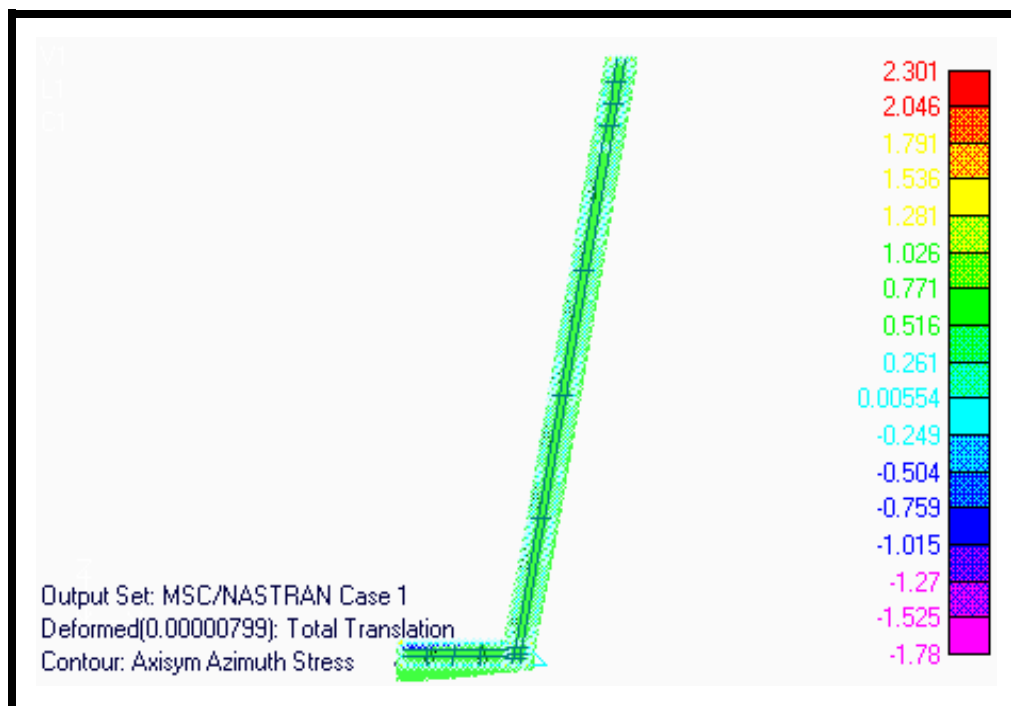


WORKSHOP 13b

Axisymmetric Analysis of a Coffee Cup



Objectives:

- Manually create a cross section of the coffee cup using the given dimensions and apply axisymmetric element mesh.
- Input the hydrostatic loading conditions by creating a function.
- Submit the job for analysis.
- Review the results from the analysis.

Model Description:

In the previous exercise, the coffee cup was modeled by modeling a 1/8th section. Then it was meshed with quad elements with plate properties. In this exercise, we will take a different approach in solving the same problem. We will analyze it with axisymmetric element properties. We will manually create the 1/2 cross section geometry in the ZX plane (required for axisymmetric analysis), utilizing some of Nastran for Windows' CAD features. We will then mesh it with tri elements and then apply the axisymmetric property to the mesh. This 2D finite element model will idealize the full cup geometry since the axis of symmetry exist along the axis of revolution. We will apply the constraint in the z-direction on the node at the lower right corner of the model. This will emulate a constraint on the bottom lip of the cup (where it touches the table). We will apply the pressure loading on the inner curves of the cup using an equation. We will run the analysis and read results which should be similar to the previous exercise.

Figure 13b.1 - Coffee Cup

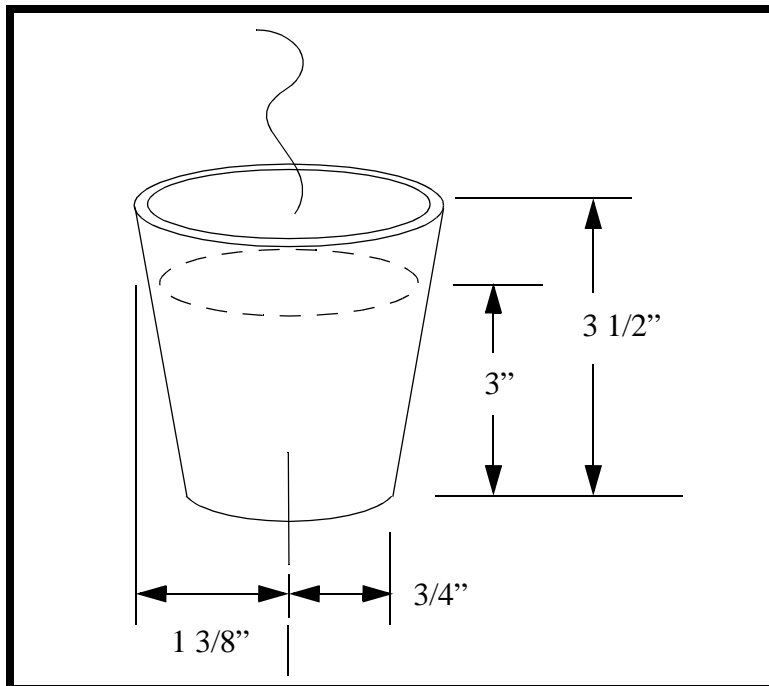


Table 13b.1 - Material Properties

Thickness:	1/8 in
Youngs Modulus:	4.7E+05 psi
Poisson's Ratio:	0.333

Suggested Exercise Steps:

- Create the material properties.
- Create the axisymmetric element properties.
- Create the curves that define the outer edge of the cup (on the XZ global plane).
- Offset these curves by 0.125 to define the thickness.
- Create curves to define the water level and the top of the cup.
- Use these curves to edit the existing curves to obtain surfaces.
- Create the surfaces using the Ruled option.
- Specify mesh size on the surfaces.
- Mesh the surfaces.
- Add midnodes to the elements.
- Apply constraints and pressure equation.
- Submit for analysis.
- Postprocess the results

Exercise Procedure:

1. Start up MSC.Nastran for Windows 4.0 and begin to create a new model.

Double click on the icon labeled **MSC.Nastran for Windows V4.0**.

On the *Open Model File* form, select **New Model**.

Open Model File:

2. Create a material called **mat_1**.

From the pulldown menu, select **Model/Material**.

Model/Material...

Title:

Youngs Modulus:

Poisson's Ratio:

3. Create a property called **axisym** to apply to the members of the cup itself.

From the pulldown menu, select **Model/Property**.

Model/Property...

Title:

Elem/Property Type...

Volume Elements

Axisymmetric

Material:

-
4. Create the cup's geometry.

Tools/Workplane...

Move Plane:

Rotate

Base:

X:
0

Y:
0

Z:
0

Tip:

1

0

0

OK

Rotation Angle:

90

OK

View/Rotate... <F8>

ZX Front

OK

NOTE: MSC.Nastran requires that the model reside in the positive zx-plane, and the z-axis is the centerline of the part. We will build the geometry in this quadrant.

Geometry/Curve-Line/Coordinates...

Enter First Location for Line of first curve. (**Curve 1**)

X:

Y:

Z:

0

0

0

OK

Enter Second Location for Line.

X:

Y:

Z:

0.75

0

0

OK

Enter First Location for Line of second curve. (**Curve 2**)

X:

Y:

Z:

0.75

0

0

OK

Enter Second Location for Line.

X: Y: Z:

View labels of the curves.

View/Options <F6>

Turn off the workplane.

Tools/Workplane...

Draw Workplane

Refit the model to the screen

View/Autoscale <Ctrl+A>

Offset **Curve 1** and **Curve 2** by the cup's thickness of 0.125.

Geometry/Curve-Line/Parallel..

From Curve:

Offset:

<Click above **Curve 1** using your mouse.>

From Curve:

2

Offset:

0.125

OK

<Click to the left of **Curve 2** using your mouse.>

OK

Cancel

Modify/Extend...

<Select **Curve 3**>

OK

Methods^

Onto Curve

Enter the location to Extend to. We want Curve 3 to be extended to meet Curve 2. Point 6 is the closest point on Curve 3 to Curve 2.

Choose snap to point icon, located in the toolbar.

+

	X:	Y:	Z:
<i>Base:</i>	XPT(6)	YPT(6)	ZPT(6)
<i>Curve ID:</i>	2		

OK

After extending Curve 3, we need to extend Curve 4 as well.

<Select **Curve 4**>

OK

Enter the location to Extend to. We want Curve 4 to be extended to meet Curve 1. Point 7 is the closest point on Curve 4 to Curve 1.

	X:	Y:	Z:
<i>Base:</i>	XPT(7)	YPT(7)	ZPT(7)
<i>Curve ID:</i>	1		

OK

Cancel

Create the line to define the fluid level of the cup as well as a line to define the top of the cup.

Geometry/Curve-Line/Horizontal

Methods^			
Locate			
X:	Y:	Z:	
1.375	0	3	OK
X:	Y:	Z:	
1.375	0	3.5	OK
Cancel			

We need to shrink Curve 4 to the newly created Curve 6.

Modify/Extend...

<Select **Curve 4**>

OK
Methods^
Onto Curve

Enter the location to Shrink to. We want Curve 4 to be extended to meet Curve 6. Point 8 is the closest point on Curve 4 to Curve 6.

	X:	Y:	Z:	
<i>Base:</i>	XPT(8)	YPT(8)	ZPT(8)	
<i>Curve ID:</i>	6			OK
Cancel				

View/Options <F6>

- **Labels, Entity and Color**

Options:(highlight)

Point

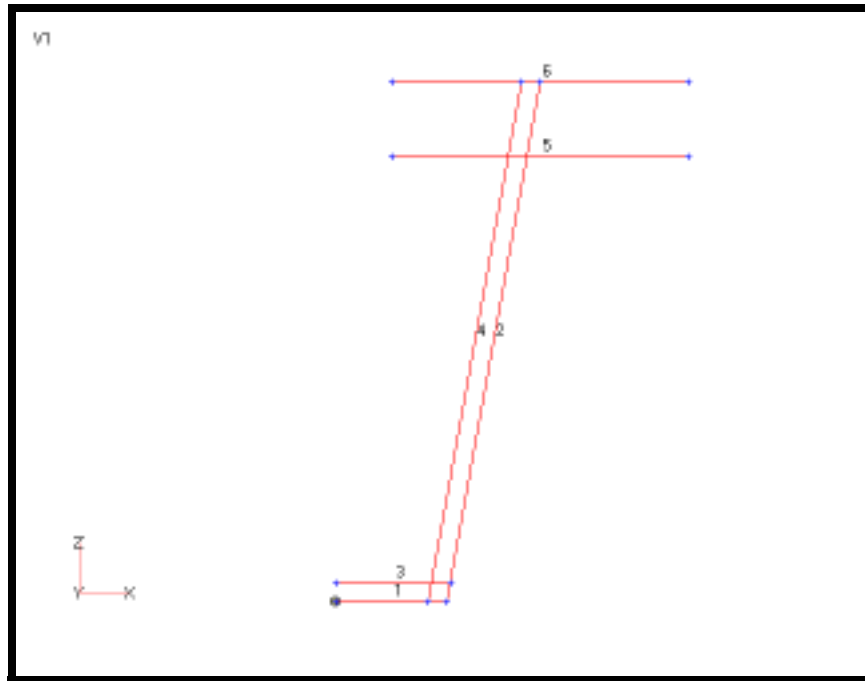
Label Mode:

0..No Labels

OK

Refer to the following picture for locations of curves.

Figure 13b.2



At this point you can edit the curves further by trimming and breaking them in order to create the surfaces. However, the next few steps will only involve creating points at the intersections of these curves which we will later use to help create the ruled surfaces. This will simplify the process of obtaining the surfaces to mesh.

Create points at the intersections of Curve 5 at Curve 4 and Curve 2. And also at the intersection of Curve 3 and Curve 4.

Geometry/Point

Methods^

Intersect - Curves

Curve ID 1:

5

Curve ID 2:

4

OK

<i>Curve ID 1:</i>	<input type="text" value="5"/>
<i>Curve ID 2:</i>	<input type="text" value="2"/>
<input type="button" value="OK"/>	
<i>Curve ID 1:</i>	<input type="text" value="3"/>
<i>Curve ID 2:</i>	<input type="text" value="4"/>
<input type="button" value="OK"/>	
<input type="button" value="Cancel"/>	

Temporarily turn off curve labels and turn on point labels.

View/Options... <F6>

<i>Options:</i> (highlight)	<input type="button" value="Curve"/>
<i>Label Mode:</i>	<input type="button" value="0..No Labels"/>
<i>Options:</i> (highlight)	<input type="button" value="Point"/>
<i>Label Mode:</i>	<input type="button" value="1..ID"/>
<input type="button" value="OK"/>	

Delete all curves. The points will be retained.

Delete/Geometry/Curve...

<input type="button" value="Select All"/>
<input type="button" value="OK"/>

Click Yes to “OK to Delete 6 Selected Curve(s)?”

<input type="button" value="Yes"/>

Get rid of coincident points.

Tools/Check/Coincident Points...

<input type="button" value="Select All"/>
<input type="button" value="OK"/>

When asked if it is OK to Specify Additional Range of Points to Merge, click NO.

No

Merge Coincident Entities

OK

The Messages and Lists windows will say that 1 Point was merged.

View/Autoscale <Ctrl+A>

Create lines connecting point to point..

Geometry/Curve-Line/Points...

From Point:

To Point:

OK

From Point:

To Point:

OK

From Point:

To Point:

OK

From Point:

To Point:

OK

From Point:

To Point:

OK

From Point:

To Point:

OK

Cancel

Now we can delete all unnecessary points. When you hit select all points, only points that are not connected to curves will be deleted.

Delete/Geometry/Point...

Select All

OK

Yes

Now turn on curve labels and turn off point labels.

View/Options... <F6>

Options: (highlight)

Curve

Label Mode:

1..ID

Options: (highlight)

Point

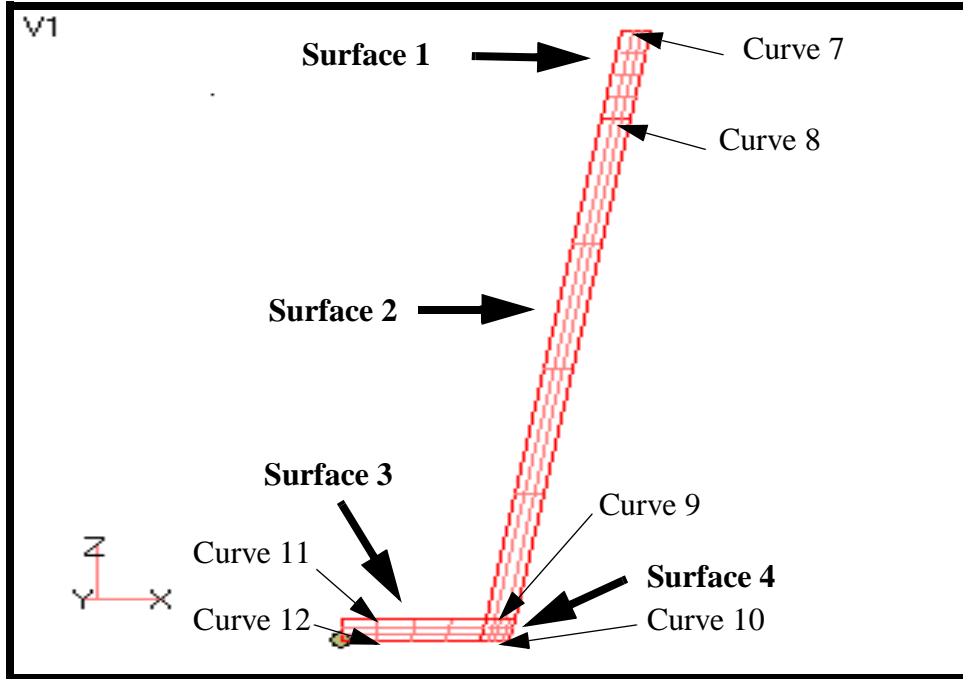
Label Mode:

0..No Labels

OK

Refer to the following figure for curve locations. We will use these curves to create the ruled surfaces.

Figure 13b.3



5. Create surfaces for the cup.

NOTE: Only a section of the cup will be modeled. The solution will use symmetry for the overall analysis.

Geometry/Surface/Ruled...

<i>From Curve:</i>	<input type="text" value="7"/>
<i>To Curve:</i>	<input type="text" value="8"/>
<input type="text" value="OK"/>	
<i>From Curve:</i>	<input type="text" value="8"/>
<i>To Curve:</i>	<input type="text" value="9"/>
<input type="text" value="OK"/>	
<i>From Curve:</i>	<input type="text" value="9"/>
<i>To Curve:</i>	<input type="text" value="10"/>
<input type="text" value="OK"/>	
<i>From Curve:</i>	<input type="text" value="11"/>
<i>To Curve:</i>	<input type="text" value="12"/>
<input type="text" value="OK"/>	

Cancel

Now delete the rest of the curves and points. We won't need them anymore. The curves which belong to the surfaces will not be deleted.

Delete/Geometry/Curve...

Select All

OK

When asked if it is OK to delete 22 Selected Curve(s), Click Yes.

Yes

Delete/Geometry/Point...

Select All

OK

When asked if it is OK to delete 26 Selected Point(s), Click Yes.

Yes

View/Autoscale... <Ctrl+A>

- Now define the mesh size on the cup section.

When defining the mesh control, notice that after you select a surface, the "s" direction for the selected surface is colored red on your display.

Mesh/Mesh Control/Mapped Divisions on Surface...

<Select Surface 1>

(refer to Fig. 13b.3 for surfaces)

OK

	s	t	
<i>Number of Elements:</i>	<input type="text" value="4"/>	<input type="text" value="15"/>	
<i>Bias:</i>	<input type="text" value="1"/>	<input type="text" value="1"/>	<input type="text" value="OK"/>

<Select **Surface 2**>

(refer to *Fig. 13b.3* for surfaces)

OK

s

t

Number of Elements:

4

90

Bias:

1

1

OK

<Select **Surface 3**>

(refer to *Fig. 13b.3* for surfaces)

OK

s

t

Number of Elements:

4

4

Bias:

1

1

OK

<Select **Surface 4**>

(refer to *Fig. 13b.3* for surfaces)

OK

s

t

Number of Elements:

15

4

Bias:

1

1

OK

Cancel

7. Finally, create the finite element entities.

Mesh/Geometry/Surface...

Select All

OK

Property:

1..axisym

Element Shape:

● **All Triangles**

OK

The *Messages and Lists* window should confirm with “Merging”. This signals auto-merging of the coincident nodes.

Turn off the labels.

View/Options <F6>

Quick Options...

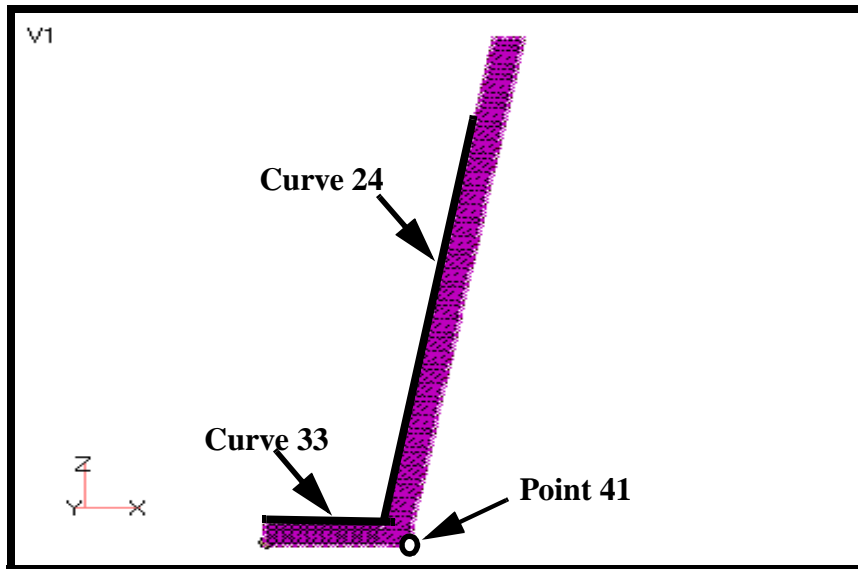
Labels Off

Done

OK

The viewport should appear as follows:

Figure 13b.4



8. Create the midside nodes.

Modify/Update Elements/Order...

When asked if it is OK to Convert to Parabolic Elements, click Yes.

Yes

When asked if it is OK to Create Midside Nodes, click Yes.

Yes

Select All

OK

9. Create the constraints.

Model/Constraint/Set...

ID:

1

Title:

constraint

OK

Now define the relevant constraint for the center of the cup.

Model/Constraint/Nodal...

Method^

On Point

< Select **Point 41** >

(see **Fig. 13b.4** for location of point 41)

OK

DOF (click to select):

TZ

OK

Cancel

10. Create the loading condition.

Model/Load/Set...

Title:

pressure

OK

Now define the pressure on the relevant surfaces. The pressure that will be created will be applied to the center of each element. Later in the exercise, you will create a pressure applied over the entire element.

Model/Load/On Curve...

<Select **Curves 24** and **33**>

(see **Fig. 13b.4** for location of curves)

OK

Create Loads on Curves:

(highlight)

Pressure

Method:

Variable

Advanced...

Equation

Multiply By:

Equation:

0.0362*(3-!z)

OK

Pressure/Value:

1

OK

Cancel

Transfer the pressure load to finite element to see the pressure contour

Model/Load/Expand...

OK

View/Options... <F6>

Options:

Load Vectors

Vector Length:

1..Scale by Magnitude

OK

Tools/Check/Coincident Nodes...

Select All

OK

When asked if it is OK to Specify Additional Range of Nodes to Merge, click NO.

No

Merge Coincident Entities

OK

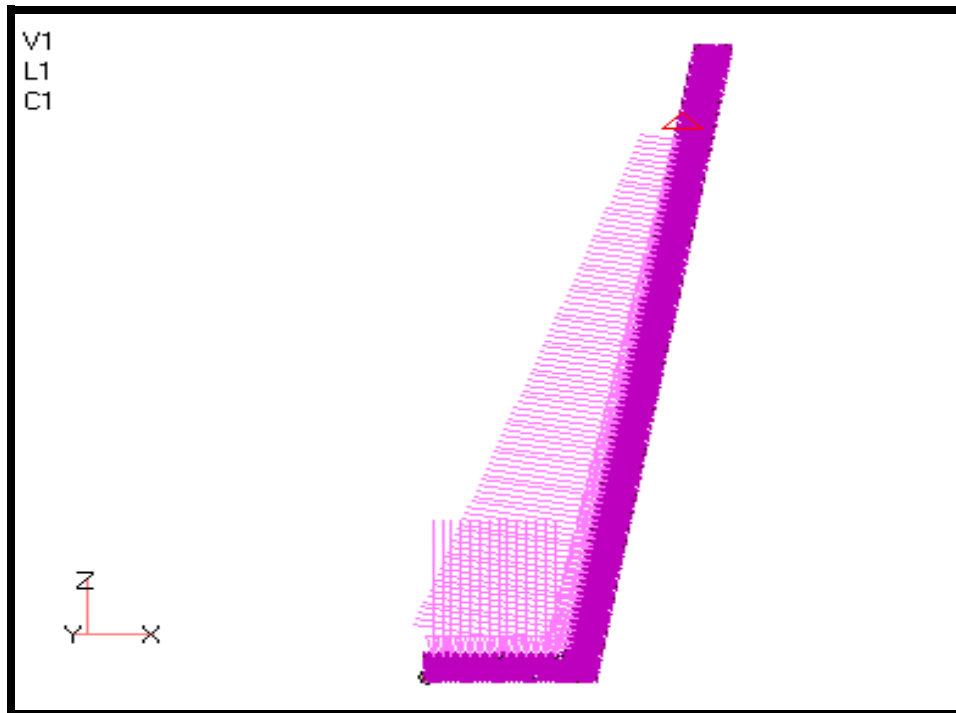
The status window should reveal that there were no coincident nodes.

Refit the model to the screen.

View/Autoscale <Ctrl+A>

The viewport should appear as follows:

Figure 13b.5



11. Create the input file for analysis.

File/Export/Analysis Model...

Type:

1..Static

OK

Change the directory to **C:\temp**.

File name:

axisymmetric_cup

Write

Run Analysis

Advanced

OK

Output Requests

2..Print and PostProcess

OK

OK

When asked if you wish to save the model, respond **Yes**.

Yes

File name:

axisymmetric_cup

Save

When asked “OK to read axisymmetric element corner stresses?” answer **Yes**.

Yes

When the MSC.Nastran manager is through running, MSC.Nastran will be restored on your screen, and the *Message Review* form will appear. To read the messages, you could select **Show Details**. Since the analysis ran successfully, we will not bother with the details this time.

Continue

12. Now, we will postprocess the results.

View/Options... <F6>

Category:

Post Processing

Options:

Deformed Style

Scale %:

1

Scale Act:

1

OK

View/Select... <F5>

Deformed Style:

Deform

Contour Style:

Contour

Deformed and Contour Data...

Output Vectors/Deformation:

1..Total Translation

Output Vectors/Contour:

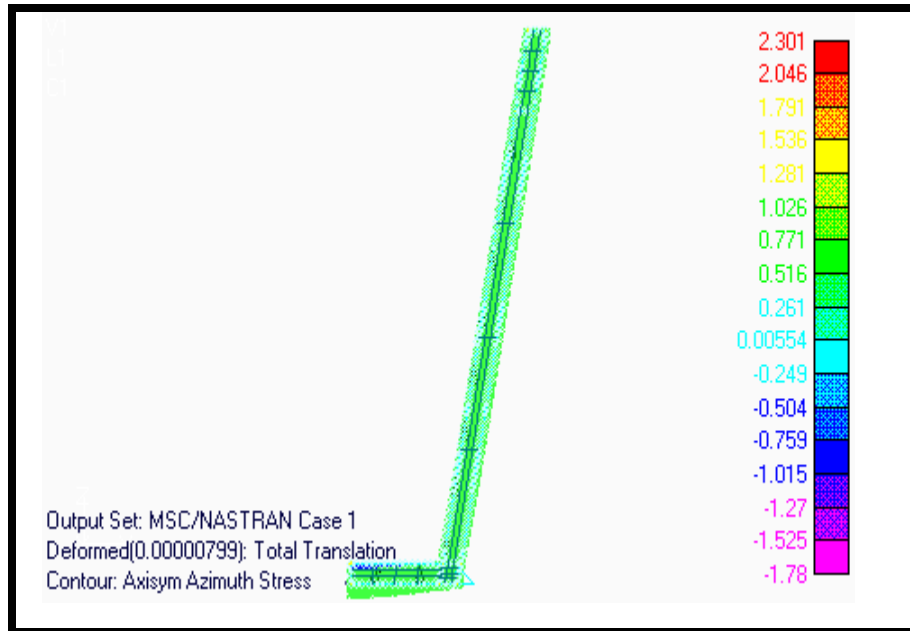
6029..Axisym Azimuth Stress

OK

OK

The final results plot should appear as shown below. Notice the results are close to that of the previous exercise. A finer mesh would get us more accuracy.

Figure 13b.6



This concludes this exercise.

File/Save

File/Exit