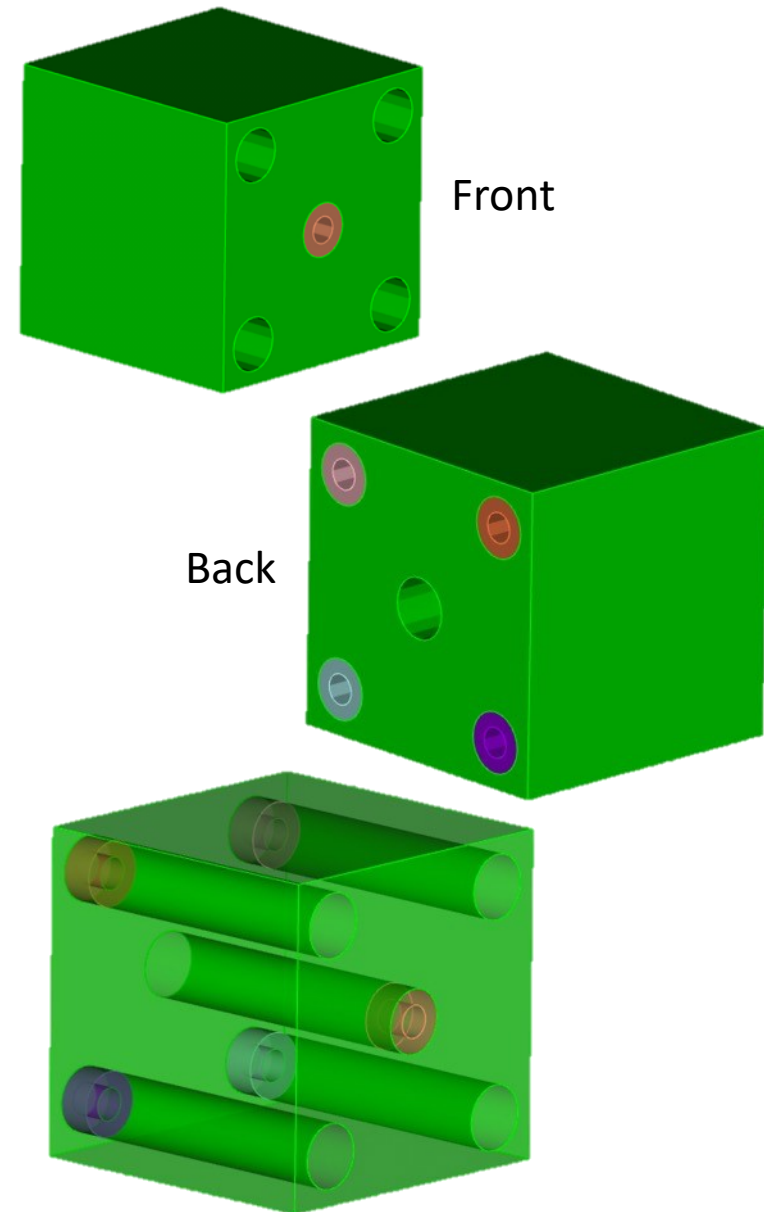


# Fixed Blocks Tutorial

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc. for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

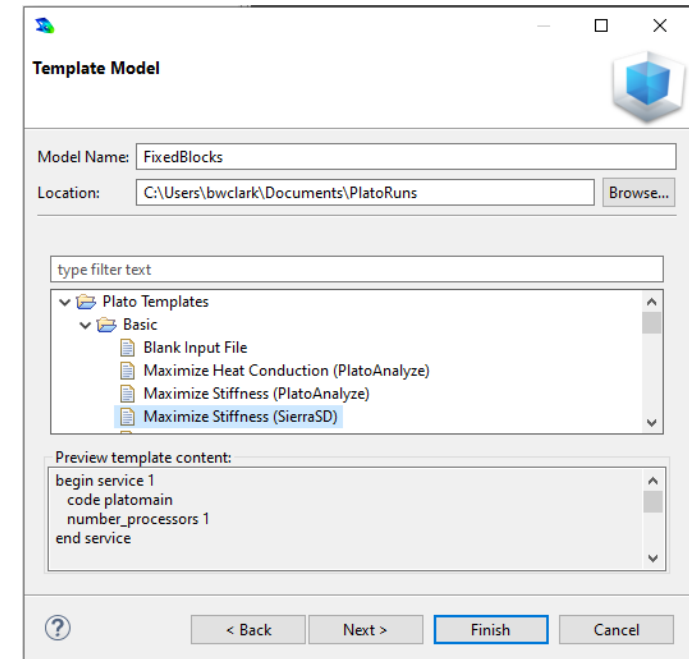
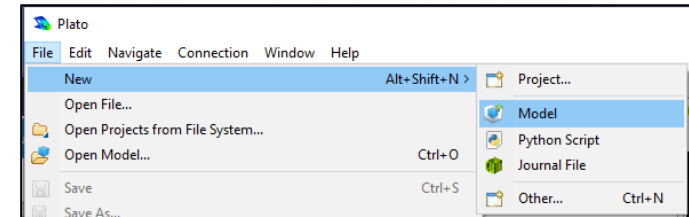
# Problem Description

- We will be designing a bracket that will be bolted to a wall using the 4 cylindrical collars on the back side of the model and will support a load applied on the single cylindrical collar on the front of the model.
- We have hollowed out part of the design domain so that there will be access to the bolt-down locations.



# Create a New Model

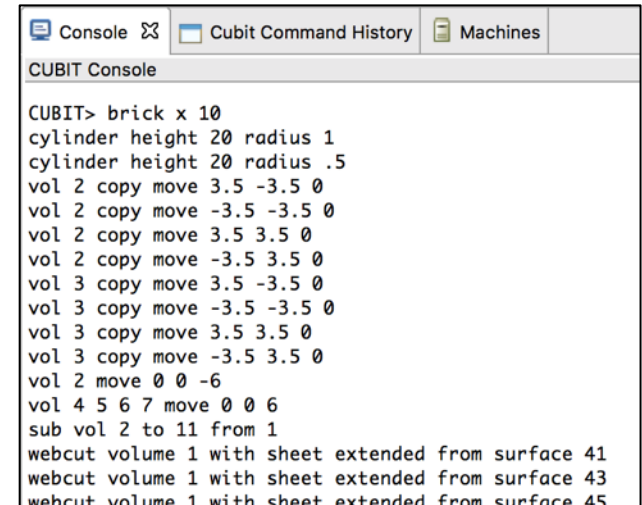
- Choose **File->New->Model** in the menu
- Choose **New Model** then **Next**
- Choose **Create From Template** then **Next**
- Enter **FixedBlocks** as the **Model Name**
- Choose the **Plato Templates->Basic->Maximize Stiffness (SierraSD)** template and then **Finish**



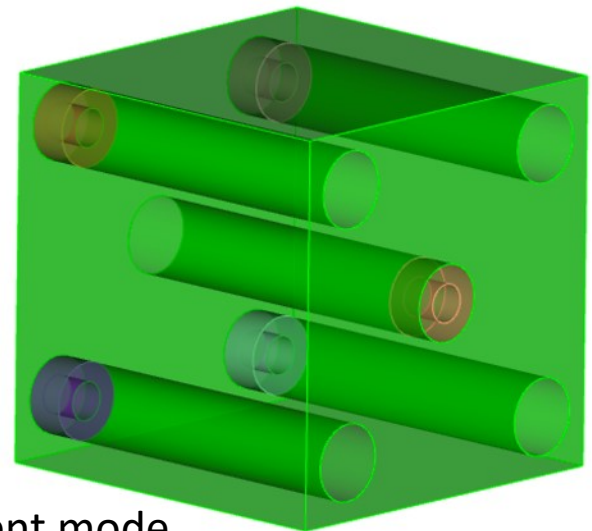
# Create the Design Domain

- At the **CUBIT** command prompt copy and paste the following commands (see Hint on next slide):

```
brick x 10
cylinder height 20 radius 1
cylinder height 20 radius .5
vol 2 copy move 3.5 -3.5 0
vol 2 copy move -3.5 -3.5 0
vol 2 copy move 3.5 3.5 0
vol 2 copy move -3.5 3.5 0
vol 3 copy move 3.5 -3.5 0
vol 3 copy move -3.5 -3.5 0
vol 3 copy move 3.5 3.5 0
vol 3 copy move -3.5 3.5 0
vol 2 move 0 0 -6
vol 4 5 6 7 move 0 0 6
sub vol 2 to 11 from 1
webcut volume 1 with sheet extended from surface 41
webcut volume 1 with sheet extended from surface 43
webcut volume 1 with sheet extended from surface 45
webcut volume 1 with sheet extended from surface 47
webcut volume 1 with sheet extended from surface 50
imprint all
merge all
```



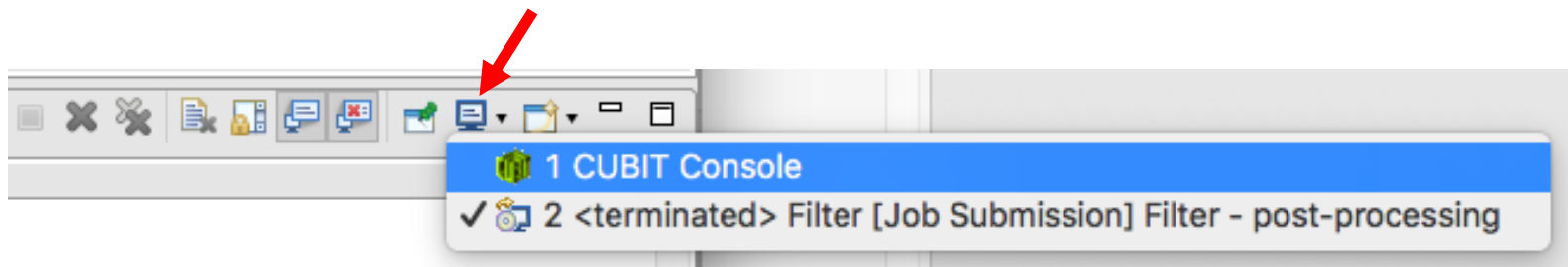
```
CUBIT Console
CUBIT> brick x 10
cylinder height 20 radius 1
cylinder height 20 radius .5
vol 2 copy move 3.5 -3.5 0
vol 2 copy move -3.5 -3.5 0
vol 2 copy move 3.5 3.5 0
vol 2 copy move -3.5 3.5 0
vol 3 copy move 3.5 -3.5 0
vol 3 copy move -3.5 -3.5 0
vol 3 copy move 3.5 3.5 0
vol 3 copy move -3.5 3.5 0
vol 2 move 0 0 -6
vol 4 5 6 7 move 0 0 6
sub vol 2 to 11 from 1
webcut volume 1 with sheet extended from surface 41
webcut volume 1 with sheet extended from surface 43
webcut volume 1 with sheet extended from surface 45
```



Model shown in transparent mode.

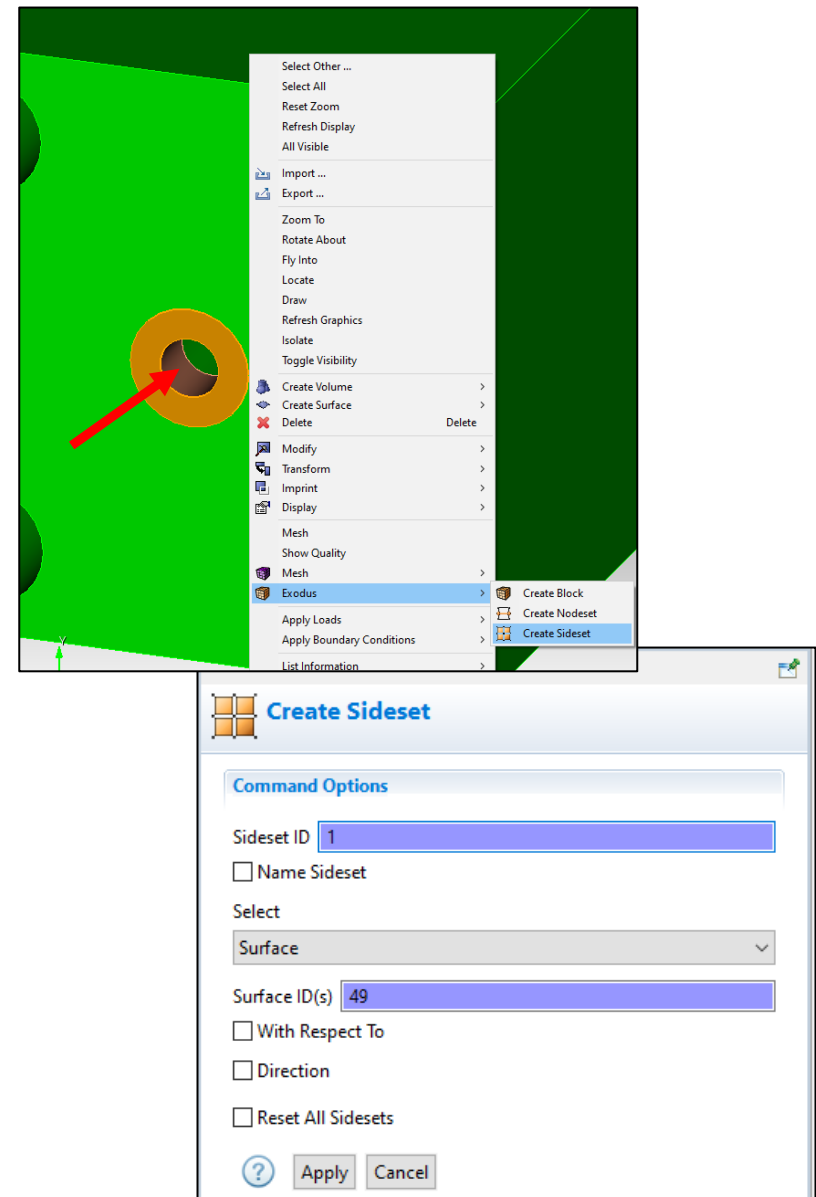
# Hint: Cubit Console

- If you don't see the **CUBIT>** prompt in the console window you are just looking at the wrong console (there may be multiple to choose from loaded in Plato that use the single console window). Click on the icon at the top right of the console window that looks like a computer screen to toggle through the different consoles that are currently loaded. Or you can click on the down arrow next to the computer screen icon to see all of the currently loaded consoles and choose one from the list.



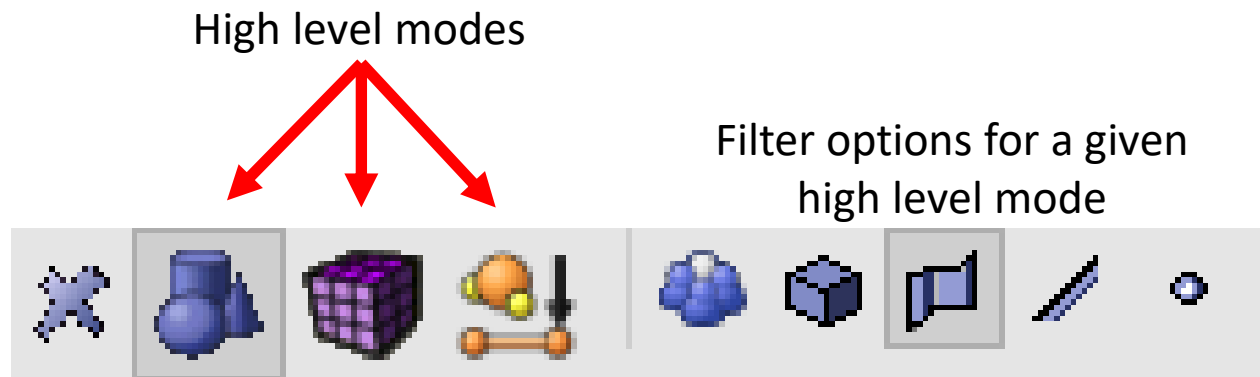
# Define Load Application Location

- Select and right-click the inner surface of the middle cylindrical collar (shown by arrow) and choose **Exodus->Create Sideset**. (see Entity Selection Hint on next slide)
- In the Create Sideset panel click the “Apply” button to accept the default values and create the sideset. Note that the id of the new sidset is 1. We will use this later when creating the actual load that is applied to this sideset.



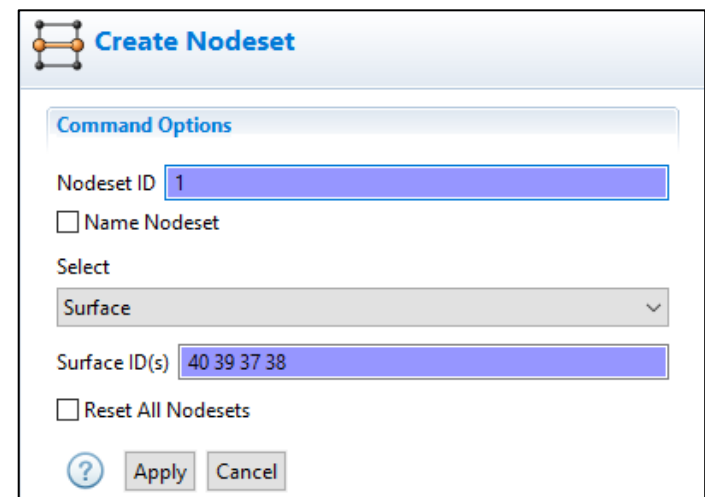
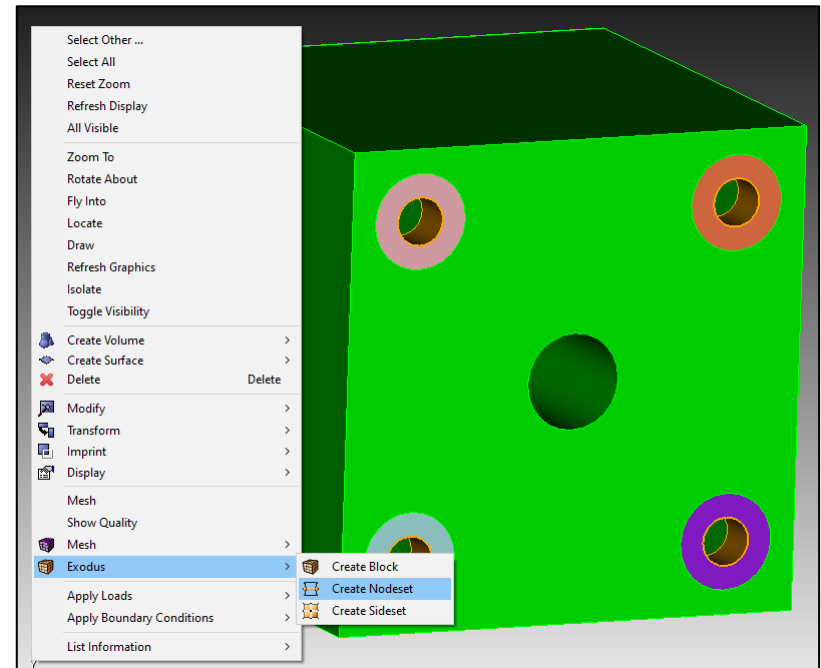
# Hint: Entity Selection

- The selection filter toolbar is at the bottom left of the graphics window.
- There are 3 high level modes: Geometry, Mesh, and Exodus
- Within each high level mode there are various options for filtering what will get selected by clicks in the graphics window.



# Define BC Application Location

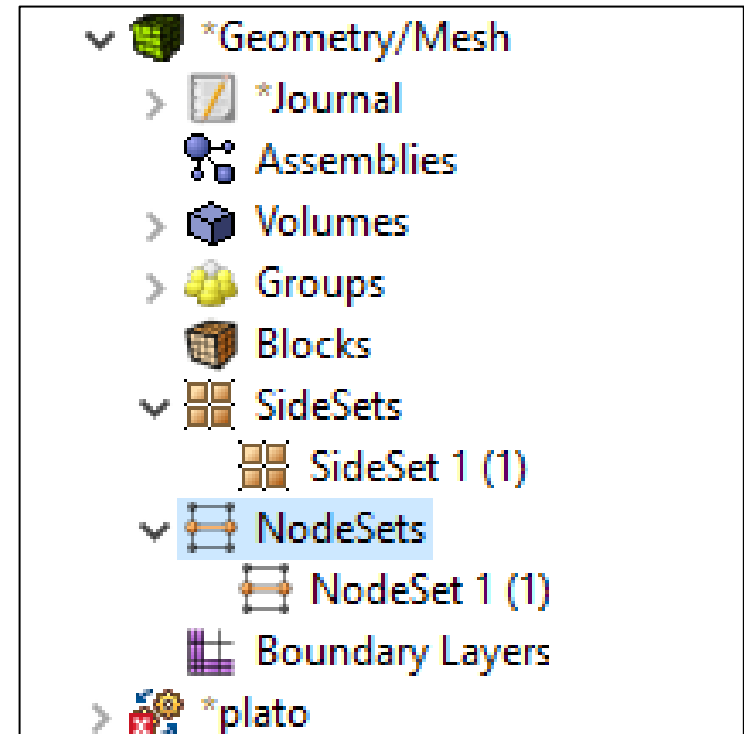
- Select the inner surfaces of all 4 of the cylindrical collars on the back side of the model (Ctrl-select on Windows/Linux, Command-select on Mac). Right-click and choose **Exodus->Create Nodeset**.
- In the “Create Nodeset” panel click the “Apply” button to accept the defaults and create the nodeset. Note the nodeset id is 1. We will use this in creating the fixed boundary condition.



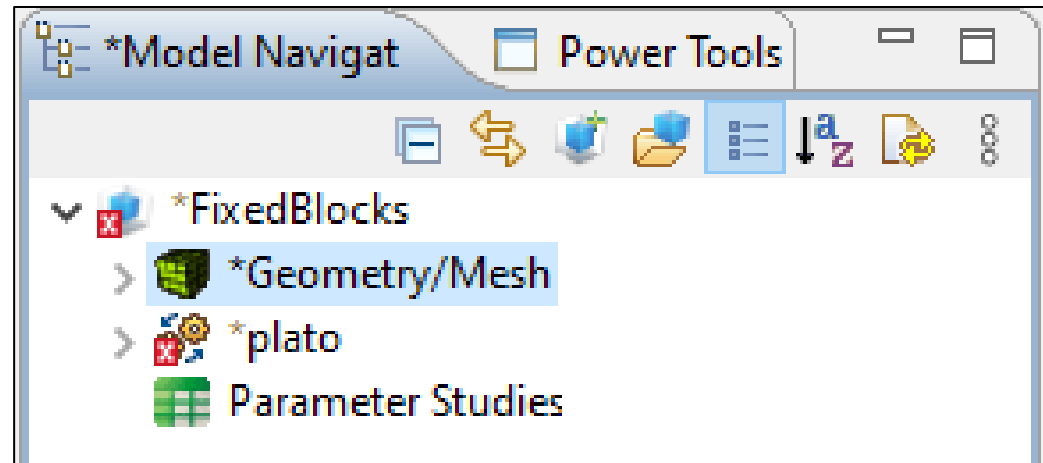


# Sidesets and Nodeset in the Model Tree

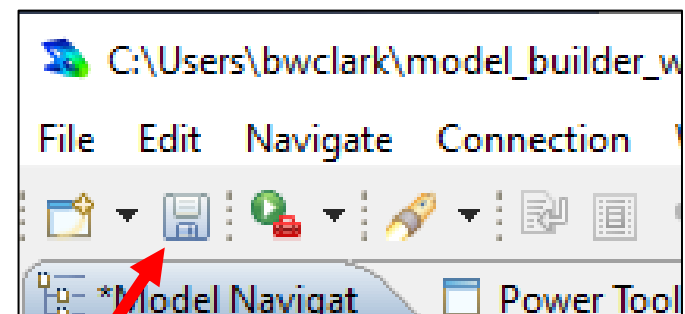
- The sideset and nodeset we just created can be seen in the Model tree under the “Geometry/Mesh” node.



# Save the Geometry/Mesh

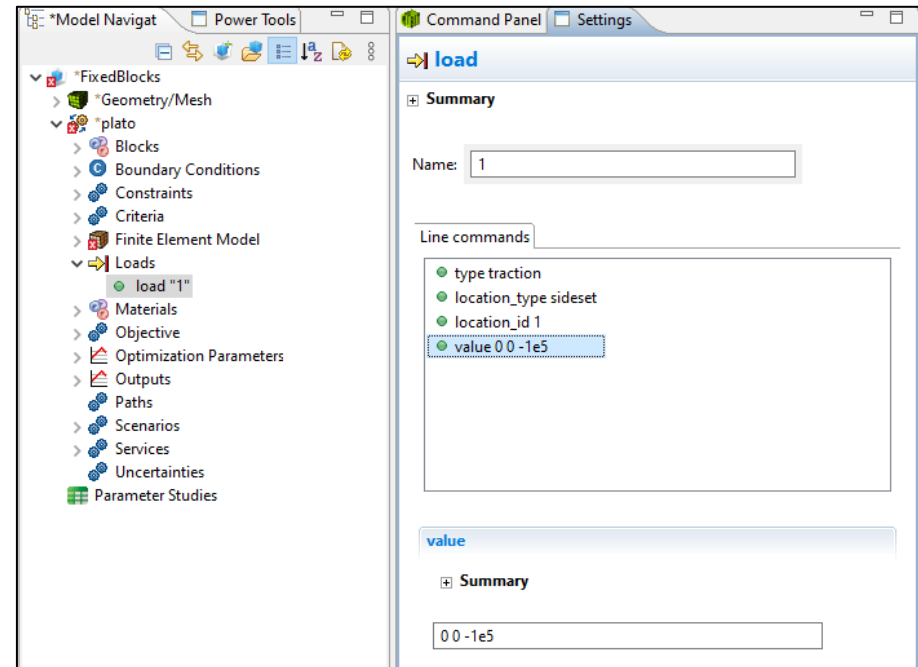


- Click on the “Geometry/Mesh” node in the tree and then click the Save icon in the toolbar.



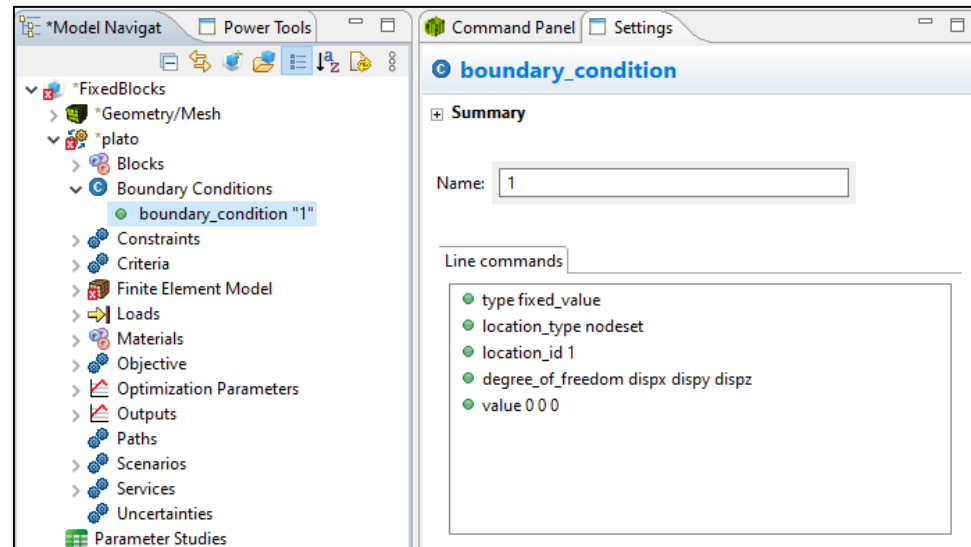
# Create the Load

- Expand the “plato” node in the Model tree and then expand the “Loads” node. In the template we used for this model there was already a load defined. Click on “load 1” in the tree to bring up its information in the Settings panel. The “location\_id” is already set to “1” meaning it will be applied to sideset 1. Change the value to “0 0 -1e5” indicating there will be a traction load with a negative z component of 1e5 applied to sideset 1.
- Note: If the template did NOT already have a load defined, we could have created one by clicking on the “Load” hyperlink that shows up in the Settings panel when you click on the “Loads” node in the tree.



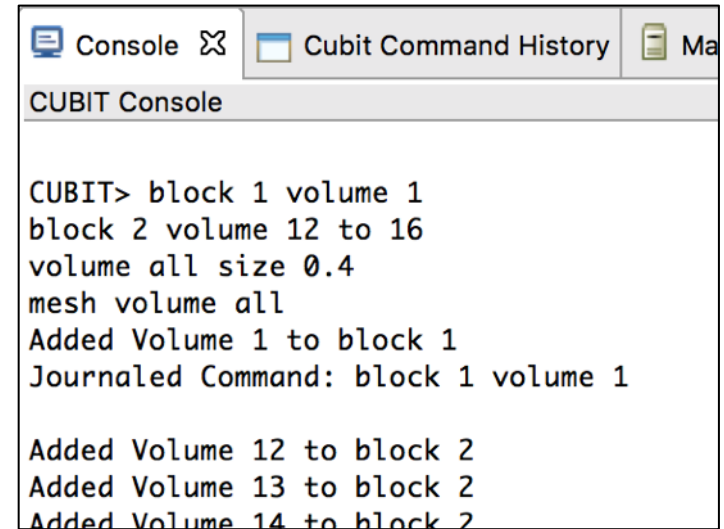
# Create the Mounting Fixed BC

- Expand the “plato” node in the Model tree and then expand the “Boundary Conditions” node. In the template we used for this model there was already a boundary condition defined. Click on “boundary\_condition 1” in the tree to bring up its information in the Settings panel. The “location\_id” is already set to “1” meaning it will be applied to nodeset 1. The “degree\_of\_freedom” and “value” parameters specify that displacement in all 3 directions will be fixed so there is nothing to change.
- Note: If the template did NOT already have a boundary condition defined, we could have created one by clicking on the “Boundary condition” hyperlink that shows up in the Settings panel when you click on the “Boundary Conditions” node in the tree.



# Define Blocks and Mesh Domain

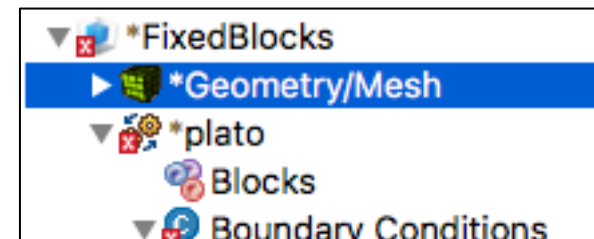
- At the **CUBIT** prompt copy and paste the following commands:  
 block 1 volume 1  
 block 2 volume 12 to 16  
 volume all size 0.4  
 mesh volume all
- Click on **Geometry/Mesh** node in the tree and then click the **Save** icon in the toolbar to save the model



The screenshot shows the CUBIT Console window with the following text:

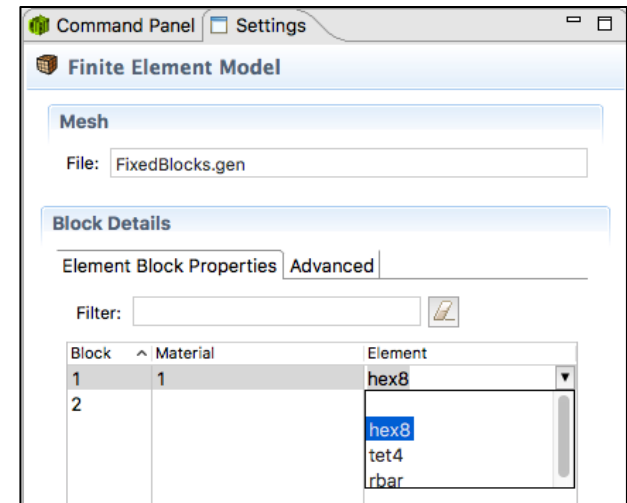
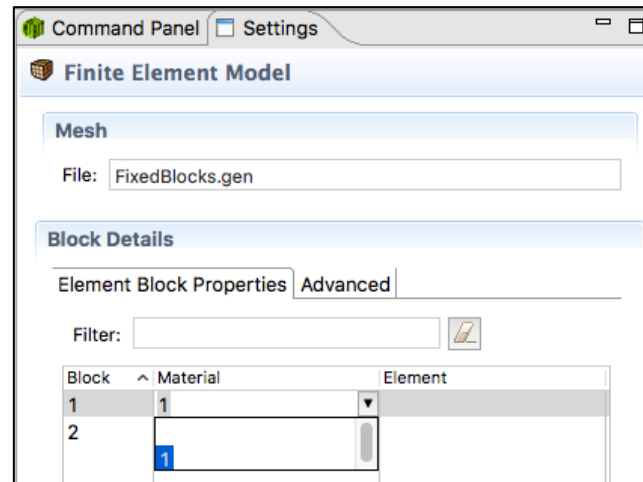
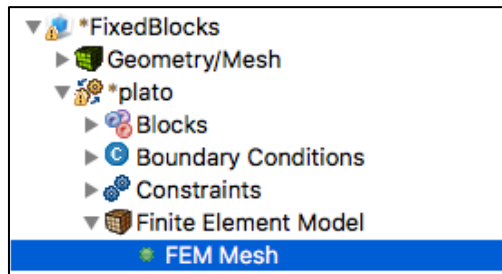
```
CUBIT> block 1 volume 1
block 2 volume 12 to 16
volume all size 0.4
mesh volume all
Added Volume 1 to block 1
Journaled Command: block 1 volume 1

Added Volume 12 to block 2
Added Volume 13 to block 2
Added Volume 14 to block 2
```



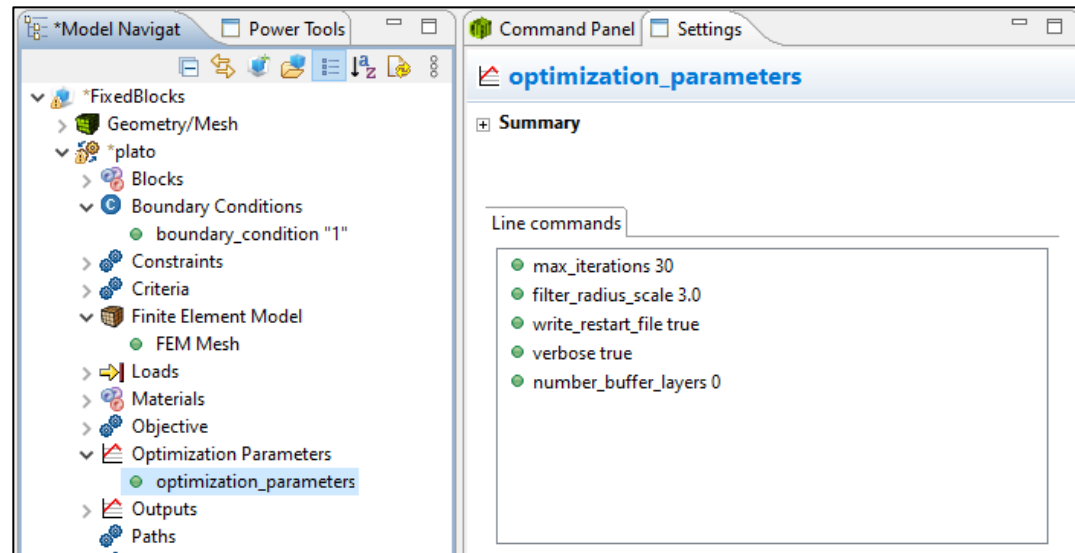
# Assign Material and Element Type

- Click on the **FEM Mesh** node in the tree under **plato**→**Finite Element Model**
- In the **Settings** panel click in the **Material** area next to Block 1 and select “1” from the dropdown list
- Then click in the **Element** area next to Block 1 and select “**hex8**” from the dropdown list
- Repeat this process for Block 2



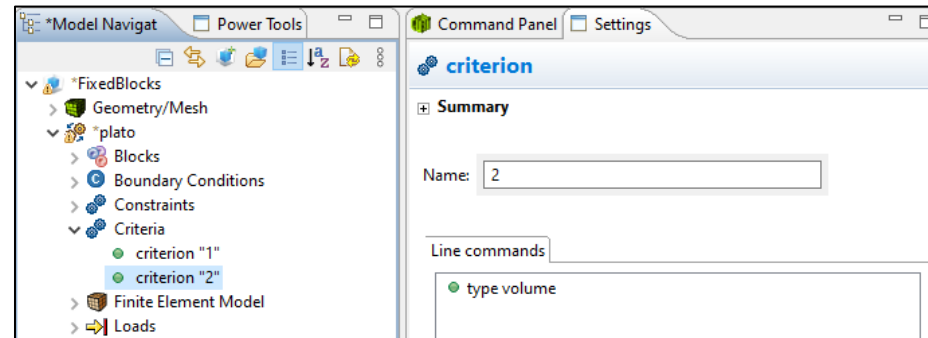
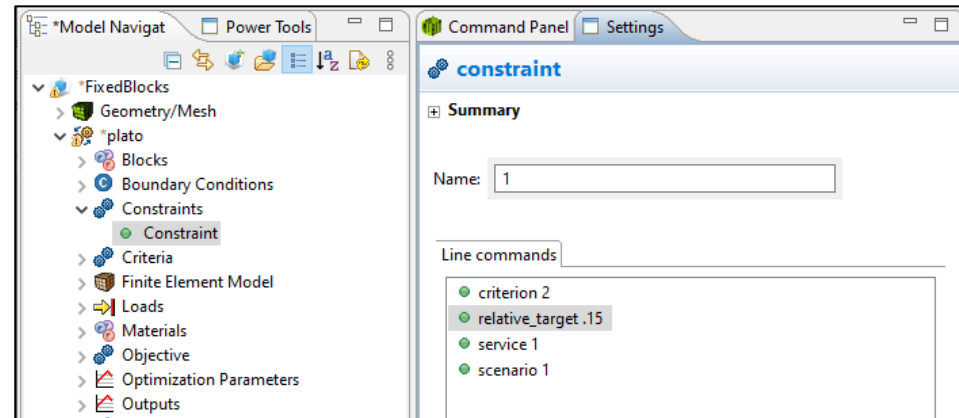
# Set the Top. Opt. Parameters

- Click on the Optimization Parameters->optimization parameters node in the tree
- In the **Settings** panel set the following parameters to the indicated values. These parameters will specify 1) how much filtering or smoothing will take place (see Filter tutorial for more on filtering), and 2) and how many iterations we want Plato to run, respectively.
  - **filter\_radius\_scale = 3.0**
  - **max\_iterations = 30**



# Set the Volume Fraction Constraint

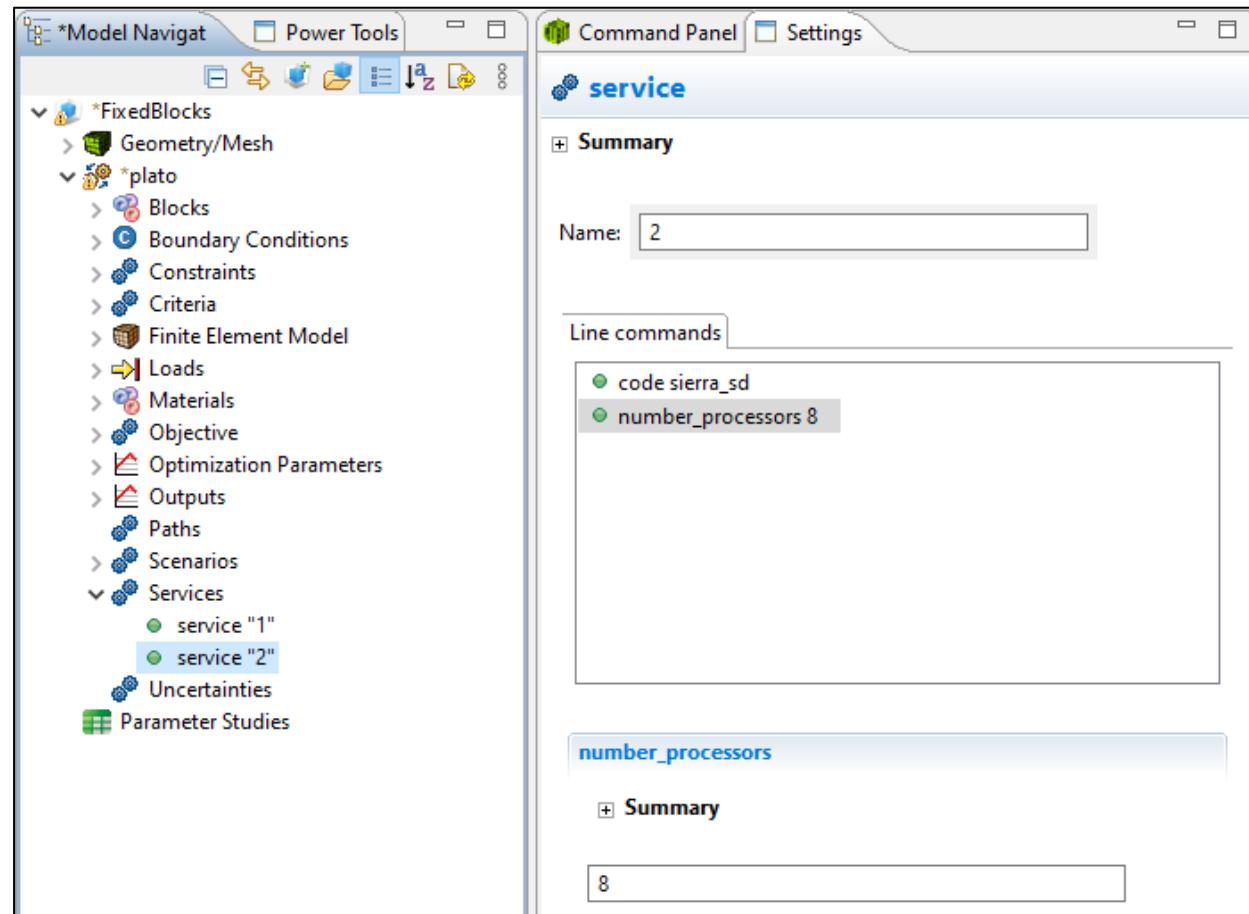
- Click on the **Constraints->Constraint** node in the tree.
- Change the **relative\_target** to be **0.15**. This will indicate that we want the final design to only use 15% of the original volume.
- Also, verify that the criterion being used in the constraint is a volume criterion by clicking on **Criteria->criterion "2"** in the tree (see bottom image on right).





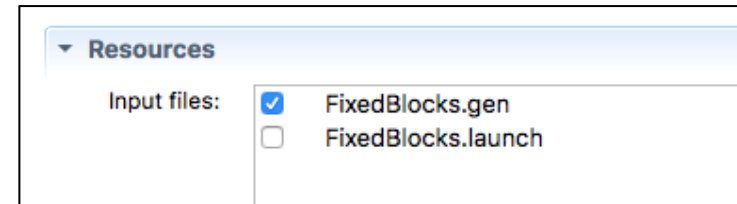
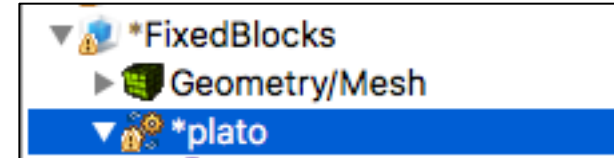
# Set the Number of Processors

- Click on **Services->service "2"** in the tree
- In the **Settings** panel change the number of processors used by this sierra\_sd service to 8 as shown in the right. This will speed up the optimization run.



# Run the Optimization

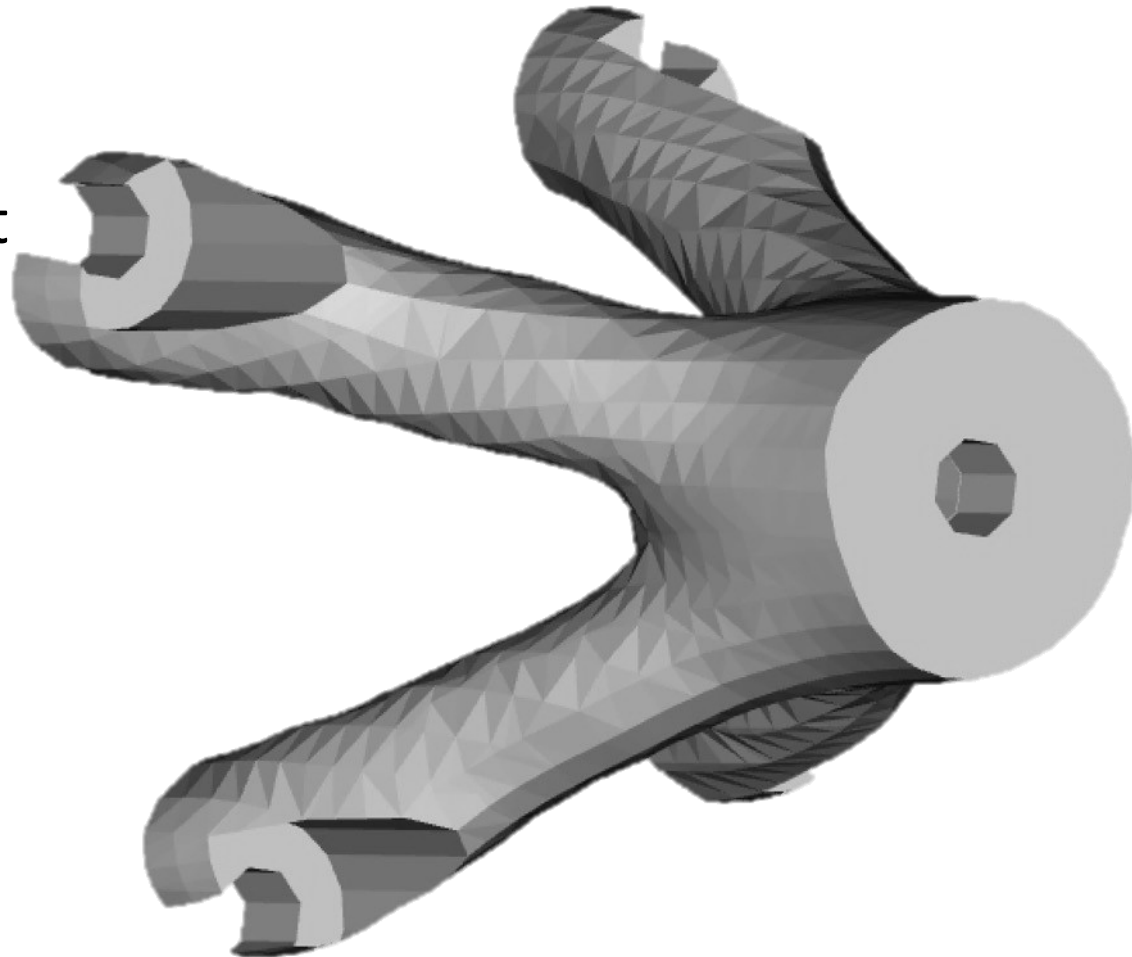
- Click on the **plato** node in the tree to bring up the job submission panel in the **Settings** view
- Choose **Plato** as the code and then choose the machine and execution template you want to use



- In the **Resources** area make sure **FixedBlocks.gen** is checked
- In the **Prune and Refine** area make sure **Prune Mesh** is unchecked and **Number Refines** is **0**. We will not use these features in this example.
- Choose any other preferences and launch the job by clicking on **Submit Simulation Job** toward the top of the panel

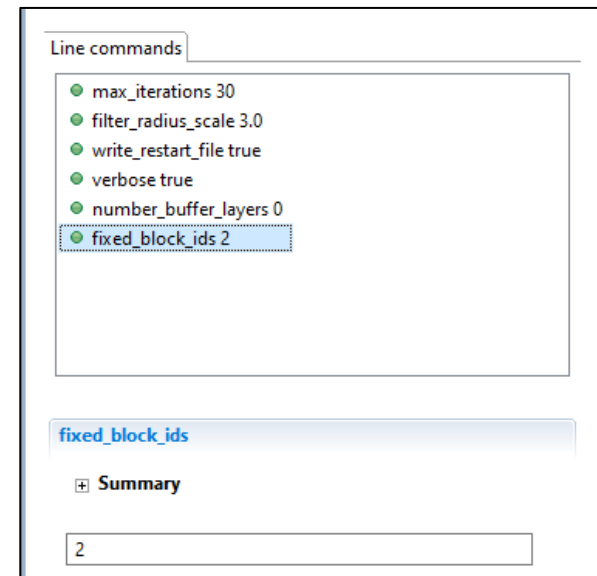
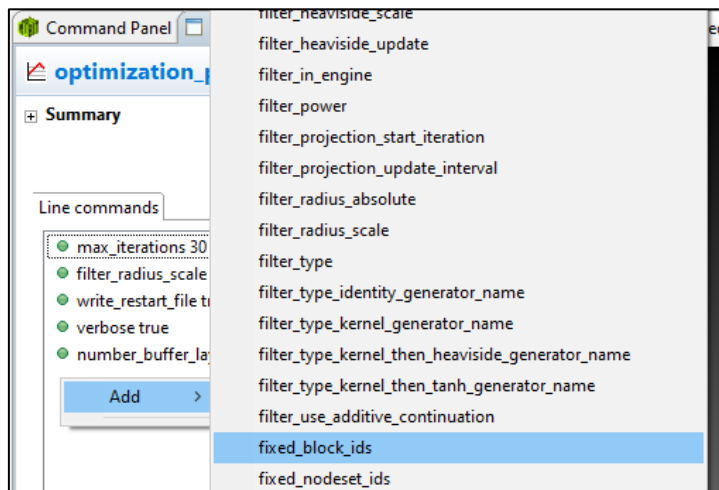
# Result with No Fixed Blocks

Notice how the optimizer removed parts of the collars that will be used to bolt down the bracket. Obviously, this isn't desirable. By using fixed blocks we can tell the optimizer not to remove material from the collars.



# Specify Fixed Blocks and Rerun

- Block 2 in our model contains the collars we want to fix.
- Bring up the topology optimization parameters by clicking on the **Optimization Parameters->optimization parameters** node in the tree.
- Right-click anywhere in the **Parameters** area and choose **Add->fixed\_block\_ids**.
- Enter **2** in edit field for the **fixed\_block\_ids** value and hit return. If you need to fix multiple blocks you can enter multiple ids separated by spaces.
- Resubmit the job with all of the same parameters by clicking on the **plato** node in the tree and then click on the **Submit Simulation Job** in the job submission area in the **Settings** panel



# Result with Fixed Blocks

With fixed blocks specified the result now maintains the collars needed for bolting the bracket down. The coarseness or roughness of the result is related to mesh resolution. See the “Prune and Refine” tutorial to learn how to efficiently generate smooth results.

