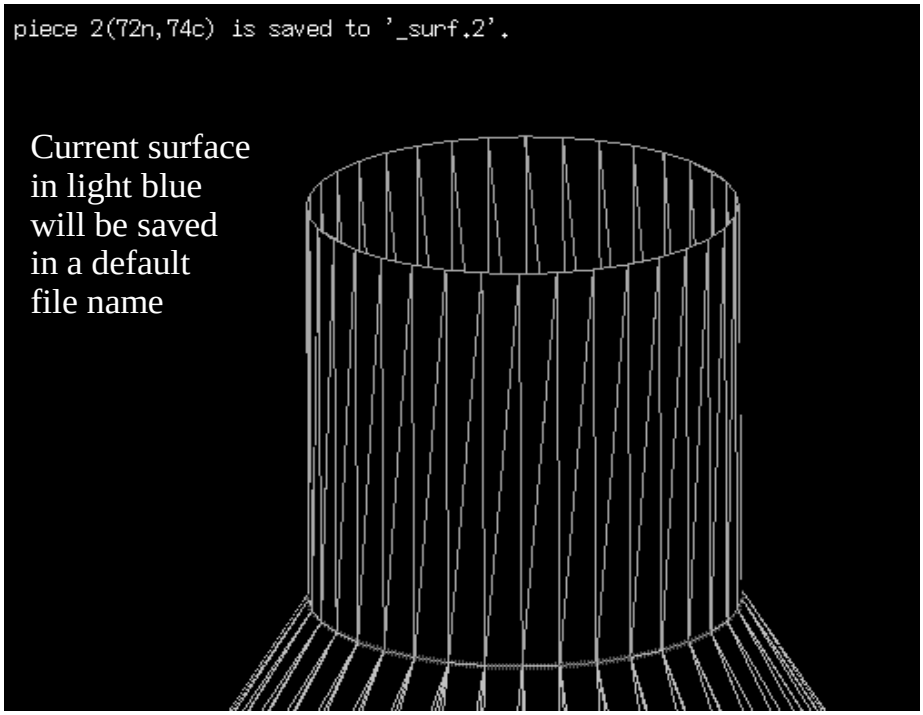
and the surfaces will be segmented into two pieces.



The surface that you will be able to save will always be the current surface. As you can see from the above picture the bottom surface is the current surface. To save the top surface, make it the current surface by clicking on the scroll buttons in the piece sub-command menu.



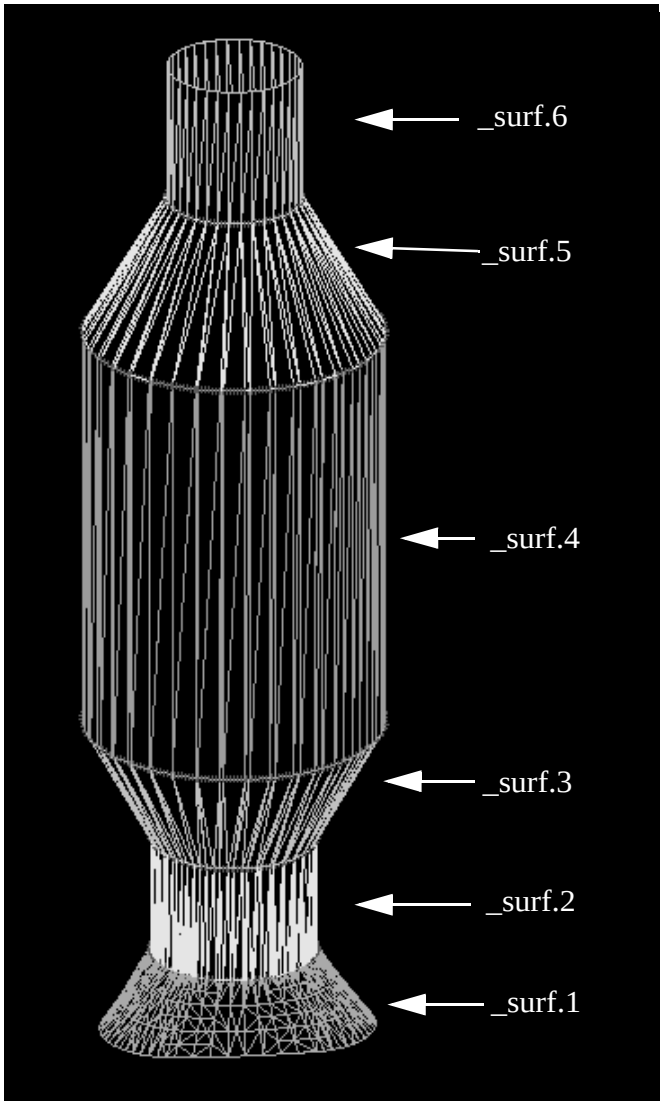
click on the save button to the right of the scroll bar and the surface will be saved in a default name.



All surfaces will be saved in a default name such as _surf.1, _surf.2 ... etc. In order to ensure that your surfaces are not overwritten, rename each surface as it is saved. Now save the bottom piece and reload it by going to the **surf/reload current** sub-menu at the top. In the **source** command prompt type in the surface name (i.e. _surf.1) and the new segmented surface will be loaded.

If the path that you are creating diverges from its intended path you can back up without deleting your previous work by using the  button. You can also delete the entire path by clicking on the <x> button and subtract using the <-> button.

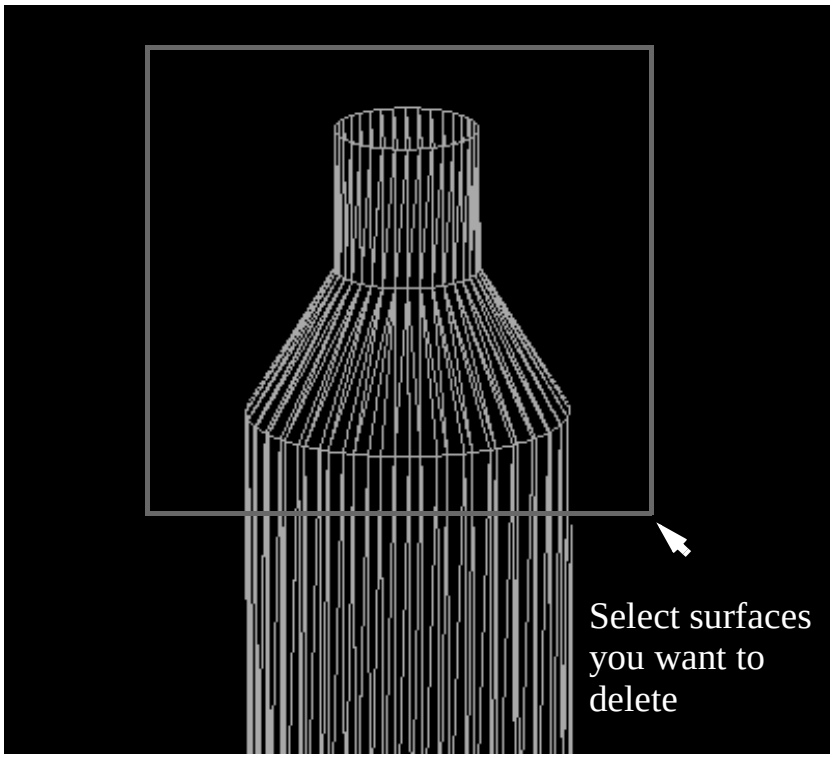
You can also create paths around various features simultaneously to segment more than two surfaces. Make sure each loop is created independently of the other by turning on and off the  button each time a loop is completed. The surface should be segmented as in the picture below. Save each piece by highlighting and saving each current surface using the **Current Piece** sub-command panel.



Delete all of the surfaces and re-import the surfaces you would like to work on separately. After surface correction (see above steps), you can build the topology around each of these surfaces to make one grid, or you can merge all of the surfaces back into one surface.

A quick way to delete or segment a portion of the surface is to use the cell deletion command. Test this technique by loading the **surf_main** surface again, be sure that it is imported as a **tria** surface. Click on the <-> button in the **cell deletion** sub-command panel

Now drag a purple box around the surfaces you want deleted with your right mouse button and all surfaces in the selection box will be automatically deleted.



You can add those same surfaces again by clicking on the <+> button in the **cell deletion** sub-command menu and retracing them with the right mouse button. All of the surfaces can also be added at any time by clicking on the <all> button. A selection of the surfaces can also be chosen by using the <*> button allowing you to only select that part of the model you want gridded while deleting all of the other surfaces (this functions as the reverse of the <-> command). Save the surfaces by using the save procedure as described above.

Step 11 Surface and Grid Merging Utility

All surfaces and grids can be merged as long as the nodes on the borders are properly aligned. For example, if you make changes to the nodes on the borders of the above surfaces, they cannot be merged. If you made no changes to the nodes on the borders, all of the surfaces can be merged again. The command for merging surfaces or grids is:

`mrgg file_name1 file_name2` `<return>`

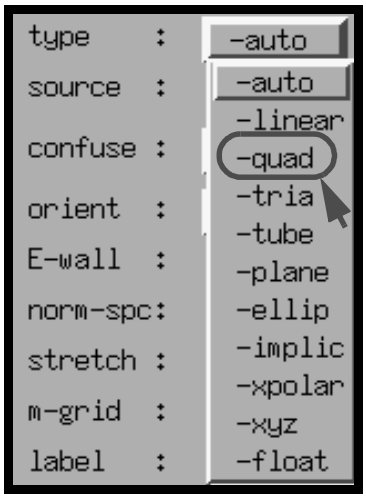
The new file will be saved as **`file_name1.tmp`**. Only two surfaces can be merged at one time, for example, all of the above six surfaces must be merged into one surface in 6 separate steps.

Part II: Surface Correction on Quads

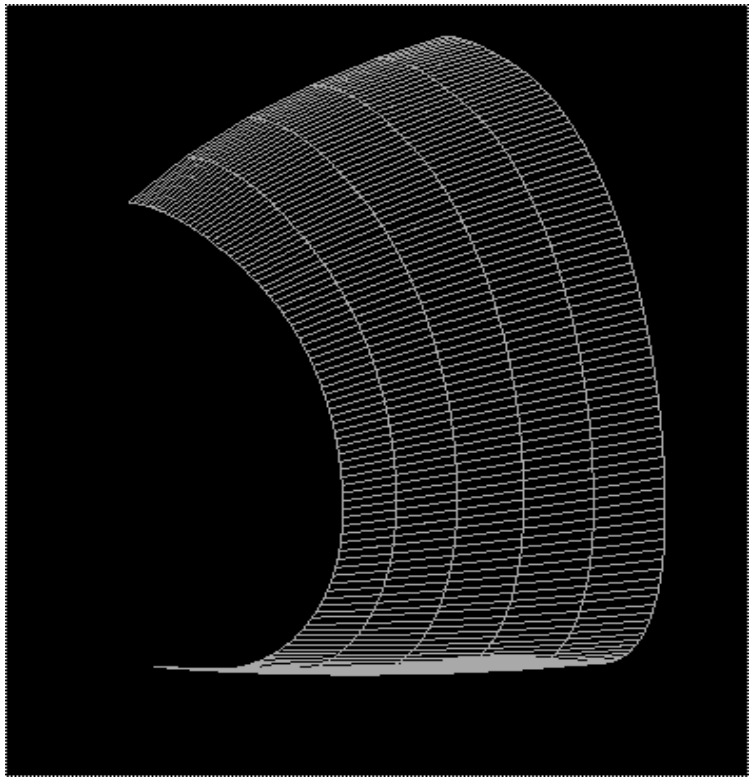
All of the correction techniques that can be used on triangular surfaces can be used on quads except that gaps on quad surfaces cannot be filled. However, an effective technique available for quad surfaces is that they can be transformed into **GridPro** topology, manipulated and then transformed back into a surface. One advantage of transforming the surfaces into topology is that all of the topology tools, such as insert topology sheet, can also be used for surface correction.

Step 1 Surface Correction on Quads

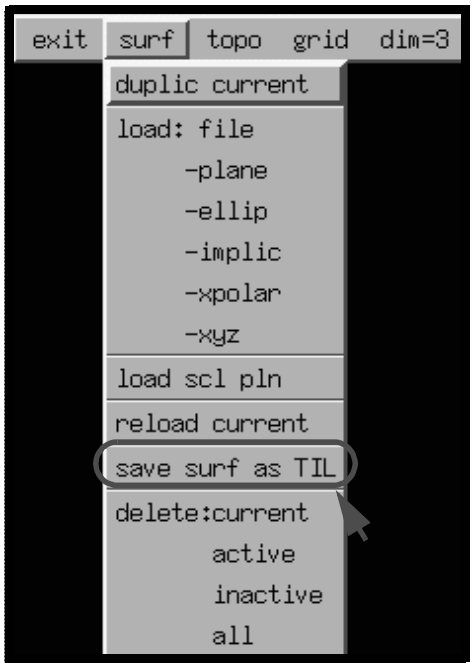
One way to conduct surface manipulation on quads is to transform the surface into **GridPro** topology. Let's learn about this procedure by going to the surf sub-menu at the top and choosing **load:file** to load in the **quad_surf** file. Make sure it is loaded in as a quad surface by choosing **quad** in the **type** sub-menu.



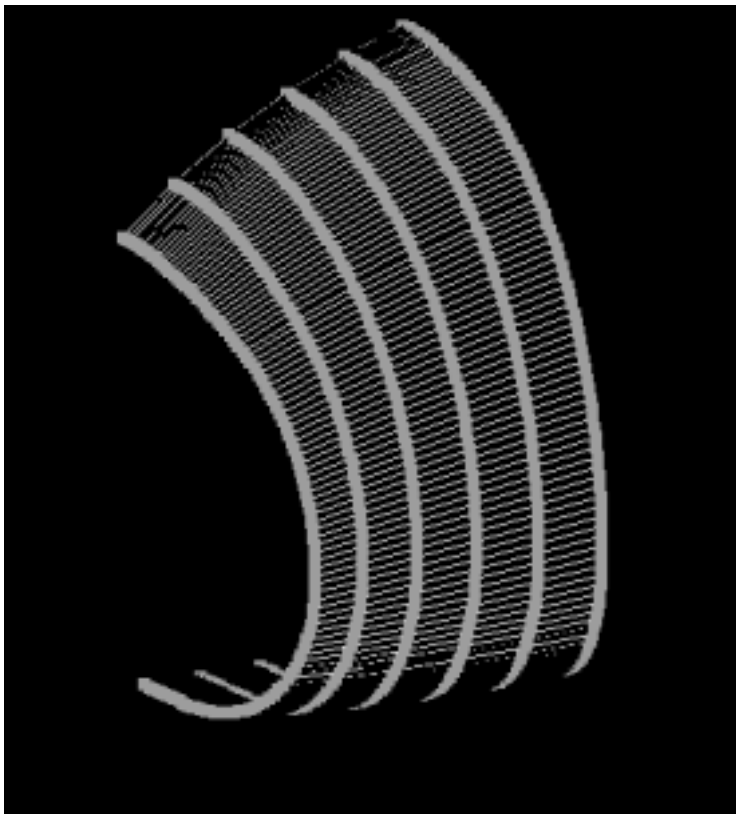
The surface is displayed as:



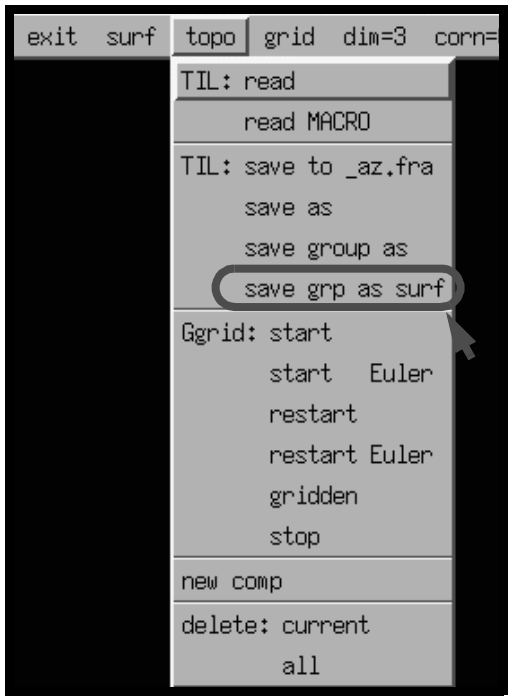
Now save the surface as a **Topology TIL file** by going to the **surf** sub-menu and clicking on **save surf as TIL.**



The surface will be save as `surf.tmp.fra`. Now delete the current surface and go to the **topo** menu and choose **TIL: read** to import the topology file. The topology should look like the picture below.



Make manipulations to the topology using the same techniques as we used on the triangular surface. You can also use any topology manipulation tool. When you are finished, add the topology to a group and save it as a quad surface by choosing **TIL: save grp as surface** in the **topo** submenu.


exit
surf
topo
grid
dim=3
corn=
TIL: read
read MACRO
TIL: save to _az.fra
save as
save group as
save grp as surf
Ggrid: start
start Euler
restart
restart Euler
gridden
stop
new comp
delete: current
all