

GeoXPM Tutorial Manual

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Introduction

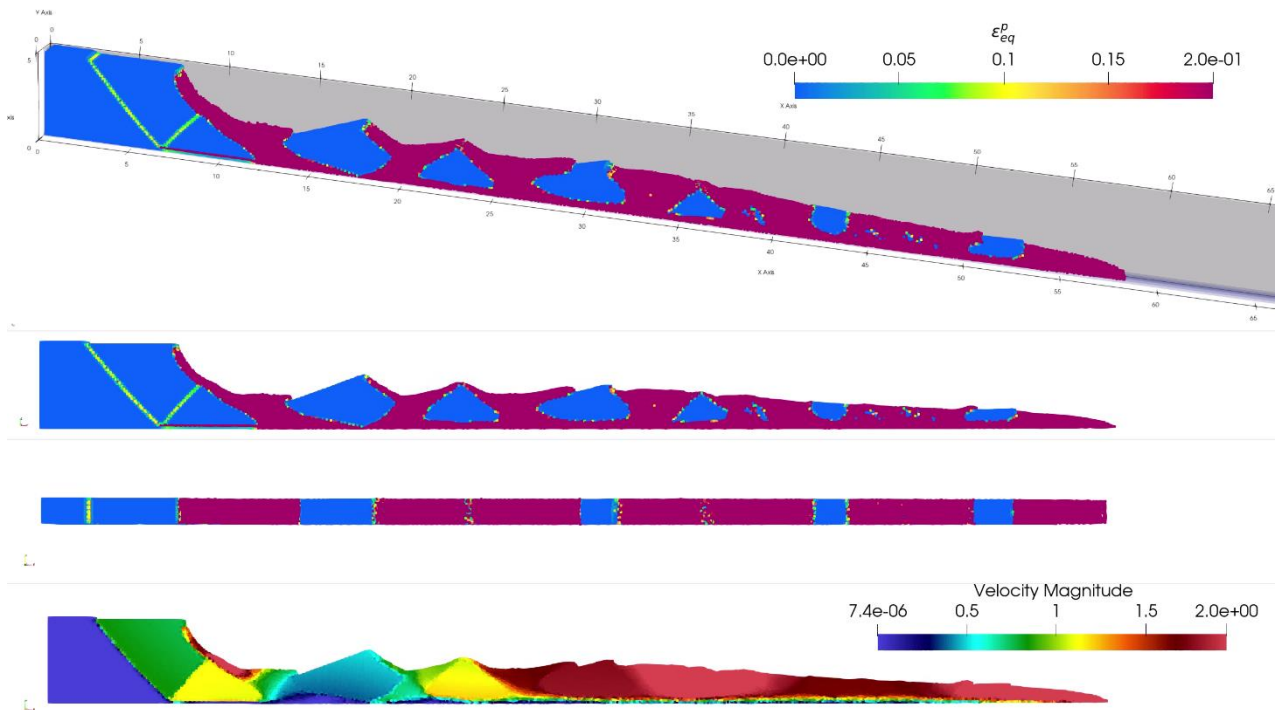
GeoXPM is a new generation of computational software package that was originally developed by Prof Ha H. Bui and his research team at Monash University in Australia based on the Smoothed Particle Hydrodynamics (SPH) method. It has been developed specifically to address the ever-evolving demands of solving intricate geotechnical engineering, geomechanics and geophysics challenges, particularly those involving fracturing, large deformation and flow behaviours of geomaterials. One standout feature of GeoXPM is its interactive graphical user-interface, which empowers users to effortlessly generate and modify complex computational models without encountering any obstacles. The calculation procedure within GeoXPM is both robust and fully automated, eliminating the need for extensive training or specialised knowledge. With GeoXPM, academics and professionals alike can unlock the full potential of engineering applications, pushing boundaries and delivering remarkable results that exceed expectations.

The tutorial explores a wide range of challenging and practical scenarios that encompass the intricate aspects of large deformation and post-failure behaviour in geomaterials. The main aim is to equip new users with a comprehensive understanding of GeoXPM. However, it is crucial to recognise that this tutorial should not be solely relied upon as the basis for practical projects. Instead, it serves as an invaluable resource to familiarise users with the functionalities and capabilities of the software.

Users are expected to possess a fundamental understanding of the SPH method and constitutive modelling of geomaterials. For those who are new to the software, it is highly recommended that they adhere to the default setting parameters and follow the step-by-step procedure meticulously to ensure accurate results. It is important to note that variations in hardware and software configurations may yield slight differences in the obtained results.

This Tutorial Manual does not provide the theoretical background information on the SPH method or elaborate on the specific details of the constitutive models utilised within the software. Therefore, users are highly advised to refer to the provided references for comprehensive information regarding the SPH method and constitutive models implemented in GeoXPM. These references offer in-depth insights into the underlying principles and methodologies employed, allowing users to gain a thorough understanding of the theoretical aspects involved.

Example: 3D Retrogressive failure



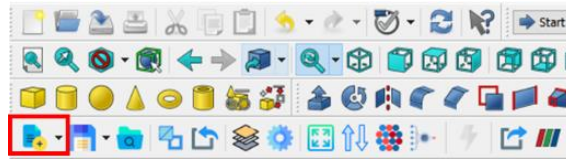
In this project, you will apply a softening plasticity model to analyse retrogressive failure.

We will follow the below standard workflow:

1. Create a new project.
2. Create initial geometry.
3. Input SPH parameters.
4. Create material models.
5. Include objects in simulations and assign material properties.
6. Define construction stages.
7. Define meshing sequences.
8. Mesh objects – generate particles for calculations.
9. Calculate.
10. Post-processing - Visualisation: extract, data mining.

➤ Step 1. Create a project

- Click the “New Project” button in the dialogue below to create a new project.
- Enter the project name and project description.



Project and constant definition


Project Name:

Project Description:

Gravity (m/s²):

Fluid reference density (kg/m³):

➤ Step 2. Create initial geometry

- Using the “Primitives” toolbox (Cube tool  in this case) to draw the geometries of soil (named “SensitiveClay” object) and Boundaries (named “Bottom”, “Front”, “Back”, and “Left” objects).
- Define the dimensions and positions of each object.



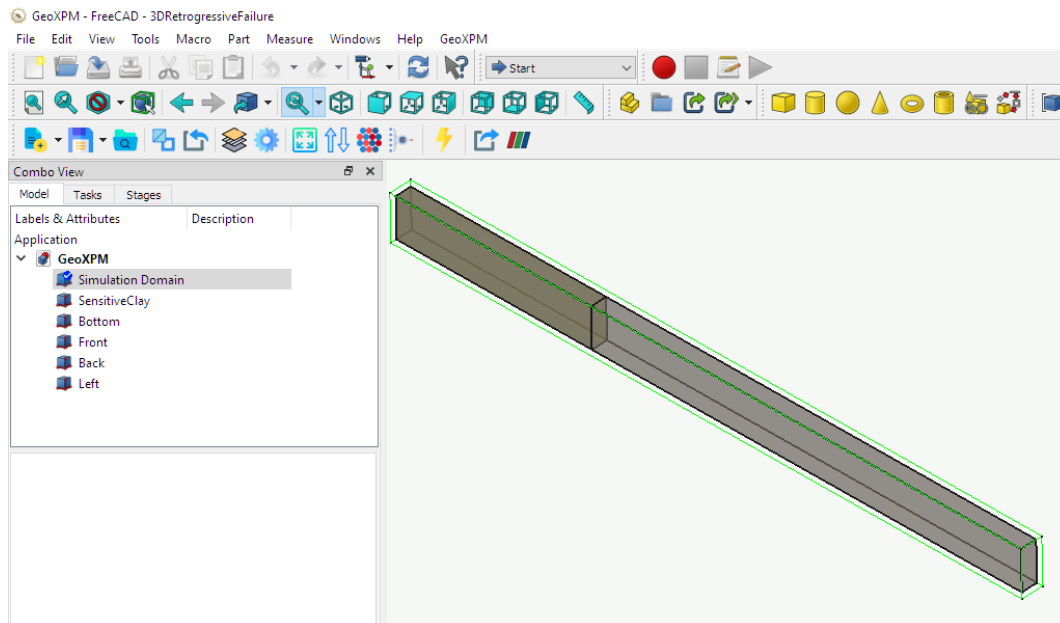
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Attachment	
Support	
Map Mode	Deactivated
Base	
Placement	[(0.00 0.00 1.00); 0.00 °; (0.00 mm 0....
Angle	0.00 °
Axis	[0.00 0.00 1.00]
Position	[0.00 mm 0.00 mm 0.00 mm]
x	0.00 mm
y	0.00 mm
z	0.00 mm
Label	SensitiveClay
Box	
Length	25.00 m
Width	2000.00 mm
Height	5000.00 mm

“SensitiveClay”

Property	Value
Attachment	
Support	
Map Mode	Deactivated
Base	
Placement	[(0.00 0.00 1.00); 0.00 °; (0.00 mm 0....
Angle	0.00 °
Axis	[0.00 0.00 1.00]
Position	[0.00 mm 0.00 mm 0.00 mm]
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Label	Bottom
Box	
Length	80.00 m
Width	2000.00 mm
Height	5000.00 mm

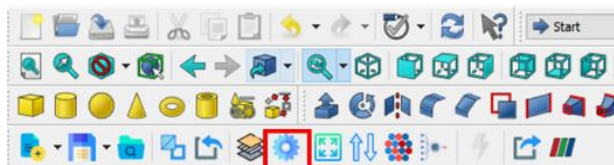
“Bottom”, “Front”, “Back” and “Left”

Hint: Since the cubes we created for the “Bottom”, “Front”, “Back” and “Left” objects have the same dimensions and positions, you can create one cube for “Front”, for example, then go to “Edit” on the menu → Duplicate selection.



➤ Step 3. Input SPH parameters

a. Enter the SPH parameters into the dialogue.



Execution parameters ? X

Interaction kernel:

Approximation algorithm:

Particle distance (m):

Critical timestep factor (CFL):

Time out data (iter):

Adaptive simulation domain:

Load initial stress:

Artificial stress

Enabled:

Eps_v coefficient:

Particle shifting

Enabled:

Detection algorithm:

Free surface threshold(<=1):

Diffusion coefficient:

Artificial viscosity

Alpha coefficient:

Beta coefficient:

Eta_v coefficient:

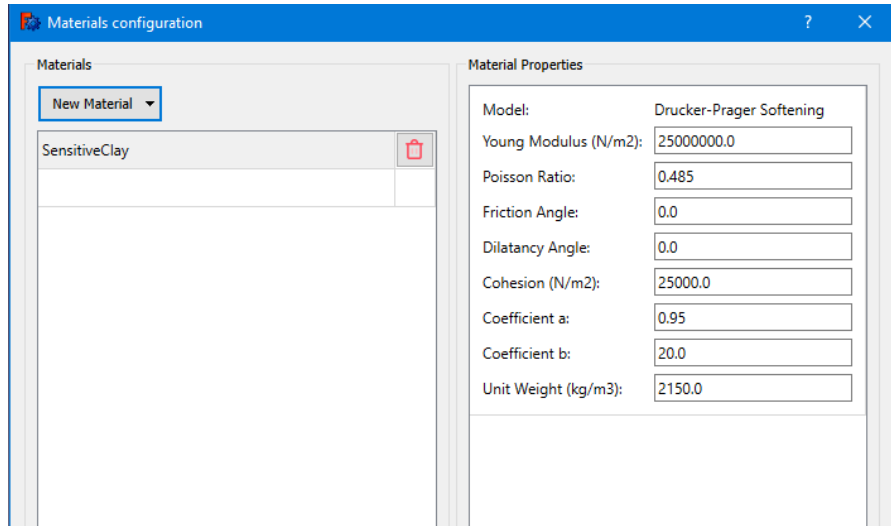
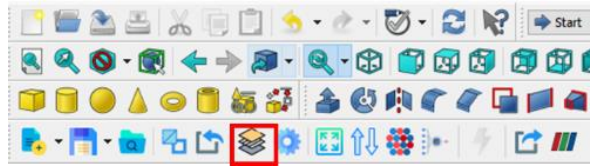
Autostop: (For plastic Stage)

Enabled:

Normalized velocity(v/dp) lower bound:

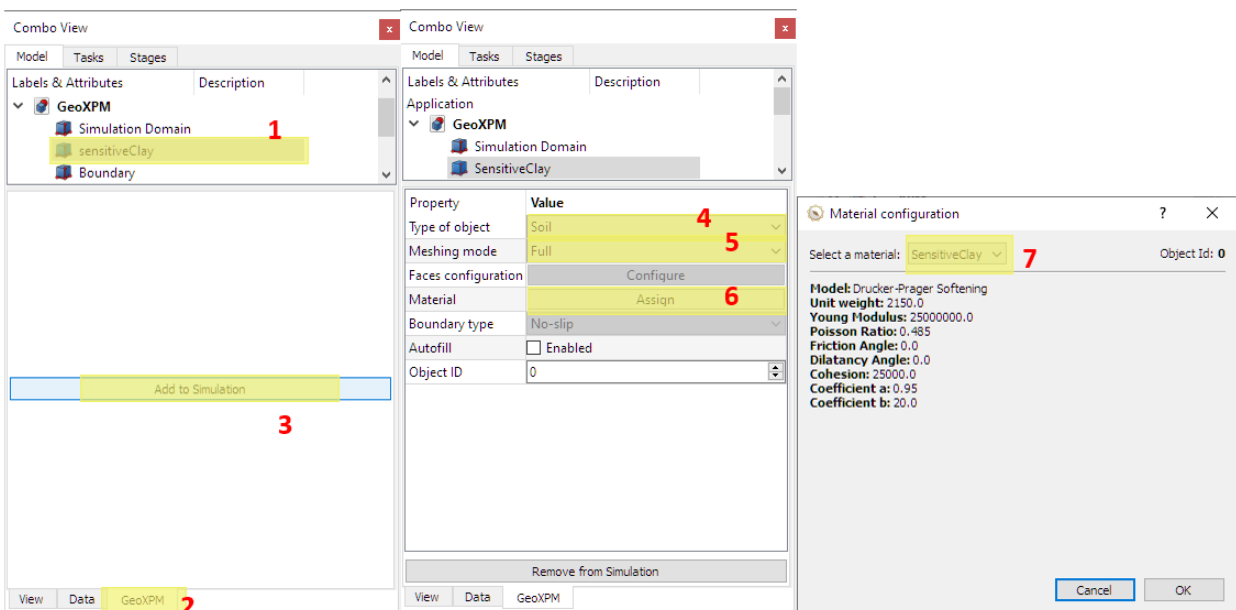
➤ Step 4. Input material properties

- a. Click the Material property button, select the used constitutive model (i.e., Softening plasticity (DP) model) provided in the “new material” button, and enter the material parameters.



➤ Step 5. Include objects in simulations and assign material properties

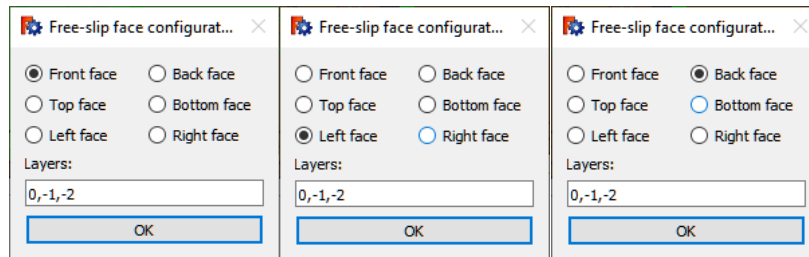
- a. Soil object: Select the “SensitiveClay” in the “Model” tab and click “Add to Simulation” under the “GeoXPM” tab. Then select the “Type of object” as “Soil” and the “Meshing mode” as “Full”. In the next step, click the “Assign” button to assign the “SensitiveClay” model to the soil in the dialogue of the material configuration.



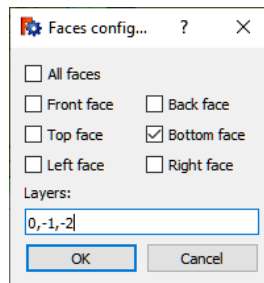
- b. Boundary objects:

- i. Select the “Front” object, and click “Add to Simulation” under the “GeoXPM” tab. Then select the “Type of object” as “Boundary”, and the boundary type

is “Free-slip”. In the next step, click the “Configure” button and define the Front face of the “Front” Box object as the meshing face by ticking the “Front face” option. Input 0,-1,-2 into the Layers textbox to create three boundary layers, with the first layer on the Box’s Front face (0) and the subsequent two layers in the inward direction of the “Front” Box object (-1,-2). Repeat the process for the “Left” and “Back” objects.

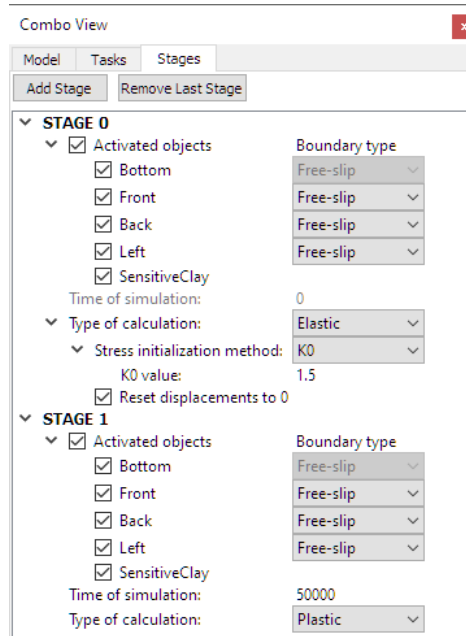


- ii. Select the “Bottom” object, and click “Add to Simulation” under the “GeoXPM” tab. Select the “Type of object” as “Boundary”, the meshing mode as “Face”, and the boundary type as “No-slip”. Click the “Configure” button, and tick the “Bottom face”. Input 0,-1,-2 into the Layers textbox.



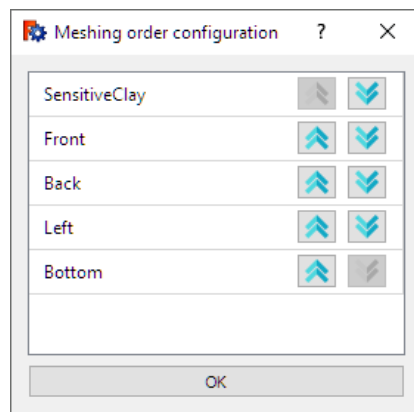
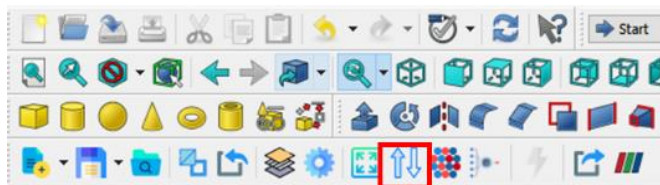
➤ Step 6. Define construction stages

- a. Go to the Stage tab and click “Add stage”.
- b. Add Stage 0 for the stress initialization using the elastic loading method.
- c. Set the “Type of calculation” to “Elastic”.
- d. Set the “Stress initialization” method to K0.
- e. Add “STAGE 1” for the elastoplastic analysis. Set the “Type of calculation” to “Plastic”. Set the “Time of simulation” to 50000.



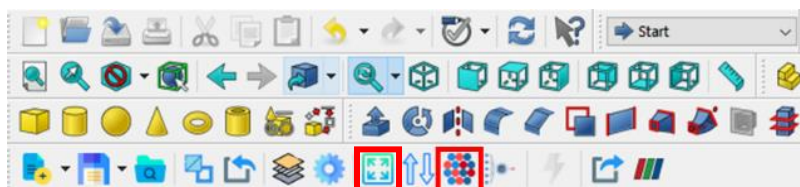
➤ **Step 7. Define the mesh sequence**

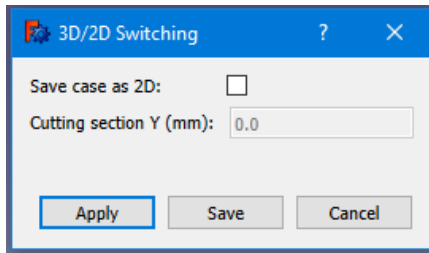
Click the “Meshing order” button, change the mesh sequence of all the objects, and be noted that the lower object will overwrite the upper one if there is any overlapping.



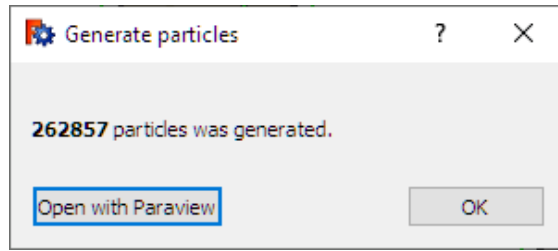
➤ **Step 8. Generate particles for computations**

- Before meshing, click the save button to save the project as 2D or 3D based on your need.
- Click the “Autofit simulation domain” button to fit all simulated objects in the calculation domain.
- Click the “Generate particles” tool to mesh the computational domain.
- After meshing, click “Open with Paraview” to view the particle configuration.





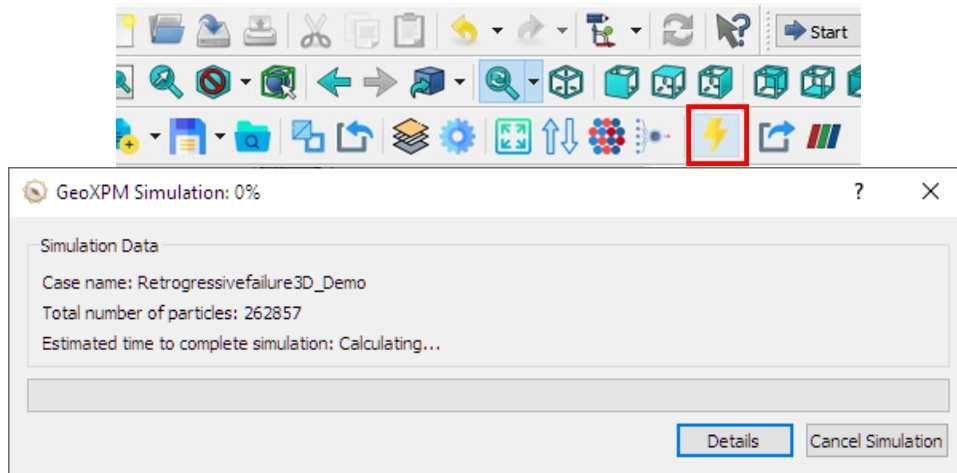
Save the project as 3D



Check the particle configuration

➤ Step 9. Start the Calculation

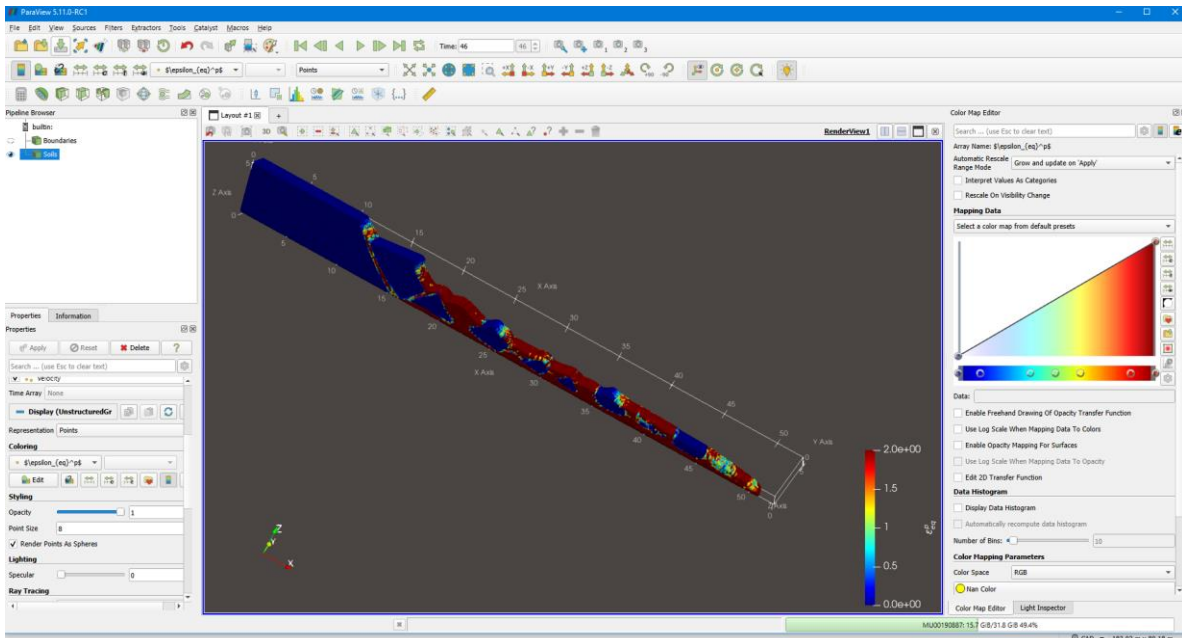
Click the “Run” button and start the calculations.



➤ Step 10. Visualization

- Click on the tool “Export output data to VTU format” to start exporting data to Paraview anytime during the simulation or after completion.
- When the export is done, Paraview will open with already imported results. All the data can be customized and visualized from here.





References:

1. Bui H.H, Nguyen V.T & Nguyen G.D (2023). GeoXPM: Particle-based continuum solutions for extreme geoen지니어ing, geomechanics & geophysics applications, Tutorial Manual. [Link](#)
2. Bui H.H, Nguyen G.D (2021). Smoothed particle hydrodynamics (SPH) and its applications in geomechanics: From solid fracture to granular behaviour and multiphase flows in porous media, *Computers and Geotechnics* 138, 104315. [Link](#)
3. Bui H.H, Fukagawa R, Sako K & Ohno S (2008). Lagrangian mesh-free particles method (SPH) for large deformation and failure flows of geomaterial using elastic-plastic soil constitutive model, *International Journal for Numerical and Analytical Methods in Geomechanics*, Vol.32(12), pp.1537-1570. [Link](#)