Retic Systems

FILL SAFE FILL SMART

STOPE FILL 1.2

User Guide

Developed by D Coulton & L Wall

Retic Systems

Retic Systems is an engineering consultancy within the mining industry specialising in backfill system design and operation. We leverage inhouse software packages to not only streamline the design process but provide cost optimised solutions, as well as developing SCADA integrated real-time reticulation monitoring systems.

Founded by David Coulton, who has over 5 years' experience designing and providing operational support for backfill systems across Europe, Asia, and Africa. David studied as a mining engineer and has a deep understanding of the challenges associated with underground mining. Throughout his time working in the industry he has developed numerous connections with site engineers, mine design software developers, and plant operators. Endowing him with strong insights as to the current needs and difficulties with implementing backfill in mining operations.

Services

Retic Systems offers four distinct service packages, each providing solutions to operational and design problems with the reticulation networks associated with hydraulic and paste backfill systems.

Retic Router

A patent pending reticulation system design and management package, that develops an optimised branched network to deliver backfill from a surface preparation plant to all underground stopes. Utilising the mine design spatial data, the software package finds the optimal network to connect all the stopes. Retic Router considers both the capital cost (pipe purchase and installation) as well as operating expenditures, to ensure the solution delivers backfill at the lowest unit cost for the life of the mine.

Stope Fill

Stope Fill is a free backfill analysis and pour design tool developed by Retic Systems, it is a lightweight 3D environment providing real-time visualisation and customisation of your stope designs. Select the stress analysis methodology and Stope Fill will analysis the stope and calculate the strength requirement, easily include cap and plug pours just specify the thickness and strength requirement for each, a liquefaction limit can also be applied to set the minimum strength requirement. Stope Fill segments the stope into discrete pours, optimising the binder usage for each segment and outputting a composite pour, detailing pour volumes and binder dosage rates for each segment.

Active Retic Monitoring

Determining if a system is in slack flow traditionally requires accurate hydraulic models and survey data of the pipe routing, these are difficult to obtain due to the high dynamic nature of mining operations. Additionally, it is difficult to convey the outputs of these hydraulic models to system operators, as it normally entails monitoring dozens of pressure sensor values simultaneously. We offer several solutions, unconstrained by accurate survey data nor rheological models, that automate this detection process by utilising the pressure sensor data directly within the SCADA system.

Material Mapping

Our approach to design, and the material testing required as a basis for that design, starts with understanding your process variability. We map your material to a multivariant probability density function which defines the strength and rheological properties of your backfill across the entire operating window. By undertaking a streamlined and highly targeted testing campaign, we develop statistical models of the variance each process parameter has on the backfill.

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1. What Is Stope Fill?

Stope Fill is a free desktop application developed by Retic Systems to simplify the backfill and pour design process. Stope models can be imported from your preference of mine design software. Upon selecting the stress analysis methodology Stope Fill automatically assess your stope to determine the minimum strength requirement across your stope. Customisation of the stope design is possible by including plug and cap pours or setting a liquefaction limit. Once the stope design is complete Stope Fill will develop a composite pour plan with the primary goal to minimise cements whilst maintaining stability. The pour design can also be customised by setting pour variables such as: filling location, minimum batching size, and beach slope angle.

1.1. Why Should I Use Stope Fill?

Stope Fill was developed to service a single purpose, provide you the tools and data you need to start engineering your backfill. Transitioning from a single homogeneous pour to a composite pour will significantly reduce your unit backfill cost. Stope Fill makes this process simple and intuitive, whilst permitting customisation as you see fit. Stope Fill provides a summary of each pour, detailing the required binder dosage and volume, ready to be issued to your plant operators.

1.2. Disclaimer and User Liability

Stope Fill is an **estimation tool**. Designs developed by Stope Fill must be verified and signed off by an accredited Geotechnical engineer before being implemented in a production environment.

Stope Fill calculations consider a vertical exposure within a non-confining rockmass. For exposures with confining stresses or horizontal exposures Stope Fill is **not** applicable.

By using Stope Fill you acknowledge this and waive all liability towards Retic Systems for any erroneous designs or damages arising from non-compliance with these guidelines.

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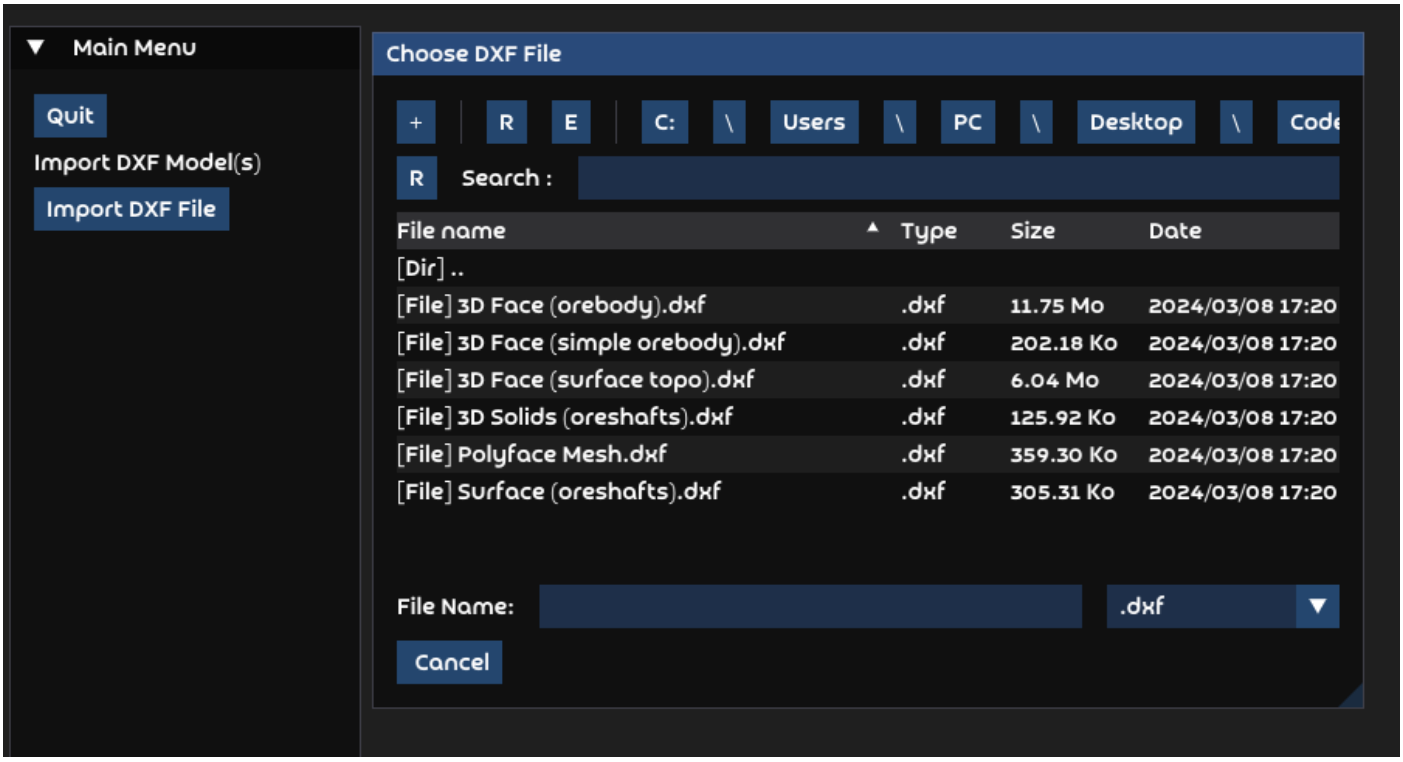
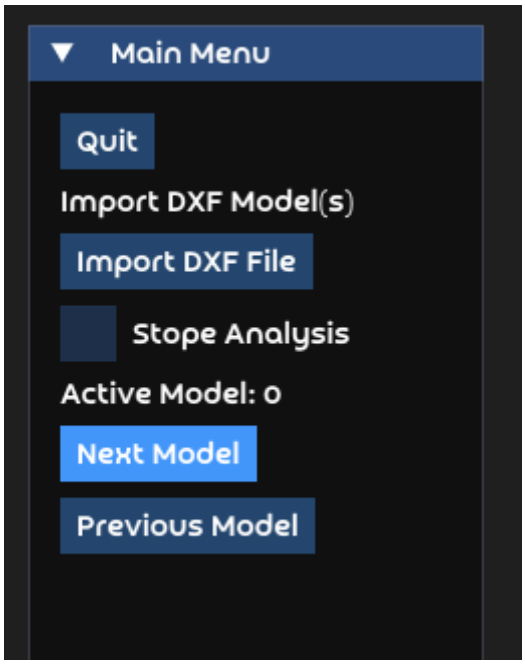
2. Importing Models

Stope Fill allows importation of DXF file formats, this is a portable exchange format readily exported from all mine design packages. Clicking “Import DXF File” will open a file explore where you can select the DXF file for importation.

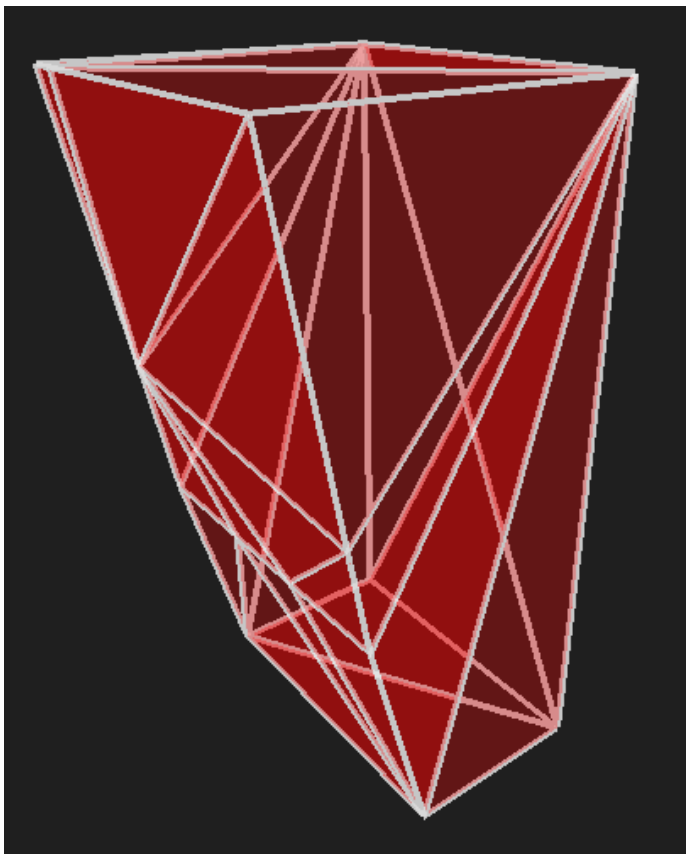
Stope Fill 1.2 supports 2 DXF encoding types: Polyface Mesh and 3DFace Mesh. Polyface Mesh files are basic stope design shapes, these files and can contain 1 or 1000+ stope objects, Stope Fill will parse the data and isolate each stope object for individual analysis. 3DFace are typically produced from CMS scans and is limited to 1 stope at a time, due to the encoding of 3DFace Meshes Stope Fill will be unable to differentiate between different objects should you import multiple 3DFace Meshes.



If you have imported several stopes, you can iterate through the models with the “Next Model” or “Previous Model" button until you find the stope you would like to develop a backfill design for.

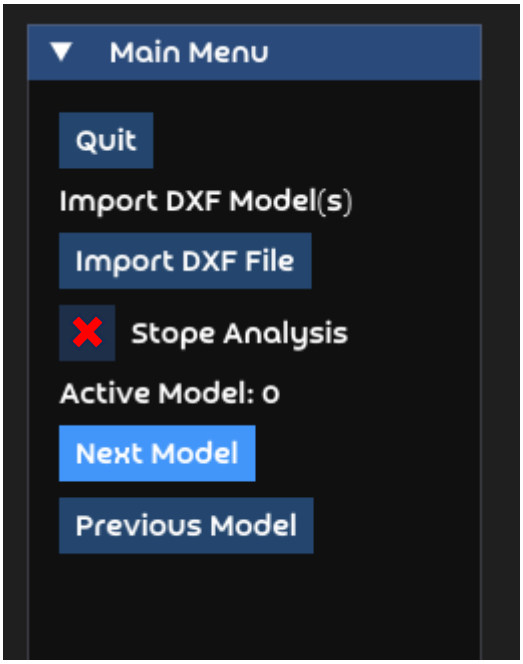


Imported stopped are represented by a surface and wireframe model, with surfaces shaded red and edges white. The model can be rotated by right holding right click down and dragging in the desired direction of rotation.



3. Stope Design

Once you found the stope you wish to design, begin the design process by clicking on the "Stope Analysis" checkbox.



3.1. Raster Resolution

Upon entering the Stope Design mode additional options will become available within the "Main Menu" window. The first option is "-" and "+" incrementors for the resolution variable, the resolution is the size of filling voxels (cubes) that have been generated by Stope Fill to represent the stope solids. Smaller resolutions permit a greater accuracy in pour volumes and allow for finer optimisation potential for systems with tight backfill control. To implement any changes in resolution, click "Re-Rasterise". Note, resolution has a minimum of 0.3m, this may cause some long loading times (1-2minutes) with large stopes (>10,000m^3) when rasterising and developing the pour plan. Retic Systems recommends a resolution of 0.5-1.0m for quick modelling, with lower resolutions reserved for small stopes or detailed optimisation work.

3.2. Model Space Navigation

Pan Mode can be toggled on and off by checking and unchecking the checkbox. Whilst Pan Mode is active, you can move the model vertically or horizontally relative to the screen by holding left click down and dragging the direction you want the model to move.

Zoom in and out of the model by pressing 'W' whilst scrolling with the mouse wheel.

Pressing 'Left Shift' + 'W' whilst scrolling allows you to shift the model up and model in the Z (elevation) axis.

'Left Shift' + 'V', can be used to reset the view to the model default if you get lost.

3.3. Show Grid

Show Grid is a view option that turns the edges of the filling voxels on and off. This is most noticeable during the Pour Design mode when voxel surfaces might not be shaded.

3.4. Show Stope Model

Show Stope Model is a view option that toggles the original stope model (red surfaces) on and off. Viewing the Stope Model concurrently with the filling voxels provides a visual check for the accuracy of Stope Fill.

3.5. Stress Analysis

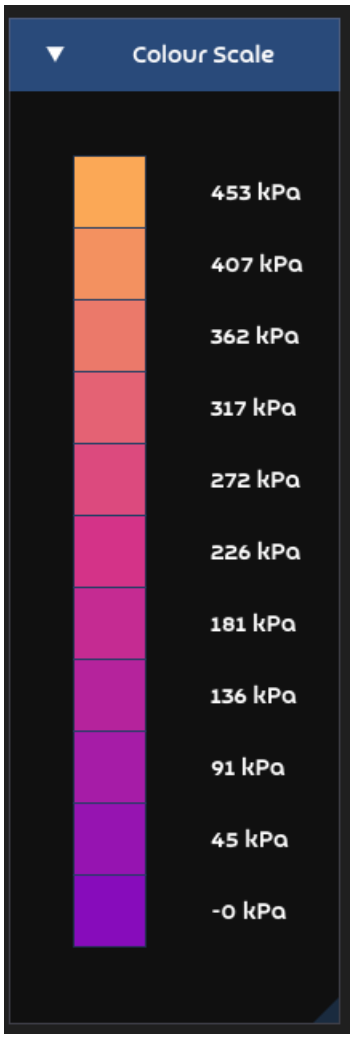
Stope Fill currently has two available stress analysis methodologies: “Geostatic Load” and “Mitchell Analysis”. These are mutually exclusive, and one must be selected before advancing to the “Pour Design” stage.

Geostatic Load applies a conversative stress field = ρgh to the voxels (where h is depth below surface).

Mitchell Analysis carries out frictional slide block analysis, as described by Mitchell et al. 1982. See the “Stope Fill Additional Information” for details on the exact calculations used.

3.6. Heat Map

After selecting a stress analysis methodology, Stope Fill automatically colour codes each voxel relative the estimated stress at that voxel. A heat map legend can be toggled on and off to see the stress for each colour. Colours are assigned on a continuum; the heat map just illustrates the 10^{th} percentiles of that continuum.

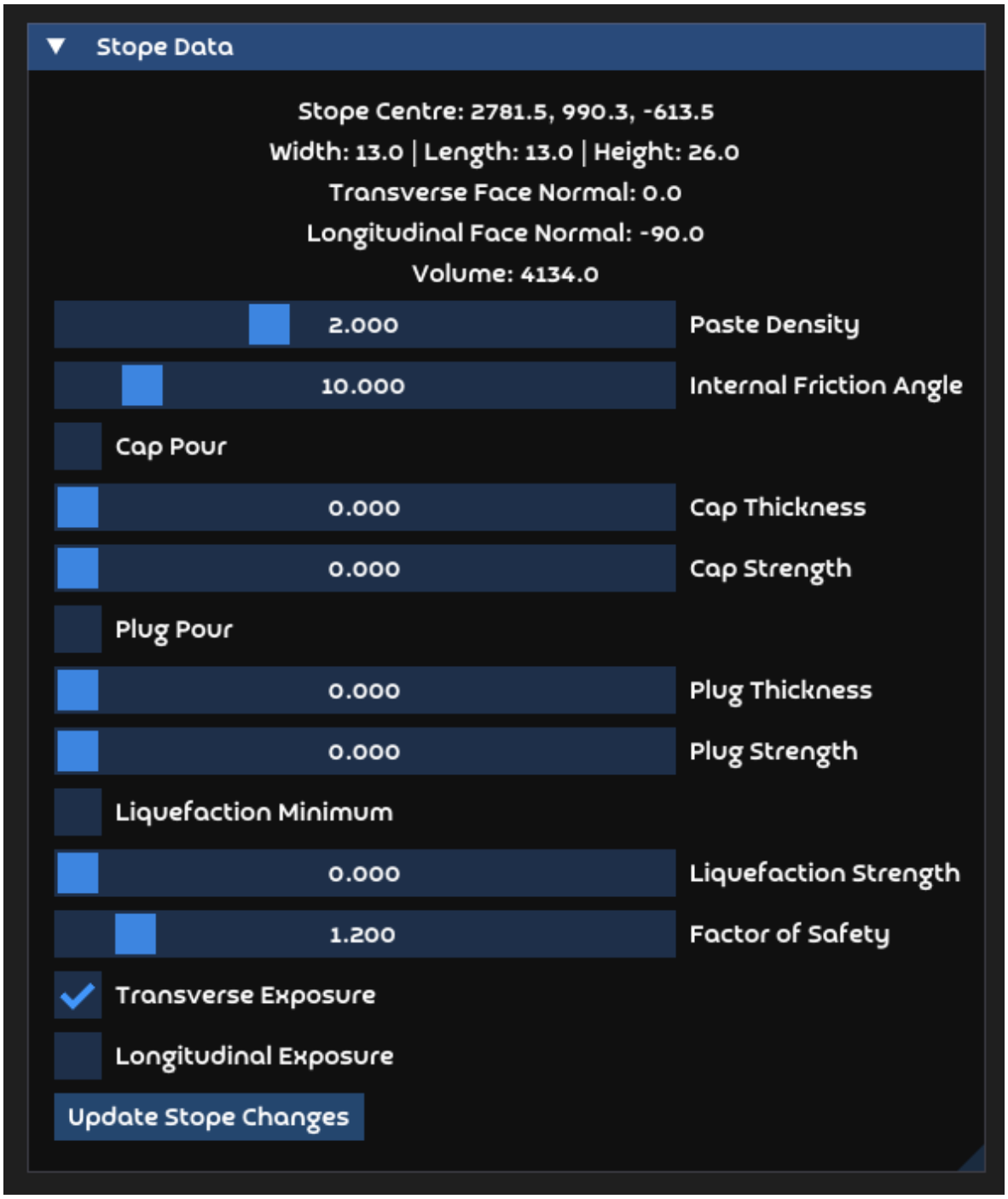


Note, if no stress analysis methodology has been selected the plot will be erroneous.

3.7. Stope Design Customisation

To customise the stope design or adjust the parameters of the stress analysis methodologies check “Stope Design”, this will open a new window named “Stope Data”. This window provides a summary of the stope characteristics including positioning, volume, size, and orientation (bearings in degrees), as well as several options to customise the stope design.

Adjust the stope design parameters to meet your specific needs, values can be set by sliding the slider or by inputting exact values. Implement any changes by clicking “Update Stope Changes”. Changes are immediately reflected in the stope model voxel colouring.



3.7.1. Backfill Properties

Density and internal friction angle of the backfill can be adjusted, these affect the stress methodology calculations and thus the required strength for each voxel. Internal friction angle only affects the Mitchell Analysis methodology.

3.7.2. Cap and Plug Pours

Cap and Plug pours can be easily toggled on and off by checking the appropriate box. The thickness and strength for each can be set independently. Inbuilt checks compare the stress analysis results and the cap/plug pour requirements and select the most onerous.

3.7.3. Design Assurances

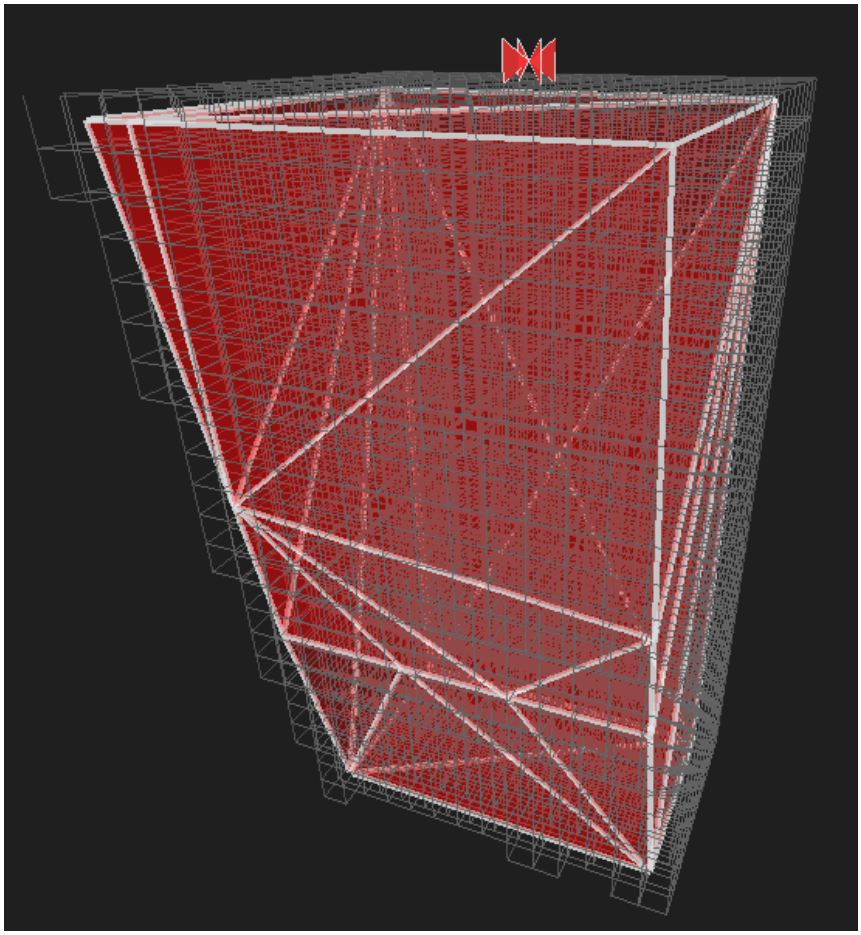
A minimum strength requirement can be defined by activating the “Liquefaction Minimum” and setting the liquefaction strength. The factor of safety used within the stress methodologies can also be adjusted to suit your preference.

3.7.4. Exposure Orientation

When carrying out Mitchell Analysis on non-square stopes, the exposure orientation can significantly affect the strength requirement. As such it is critical to select the correct exposed face. If exposing in both directions, the most onerous direction should be used.

4. Pour Design

After you have completed the stope design, proceed to the Pour Design mode by clicking "Pour Design" within the Main Menu window. The model space will then update, emptying the voxels leaving just the grid and the stope object (if you have these set to visible).

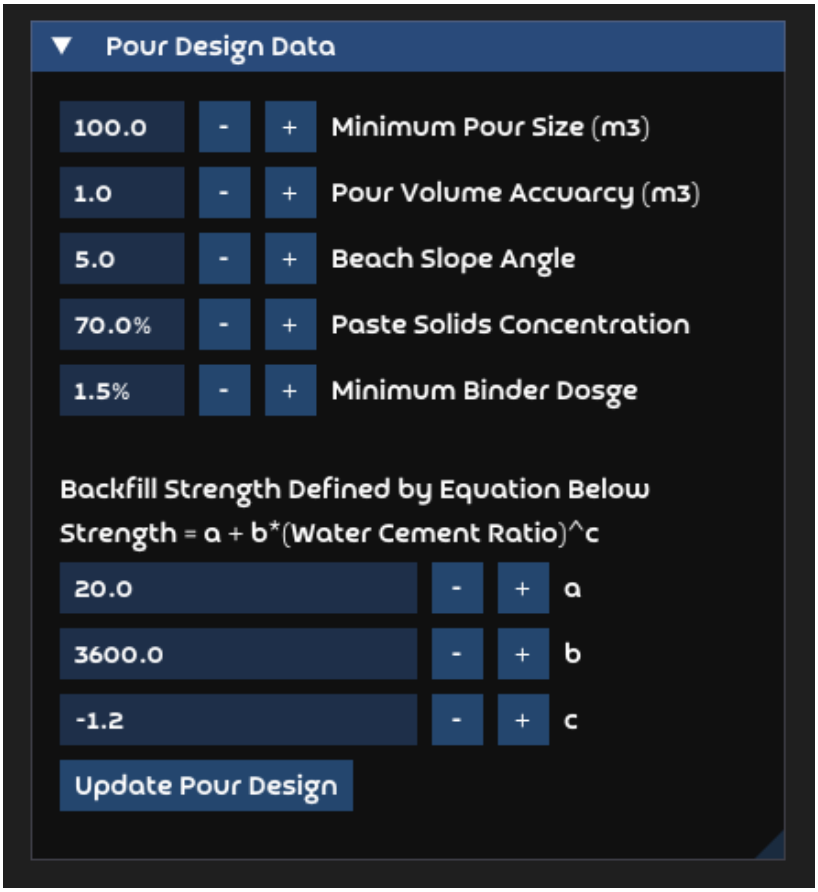


Within the main menu you can adjust the fill point position (reticulation discharge point), which is denoted by the red flag marker on top of the stope. Positioning of the fill point can be a crucial step in optimising your composite pour, particularly when working with steep beach slope angles and long/wide stopes.

Click "Re-Analysis Strength" if you wish to return to the Stope Design mode to adjust the design or to switch to another stope.

4.1. Pour Customisation

A new window will open upon entering the Pour Design mode, here you can adjust several parameters to modify the composite pour plan that Stope Fill generates.

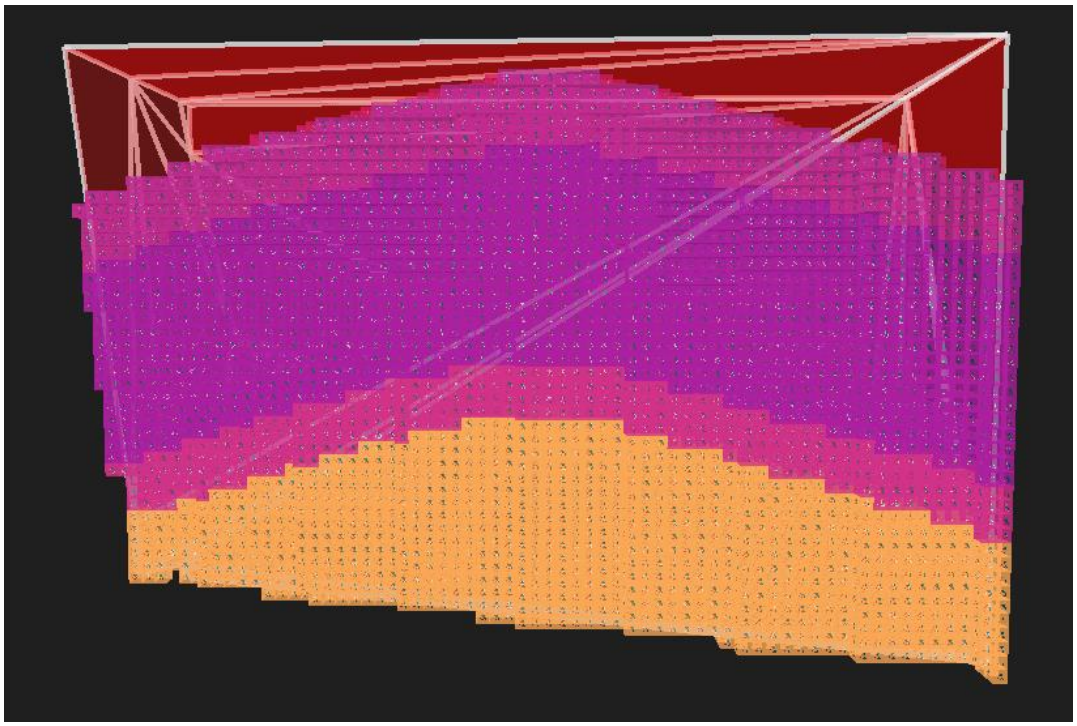


4.1.1. Pour Size

The minimum size of pour can be set, this determines how many segments (pour stages) Stope Fill will generate. Pour Volume Accuracy reflects your process control accuracy within your backfill plant – if you measured to the nearest $10m^3$ of paste volume discharged it is recommended to have at least a Pour Volume Accuracy of $10m^3$ as this would ensure the pour segments volumes have sufficient tolerance.

4.1.2. Beach Slope Angle

The beach slope angle greatly affects the filling sequence of the stope and thus the composite pour plan. Steep beach slope angles can result in only partial filling of large stopes, overlay the stope model or grid to see the implications of this.



4.1.3. Binder Dosage

The required binder dosage is calculated using the solids concentration, specified by you, and the WC Ratio Strength function (shown below) with the constants available for adjustment to match your material. Furthermore, a minimum binder dosage can be specified should you require one.

$$Strength\ (kPa) = a + b\ \times WC\ Ratio^{c}$$

4.2. Composite Pour Plan

After setting the Pour Design parameters, click “Update Pour Design” and Stope Fill will sequence and optimise the stope pour plan (for large stopes and low resolution this could take 1-2minutes). Once pour segmentation is complete, a new window will open “Composite Pour Plan”. This window provides a breakdown of the composite of each segment required to fill the stope. Segments composition is designed to ensure it meets geotechnic requirements whilst minimising the binder usage for the whole stope. Each segment can be toggled on or off for visual inspection of the composite pour plan.

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