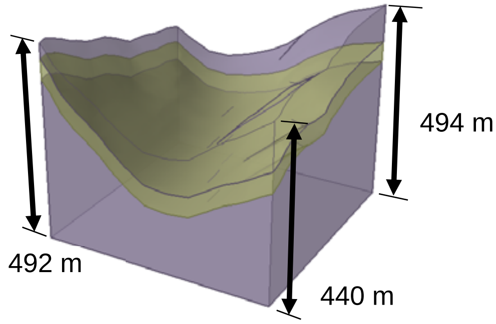
Introduction: RS³ Tutorial 5 Weak Layer Slope

Welcome to RS³. This tutorial demonstrates how to model a weak layer inside a sloped terrain. The analysis uses a Shear Strength Reduction (SSR) method to determine the factor of safety.

The finished product of this tutorial can be found in the **Tutorial 05 Weak Layer Slope.rs3dmodel** file. All tutorial files installed with RS³ can be accessed by selecting File → Recent → Tutorials folder from the RS³ main menu.



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Tutorial Key Concepts
Importing .dxf files
Shear Strength Reduction (SSR) method
Weak layer slope

Note
The SSR method involves iterative solving of the model with different guesses of the SRF for each solution, meaning the model is repeatedly solved. The created model is also made of complex geometry. These two factors makes the compute engine work for longer.

Step 1: Starting the Model

CREATING A BLANK DOCUMENT

New Project

Start RS^3 by selecting Programs → Rocscience → RS3 2.0 → RS3 from the Windows start menu. RS^3 opens to a blank screen, which allows you to create a new model by pressing the [New Project] button. If the RS^3 application window is not already maximized, maximize it now so the full screen space is available for use.

Save

First, save as **Tutorial 05 Weak Layer Slope.rs3dmodel**: File → Save.

Step 2: Editing the Project Settings

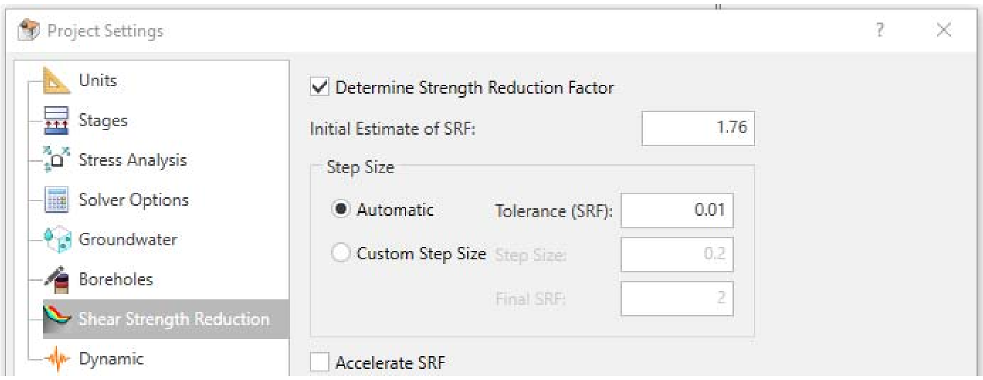
CONFIGURING THE SSR METHOD

Project Settings

The Project Settings dialog is used to configure the main analysis parameters for your RS^3 model. Open the dialog through File → Project Settings. This will open the dialog, change to tab [Shear Strength Reduction] and check Determine Strength Reduction Factor = Active, Initial Estimate of SRF = 1.76. Keep all other settings as their defaults.

> Note
> The SSR method involves iterative solving of the model with different guesses of the SRF for each solution. This means the model is repeatedly solved until the set of solutions has reached failure (giving the critical SRF aka SF) within the defined tolerance. Then generally, the closer the initial guess, the less guesses the solver has to make – meaning it should run faster than with a farther guess.

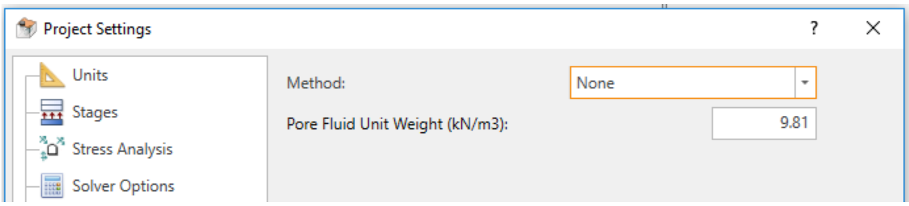
Project Settings: Shear Strength Reduction



OTHER OPTIONS

Next, select the [Groundwater] tab.

Project Settings: Groundwater



Enter Method = None, then select [Project Summary] and enter Weak Layer Slope as the Project Title. Do not change any other settings. Select [OK] to close the dialog.

Step 3: Defining the Materials

Geology

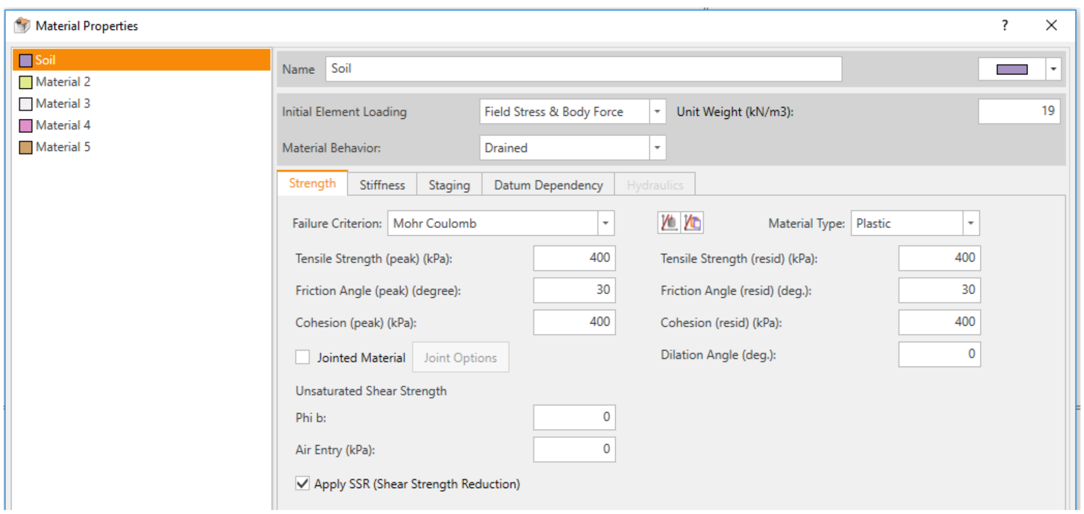
DEFINING MATERIAL PROPERTIES

Define Materials

Under the same tab (Geology or Excavations) you can assign the materials and properties of our model through Materials → Define Materials.

Enter the following properties for “Material 1” in the [Strength] & [Stiffness] tabs.

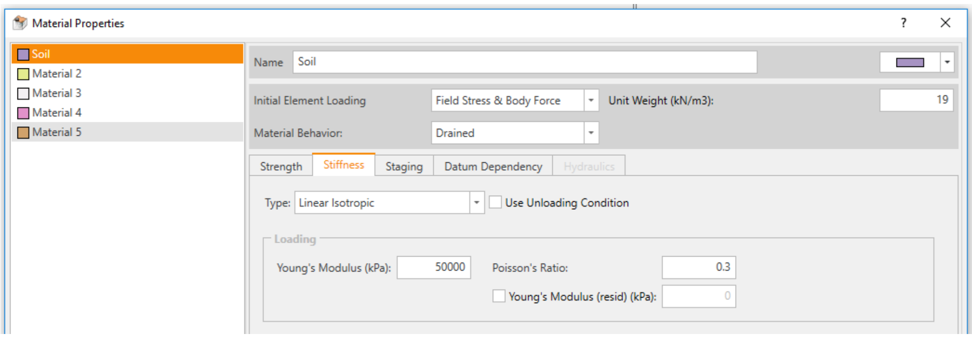
Material 1 Properties: Strength



Enter Name = Soil, Initial Element Loading = Field Stress & Body Force, Unit Weight = 19 kN/m^3, Tensile Strength = 400 kPa, Friction Angle = 30, deg, Cohesion = 400 kPa.

Material Type = Plastic, Tensile Strength (resid) = 400 kPa, Friction Angle (resid) = 30 degrees, Cohesion (resid) = 400 kPa, Dilation Angle = 0 degrees, Apply SSR = Active, then [Stiffness].

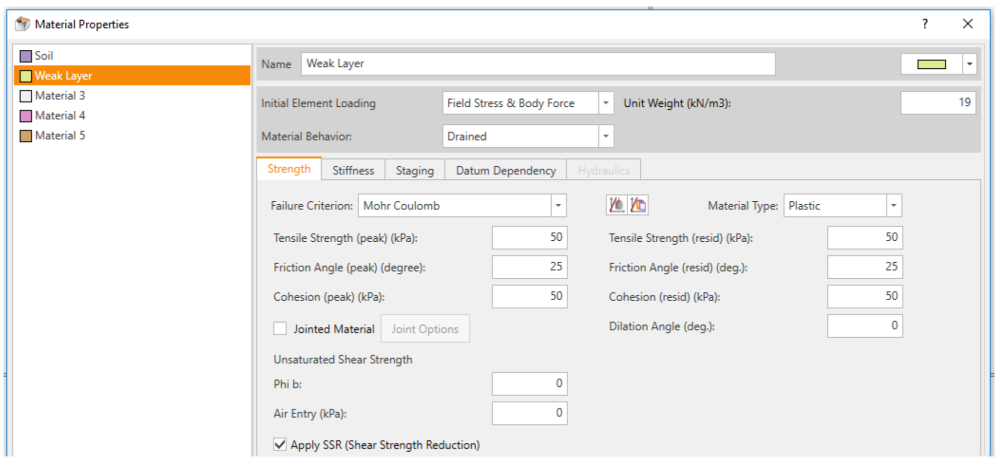
Material 1 Properties: Stiffness



Enter Young's Modulus = 50000 kPa, then [Material 2].

Enter the following properties for "Material 2" in the [Strength] & [Stiffness] tabs.

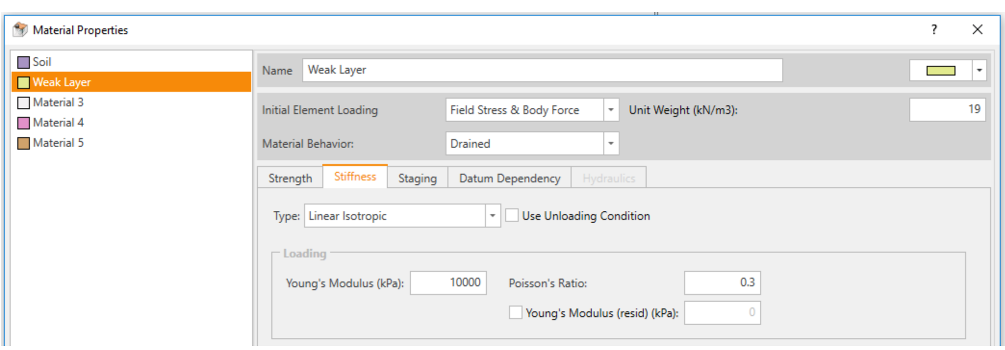
Material 2 Properties: Strength



Enter Name = Weak Layer, Initial Element Loading = Field Stress & Body Force, Unit Weight = 19 kN/m^3, Tensile Strength = 50 kPa, Friction Angle = 25 degrees, Cohesion = 50 kPa.

Material Type = Plastic, Tensile Strength (resid) = 50 kPa, Friction Angle (resid) = 25 degrees, Cohesion (resid) = 50 kPa, Dilation Angle = 0 degrees, Apply SSR = Active, then [Stiffness].

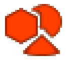
Material 2 Properties: Stiffness



Enter Young's Modulus = 10000 kPa, [OK].

Step 4: Creating Geometry

CREATING THE EXTERNAL BOX

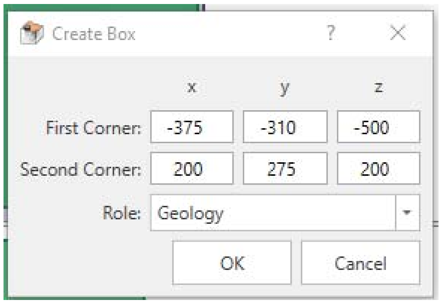


3D Primitive Geometry

Ensure the Geology tab is selected from the workflow at the top of the screen.

Select: Geometry → 3D Primitive Geometry → Box. A Create External dialog will open, enter First Corner (x, y, z) = (-375, -310, -500), Second Corner (x, y, z) = (200, 275, 200), then press [OK].

Create Box



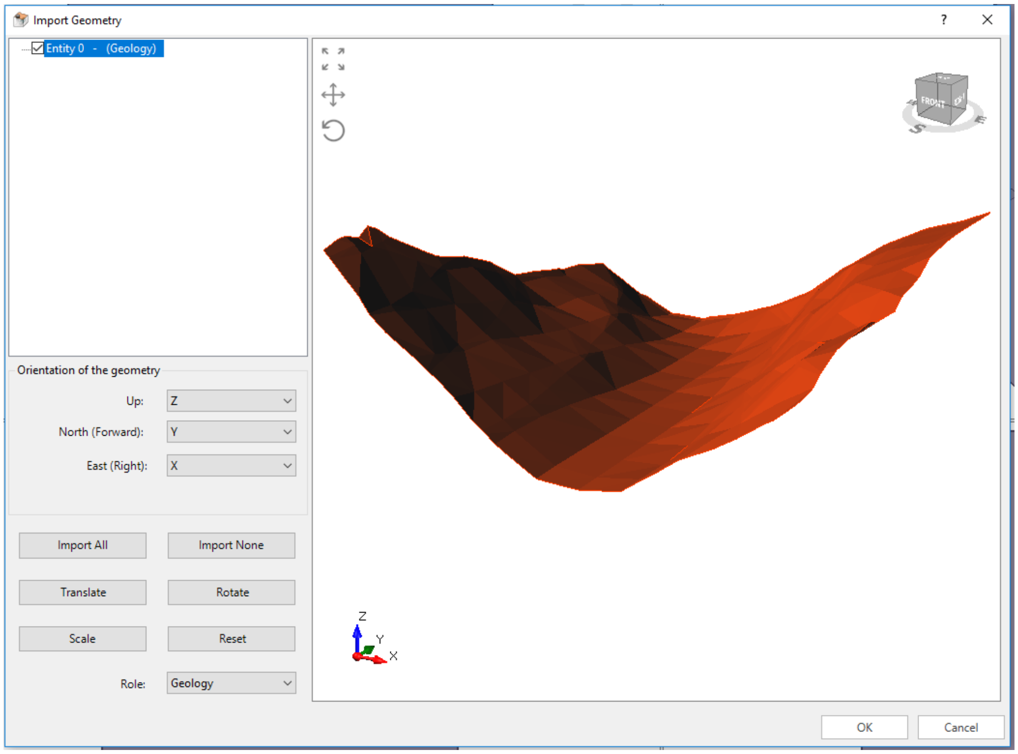
IMPORTING THE SLOPED TERRAIN

Import Geometry

Select: Geometry → Import.

Open the provided **Terrain.dxf** file, then an Import Geometry dialog will open, you can select Layer 1 to take a better look at it, then press [OK].

Import Geometry



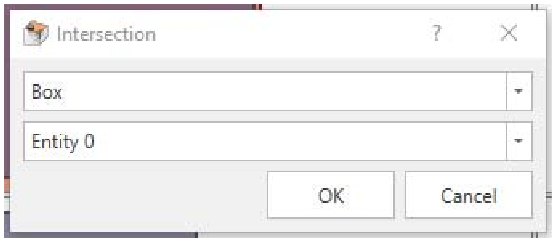
FINALIZING THE EXTERNAL BOUNDARY

Select both the box and the imported terrain in the visibility pane.

Intersect

Geometry → 3D Boolean → Intersect. An Intersection dialog will open, make sure Box and Entity are in the dropdowns, [OK].

Import Geometry



Select new body "Intersection_1" in visibility pane, then Geometry → Set as External. Then select "Intersection_1" again in the visibility pane and make sure in properties pane, the Role = Geology.

IMPORTING AND MODIFYING THE WEAK LAYER TERRAIN

Import Geometry

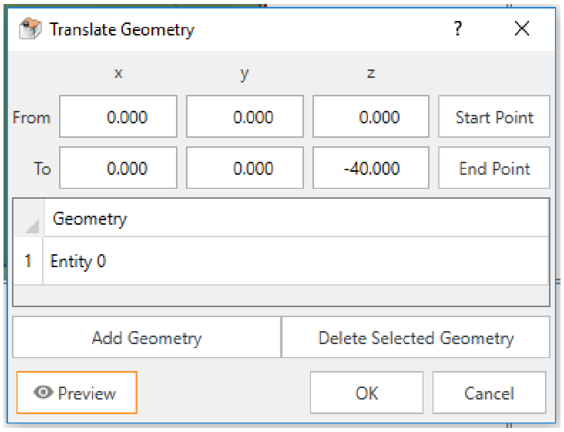
Select: Geometry → Import.

Open the provided **Terrain.dxf** file, then press [OK].

Translate

Translate Geometry

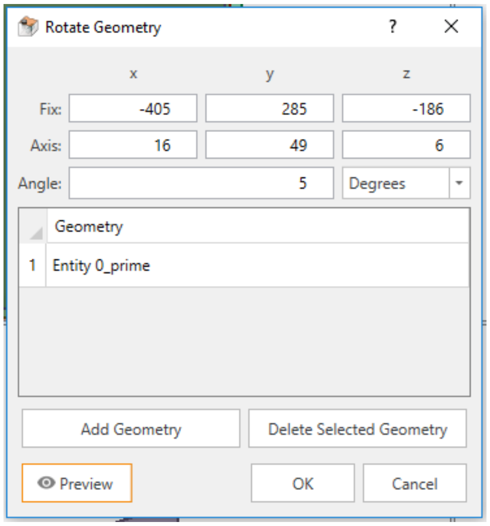
Select either of the "Entity 0" objects in the visibility pane, Geometry → Transform → Translate, From (x, y, z) = (0, 0, 0), To (x, y, z) = (0, 0, -40), [OK].



Rotate

Select "Entity 0_prime" in the visibility pane, Geometry → Transform → Rotate, Fix (x, y, z) = (-405, 285, -186), Axis (x, y, z) = (16, 49, 6), Angle = 5, [OK].

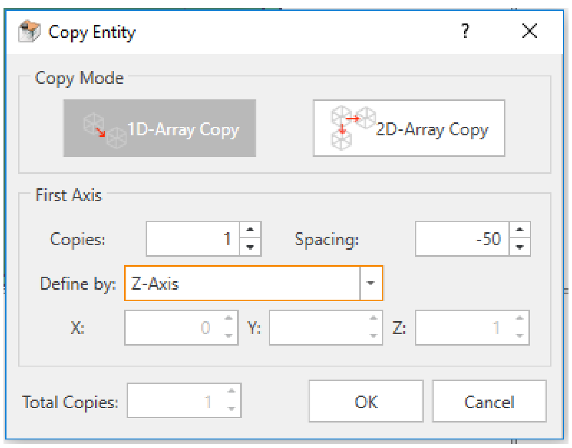
Rotate Geometry



Copy Geometry

Select “Entity 0_prime_prime” in the visibility pane (can do so by double-clicking on the desired body in the viewport), Geometry → Copy Geometry, in the Copy Entity dialog, enter Copies = 1, Spacing = -50, Define By = Z-Axis, [OK].

Copy Entity



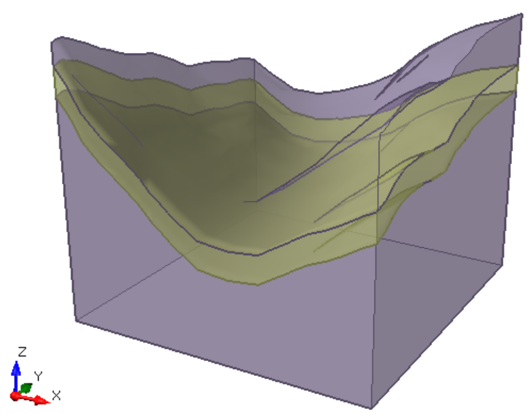
FINALIZING THE GEOMETRY

Divide All Geometry

Now we can cut into the external box with the weak layer terrains: Geometry → 3D Boolean → Divide All Geometry.

Select the middle thin layer in the visibility pane, and in the properties pane change their Applied Property = Weak Layer. Your model should now look like the following.

Current State of Model



Step 5: Adding Stress Loading

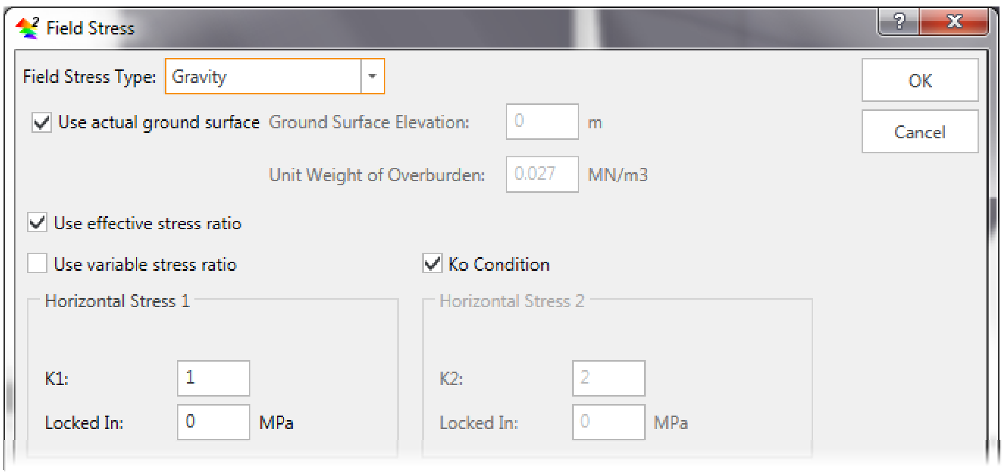
Loads

APPLYING FIELD STRESS TO THE MODEL

Field Stress

Next we go to the Loads tab. This tab allows you to edit the loading conditions. Select: Loading → Field Stress.

Field Stress



Enter Field Stress Type = Gravity, the rest should be default (check screenshot), [OK].

Step 6: Setting Boundary Conditions

Restraints

ADDING MODEL RESTRAINTS

Move to the Restraints tab to assign restraints to the external boundary of the model.

Auto Restrain (Surface)

RS^3 has a built in “Auto Restrain” tool for use on underground models. Select: Restraints → Auto Restrain (Surface).

This completes the construction of the model (in terms of geometry).

Step 7: Meshing

Mesh

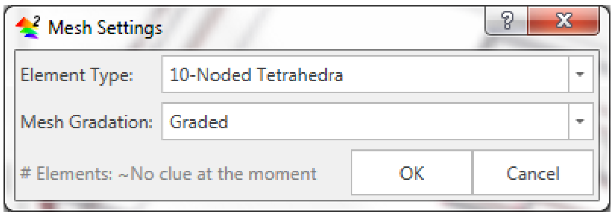
CONFIGURING AND CALCULATING MESH

Mesh Settings

Next we move to the Mesh tab. Customize mesh: Mesh → Mesh Settings.

The Mesh Settings dialog appears. This dialog allows you to customize parameters of your mesh. We want to use a graded, 10-noded element mesh.

Mesh Settings

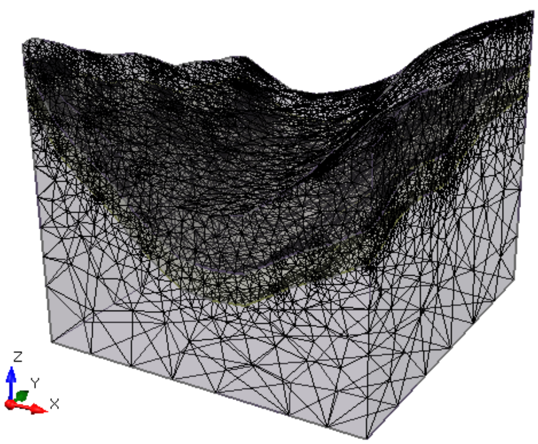


Enter Element Type = 10-Noded Tetrahedra, Mesh Gradation = Graded, [OK]

Mesh

Then mesh the model: Mesh → Mesh. The model with the generated mesh should look like the one below.

Model with completed mesh



Step 8: Computing Results

Compute

COMPUTE

Save

Next we move to the Compute tab. From this tab we can compute the results of our model. First, save: File → Save.

Use the Save As dialog to save the file, and next you need to save the compute file: File → Save Compute File. You are now ready to compute the results.

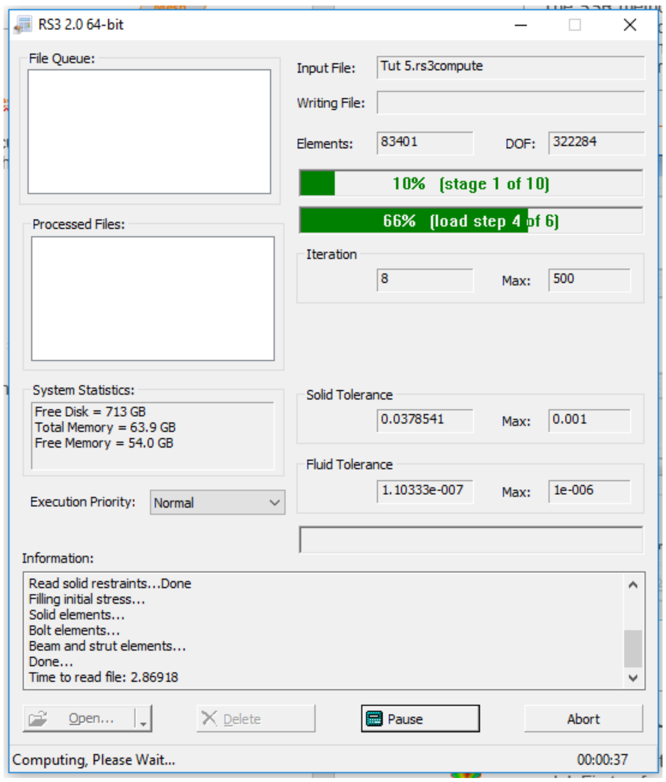
Note

The SSR method involves iterative solving of the model with different guesses of the SRF for each solution, meaning the model is repeatedly solved. The created model is also made of complex geometry. These two factors makes the compute engine work for longer.

Compute

Select: Compute → Compute.

Compute Engine



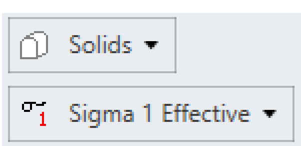
Step 9: Interpreting Results

DISPLAYING THE RESULTS

Refresh Results

Next we move to the Results tab. From this tab we can analyze the results of our model. First, refresh the results: Interpret → Refresh Results.

On the top right corner of the Results tab, you should see two drop down menus:



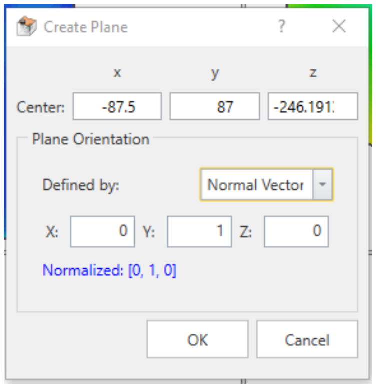
Exterior Contour

We will analyze a number of different “Data Type” results. Let’s turn on the exterior contours so we can see some results: Interpret → Show Exterior Contour.

XZ Plane

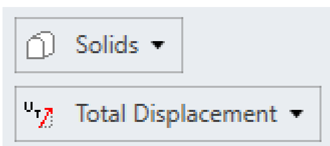
We also want to define a plane that goes through the peak. First we must define a plane, Interpret → XZ Plane. In the Create Plane dialog, enter: Plane Center (x, y, z) = (-87.5, 87, -246.191), Plane Normal (x, y, z) = (0, 1, 0), then press [OK].

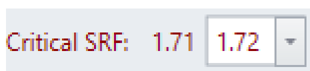
Create Plane



TOTAL DISPLACEMENT

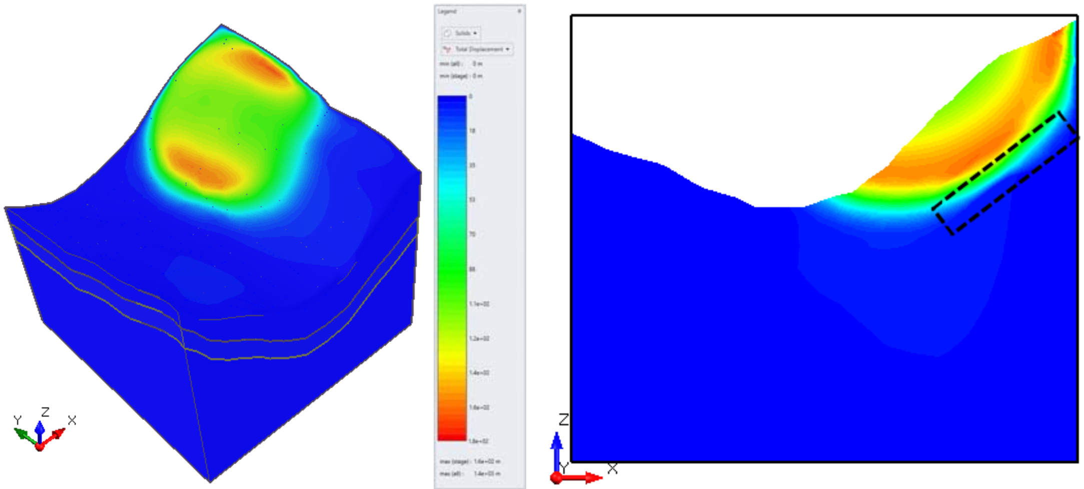
In the top right corner of the Results tab, ensure Element = Solids, and change data type = Total Displacement, and select SRF = 1.76:





Solids Total Displ

The Total Displacement results are shown below.



As expected, the displacement sharply decreases at the boundary where the weak layer ends (indicated on right image in dashed box).

Other results are available to view as well. Thank you, this concludes the tutorial.