Starting BCF

To start you must select a "Project" folder where the BCF data and results will be saved. The menu items will remain grayed out until you have selected a Project Folder.

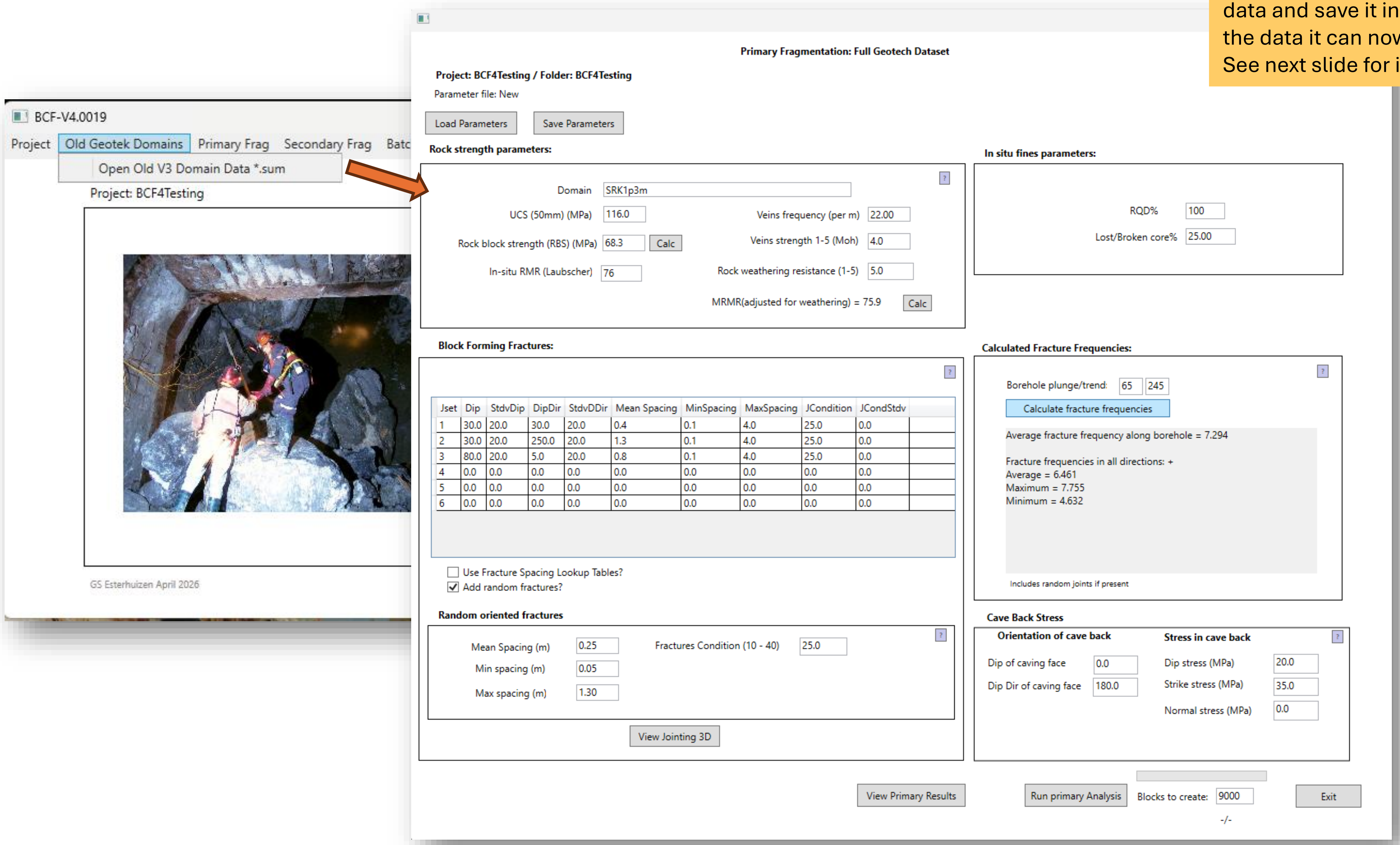
Once you selected or created a Project Folder the rest of the menu items will become available. You can then select an option to continue.

The menu options are as follows:

- **Old Geotech Domains**: Allows you to read old BCFV3 Geotech data. Note: When you save the data, it will be saved in BCFV4 format
- **Primary Frag:** Define a geotechnical domain data set and analyze the primary fragmentation associated with that geotechnical domain
- **Secondary Frag**: Define draw column parameters and analyze secondary fragmentation in the draw column using the results of a primary fragmentation analysis
- **Batch Analysis:** Run several Primary and Secondary fragmentation analyses in a batch. Summary results are provided that allows you easily compare results of the different runs
- **About:** A bit of background about BCF.

Reading old geotechnical domain data

This will allow you to read old BCFV3 Geotech data and save it in BCFV4 format. After saving the data it can now be used as input for BCFV4
See next slide for input details.



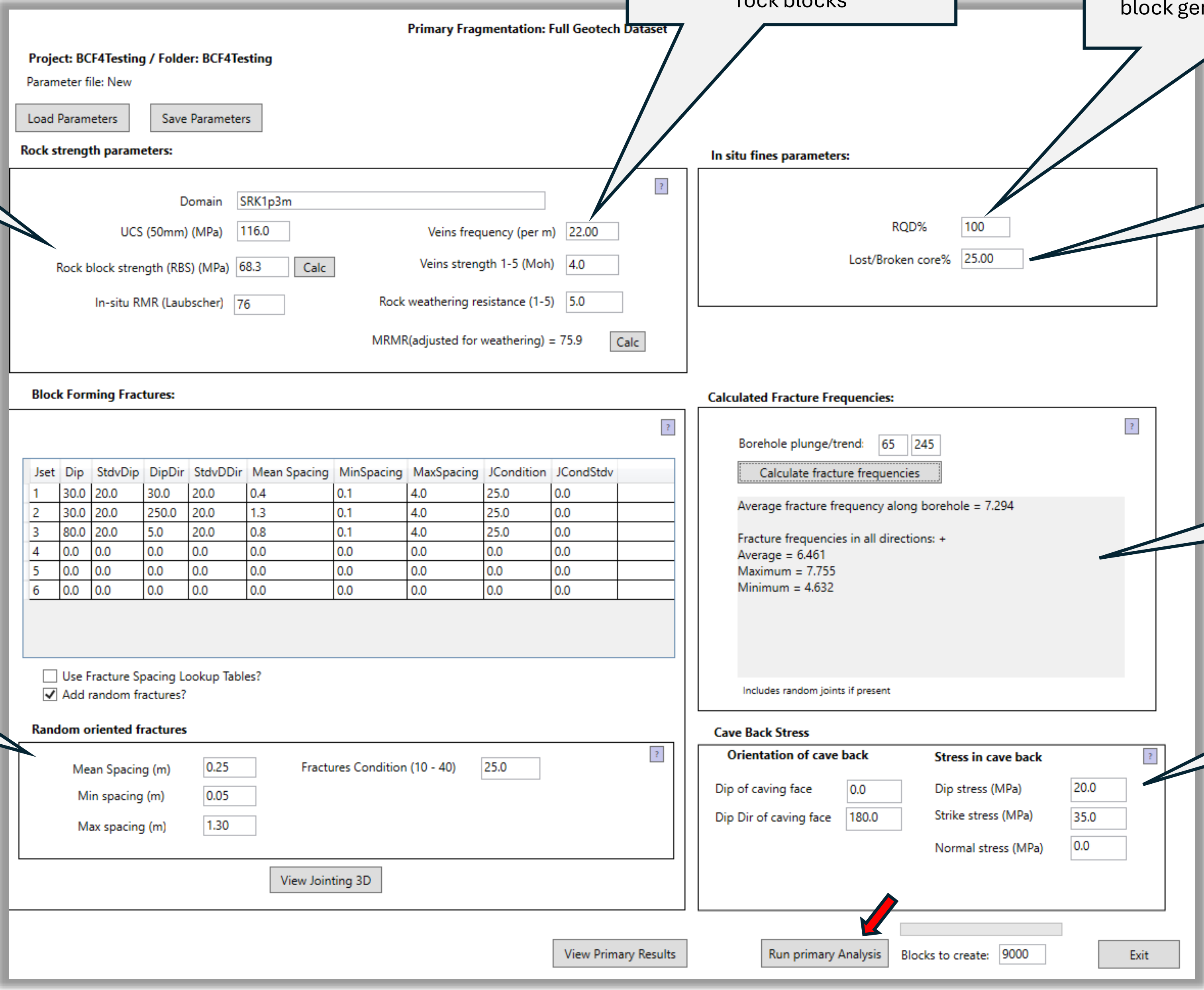
Primary Analysis: Full Geotechnical Data

Information about veins in the rock blocks

RQD should be set to 100% because it is taken into account adequately in the block generation from joint spacings

Lost & Broken core: pieces of core < 5 cm in shear zones, breccia, highly jointed classed as “fin-situ fines”

Rock and rock mass strength data



Primary Fragmentation: Full Geotech Dataset

Project: BCF4Testing / Folder: BCF4Testing

Parameter file: New

Load Parameters | Save Parameters

Rock strength parameters:

Domain: SRK1p3m

UCS (50mm) (MPa): 116.0

Veins frequency (per m): 22.00

Rock block strength (RBS) (MPa): 68.3 [Calc]

Veins strength 1-5 (Moh): 4.0

In-situ RMR (Laubscher): 76

Rock weathering resistance (1-5): 5.0

MRMR(adjusted for weathering) = 75.9 [Calc]

In situ fines parameters:

RQD%: 100

Lost/Broken core%: 25.00

Block Forming Fractures:

Jset	Dip	StdvDip	DipDir	StdvDDir	Mean Spacing	MinSpacing	MaxSpacing	JCondition	JCondStdv
1	30.0	20.0	30.0	20.0	0.4	0.1	4.0	25.0	0.0
2	30.0	20.0	250.0	20.0	1.3	0.1	4.0	25.0	0.0
3	80.0	20.0	5.0	20.0	0.8	0.1	4.0	25.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

☐ Use Fracture Spacing Lookup Tables?

☑ Add random fractures?

Random oriented fractures

Mean Spacing (m): 0.25

Fractures Condition (10 - 40): 25.0

Min spacing (m): 0.05

Max spacing (m): 1.30

View Jointing 3D

Calculated Fracture Frequencies:

Borehole plunge/trend: 65 | 245

Calculate fracture frequencies

Average fracture frequency along borehole = 7.294

Fracture frequencies in all directions: +
Average = 6.461
Maximum = 7.755
Minimum = 4.632

Includes random joints if present

Cave Back Stress

Orientation of cave back

Dip of caving face: 0.0

Dip Dir of caving face: 180.0

Stress in cave back

Dip stress (MPa): 20.0

Strike stress (MPa): 35.0

Normal stress (MPa): 0.0

View Primary Results | Run primary Analysis | Blocks to create: 9000 | Exit

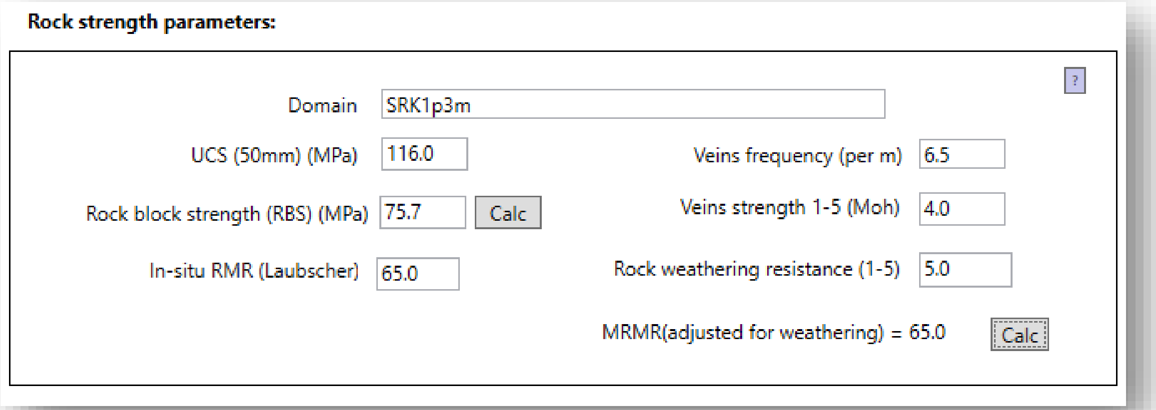
Fracture frequency calculations from jointing/fracture data

Random oriented fractures data – if needed

Cave back stress and orientation data

More details in next few slides

Primary Analysis: Rock strength data

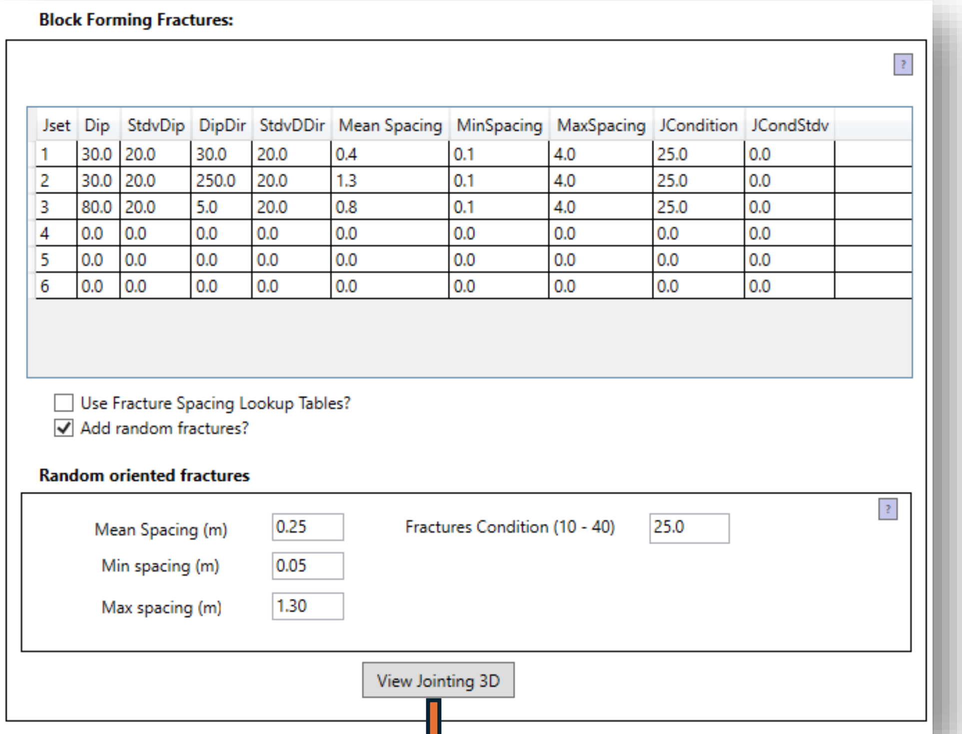


- **Domain:** Use a short domain name so that the result tables don't become too wide
- **UCS (50mm):** Enter the uniaxial compressive strength including the effect of any weakening effects of micro veins that exist in the core samples.
- **Rock block strength (RBS):** Strength of rock blocks in between block forming fractures. This should include the effect of meso-veins that are not present within UCS samples. RBS should be calculated using Laubscher & Jakubec (2001) or can be calculated approximately using the "Calc" button. This is an estimate of the 1 m-size block strength.
- **In-Situ RMR:** The unadjusted IRMR determined according to Laubscher and Jakubec (2001). This is automatically calculated from inputs on the screen. You can overwrite it if you have calculated the IRMR separately. BCF uses whatever IRMR value is in the text box when you save or start the analysis

- **Veins frequency:** Frequency of meso-veins that exist within rock blocks that are healed and do not separate under gravity – typical fill materials with Moh Hardness of 3 to 5
- **Veins strength:** Use Moh's hardness scale (1-5) to specify vein strength. Hardness greater than 5 assumed to have no impact on block strength.
- **Rock weathering resistance:** Use a scale of 1 – 5 with 1 being very low resistance and 5 being very high resistance. This can be calculated as 0.057 x W – 0.71 where W is the Laubscher & Jakubec (2001) weathering adjustment.
- **MRMR:** The weathering adjustment is applied to the IRMR to show approximately what the final Mining rock mass rating would be.

- **Calc buttons:** If you would like to calculate the RBS, IRMR and MRMR using an approximate calculation in BCF first click the RBS Calc button and then the MRMR calc button. The IRMR Calculations are quite complex, and all subtleties of the calculations are not included.

Primary Analysis: Block forming fractures data



Block Forming Fractures:

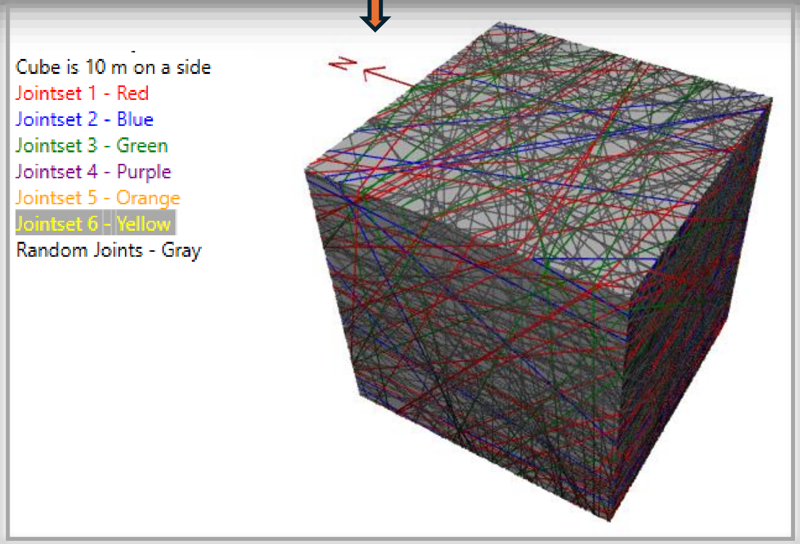
Jset	Dip	StdvDip	DipDir	StdvDDir	Mean Spacing	MinSpacing	MaxSpacing	JCondition	JCondStdv
1	30.0	20.0	30.0	20.0	0.4	0.1	4.0	25.0	0.0
2	30.0	20.0	250.0	20.0	1.3	0.1	4.0	25.0	0.0
3	80.0	20.0	5.0	20.0	0.8	0.1	4.0	25.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

☐ Use Fracture Spacing Lookup Tables?
☑ Add random fractures?

Random oriented fractures

Mean Spacing (m) 0.25
Min spacing (m) 0.05
Max spacing (m) 1.30
Fractures Condition (10 - 40) 25.0

View Jointing 3D



Data for natural fractures/joints/bedding planes etc. are entered here. Allowance is made to enter sets of joints as well as random oriented fractures. A separate screen is used for cases with random jointing only.

Fracture set data required:

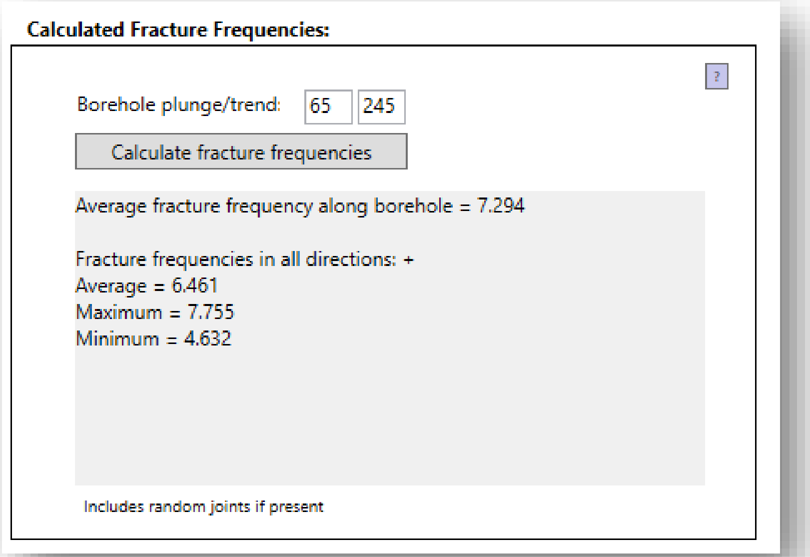
- **Dip, StdvDip:** The mean dip and standard deviation for joint planes in each joint set in degrees (0 to 90 degrees)
- **DipDir, StDvDDir:** mean and standard deviation of dip direction of joint planes in degrees (0 to 360 degrees) North zero angles measured clockwise.
- **Mean/Min/Max Spacing**: spacings in (m) measured along a line perpendicular to the mean joint orientation (true spacing)
- **JCondition/Stdv:** mean and standard deviation of the joint condition according to MRMR2001.

Random oriented fracture data:

Scattered joints that fall outside the regular joint sets can be added to the analysis. These are additional to the regular joint sets.

View Jointing 3D: This shows a 10m x 10m x 10m cube with joint traces for each set located on the cube sides. For this plot joint traces are assumed to be greater than 10m. The average joint set spacings and orientations are preserved. This provides some visual feedback of the jointing data you entered and size of blocks that could be formed. The 3D plot is not used for anything in the BCF calculations.

Primary Analysis: Verifying fracture frequencies from rock mass data

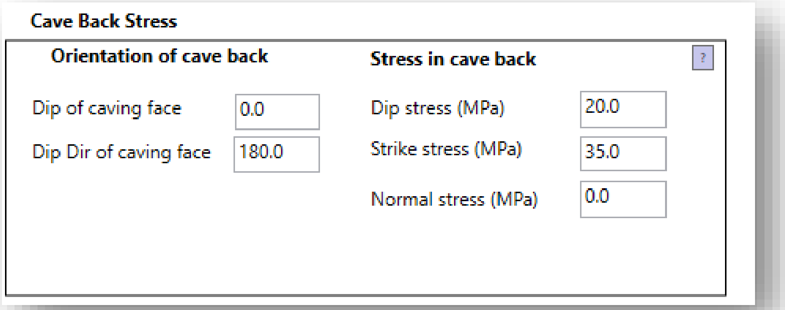


Fracture frequency data is usually the first type of rock mass data that becomes available from core drilling an orebody. After specifying joint set data this option allows you to calculate fracture frequencies along a core hole to verify if the joint set spacings are reasonable compared to measured fracture frequencies.

Borehole plunge/trend: Direction of the borehole in degrees. A vertical borehole has a plunge of 90 degrees. Trend is measured clockwise from north...same as joint orientations.

Calculate fracture frequencies: BCF will calculate the frequency of joints/fractures along the specified borehole direction and will run through the full spectrum of orientations to calculate the minimum/maximum/average fracture frequency in all directions. This calculation includes random oriented joints if specified.

Primary Analysis: Cave back stress data



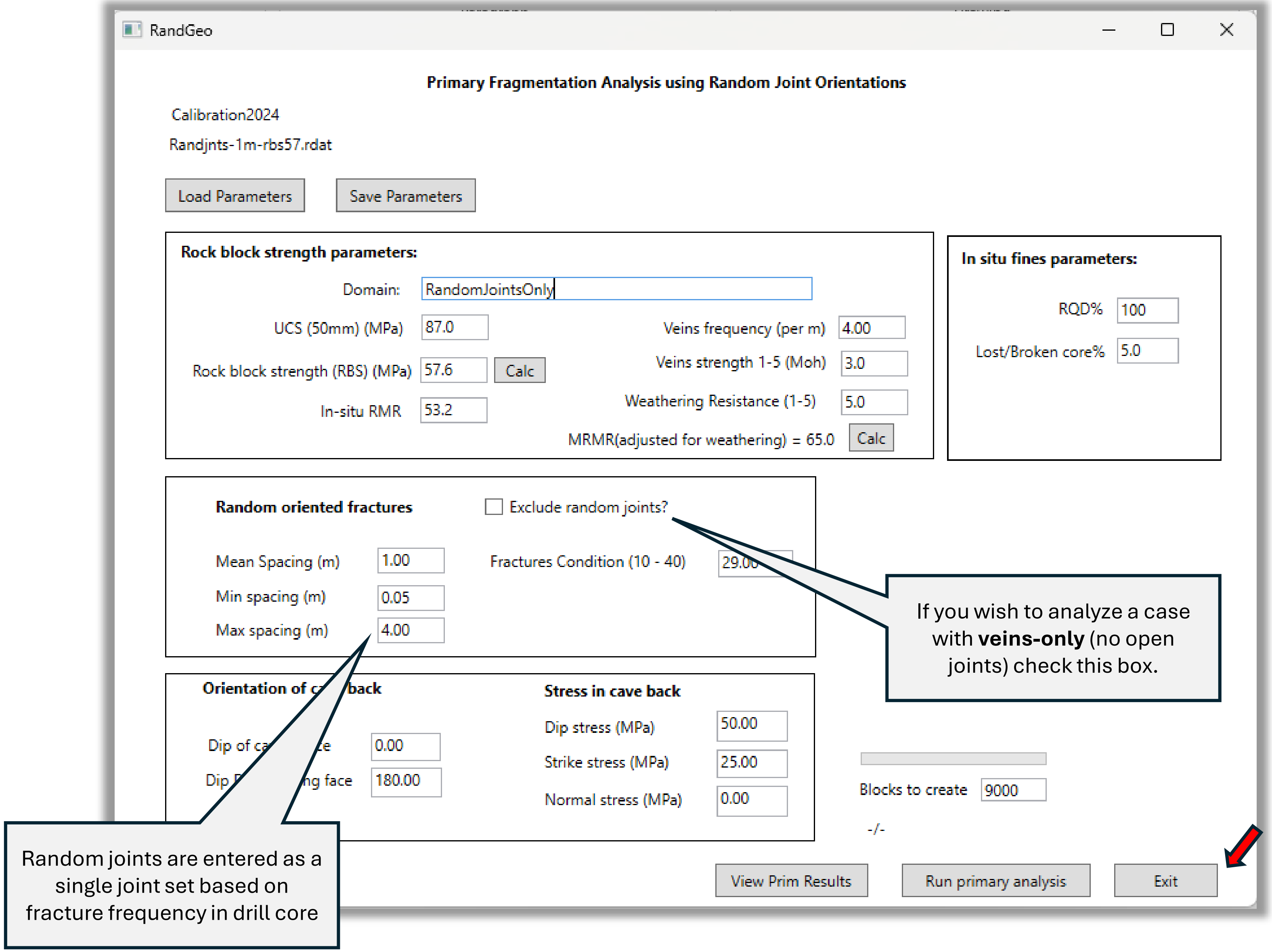
Stress in the cave back can induce fracturing and shearing along natural structures in the rock mass. The stress near the caving face is likely to be higher than the far-field ground stress that exists before mining. The mining induced stress near the cave-back can be estimated from numerical models. In general one should assume that the stress normal to the caving face is zero because of the free face at the caving boundary. If all the stress components are non-zero the rock mass is unlikely to separate under gravity, and BCF may predict huge primary fragmentation blocks.

Stress in cave back: In BCF we simplify the stress condition by considering stress in the dip and strike directions of the caving face and setting the normal stress to zero. Stresses are compressive positive entered in MPa. The Normal stress should be set to zero.

Orientation of cave back: The orientation of the cave back can be horizontal for established cave panels when caving is progressing vertically. For advancing cave fronts, for example, the cave back may be entered as dip = 55 degrees and dipdir = direction of advance (0-360 degrees clockwise from North).

***Note:** If you set all the stress components to zero or negative BCF will assume that every joint surface will separate and will produce blocks similar to DFN analyses. This is an extreme case that is not used in BCF. In the normal situation where the dip and strike stresses are compressive, block accretion occurs which can form large blocks relative to the joint spacings, depending on stress orientation, joint conditions and overall rock mass strength.

Primary Analysis: Random Joints Only (or Veins only)



The random joints option allows you to conduct analyses in cases where joint set data are not available, or the jointing is actually random.

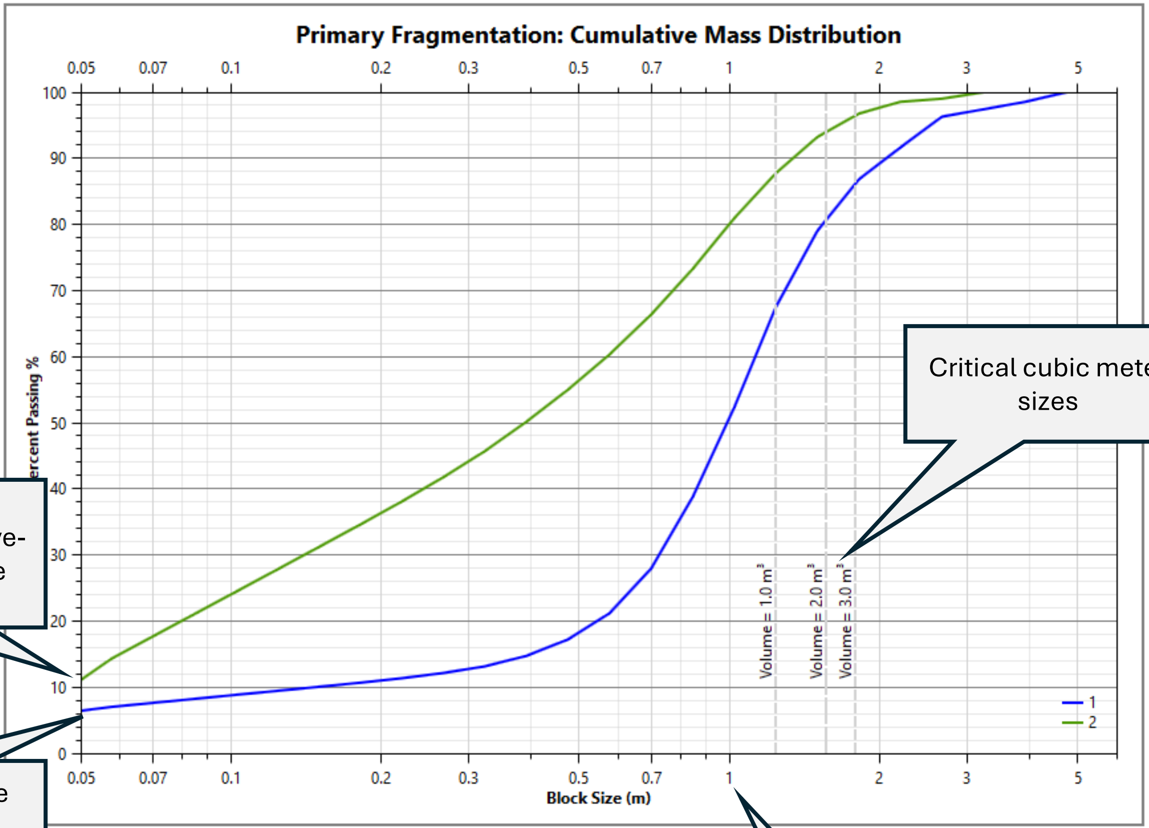
This option also allows you to conduct a **"veins only"** analysis in cases such as kimberlites where there are no open joints but healed veins exist that may separate and form blocks.

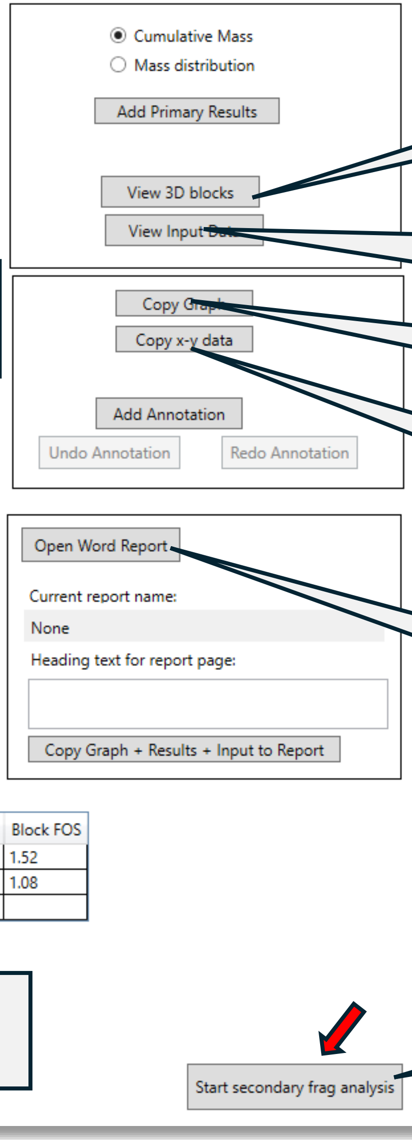
In a veins-only analysis the veins are assumed to be randomly oriented with strength based on Hormazabal and Russo (2023). The Moh-hardness is converted into cohesion and friction values for calculating vein shear resistance.

Primary Fragmentation – Results

Note: This graph shows primary fragmentation results for two cave back stress conditions in which the FOS of the in-situ rock blocks reduce from FOS=1.52 to FOS = 1.08 (See FOS values in the table). There are seven joints sets present of which one set is a random oriented joint set.

Project: BCF4Testing / Folder: BCF4Testing





Series	File	Domian	Blocks	%OvSize>2m³	Max Size (m)	[illegible]Vol	Face dip	Face ddir	σ Dip	σ Strike	σ Norm	Block FOS
1	Jarek-6sets+Norand-LoFF-1p3m-sig50.prb	Main	9000	21.0%	4.79	5[illegible]	0.00	3.14	20.00	50.00	0.00	1.52
2	Jarek-6sets+Norand-LoFF-1p3m[10].prb	Main	30000	6.8%	3.92	31.[illegible]	[illegible]	3.14	30.00	70.00	0.00	1.08

As FOS decreases block failure in the cave-back generates more fines

With high FOS we see in-situ fines of 6%

Critical cubic meter sizes

Block “size” given as a linear equivalent dimension. See technical notes at the end

View primary blocks in 3D-view

Shows a pop-up screen with all input data for the series shown in the graph

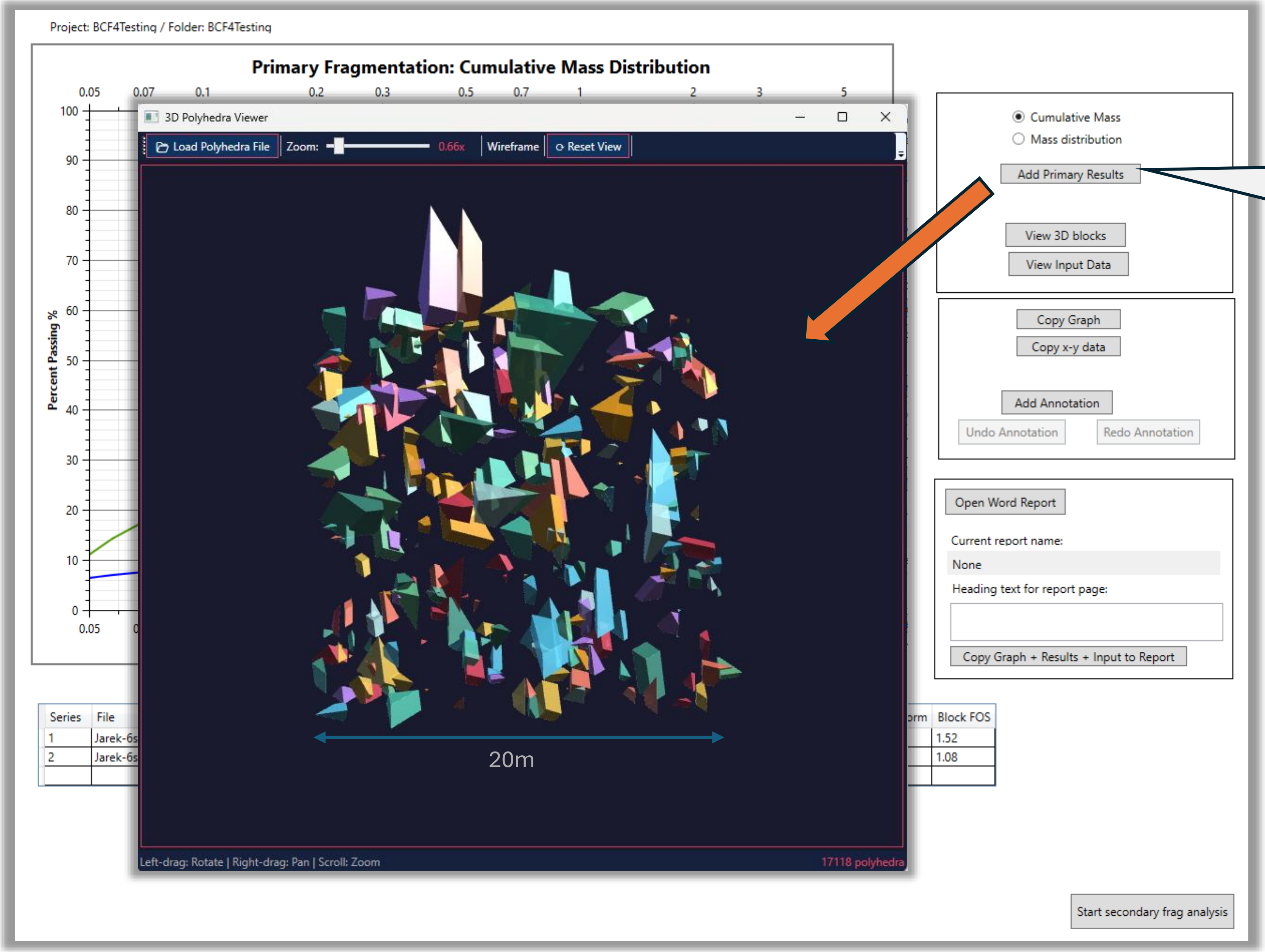
Copy the graph image to the clipboard

Copy all graph x-y data to the clipboard for pasting in Excel

Keep a log of your runs in a MSWord file which includes all inputs and results.

Start a secondary frag run using the input data of the last series added to the graph

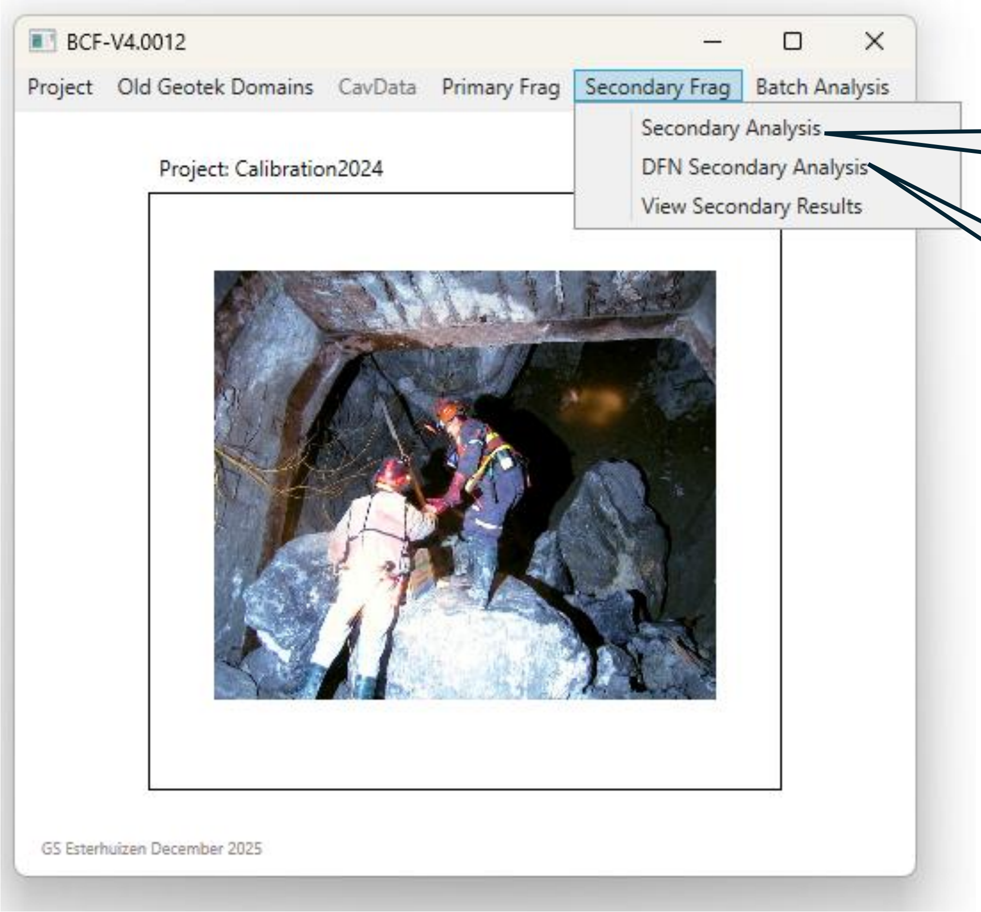
Primary Fragmentation – Results – View 3D blocks



Shows about 1000 in-situ blocks created by BCF. The blocks are randomly located in a 20 m x 20 m plane. These are individual and accreted blocks before any stress fracturing caused by cave back stress. The colors do not mean anything

Secondary Fragmentation Analysis

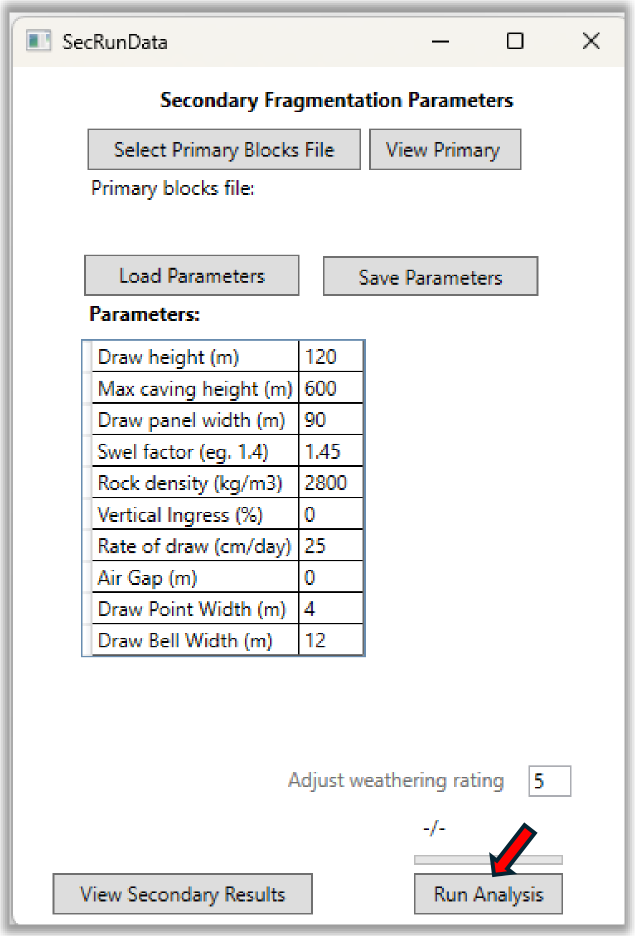
Note: The results of a primary fragmentation analysis form the input for secondary fragmentation in the draw column



Use this option to use BCF created primary blocks as input

Blocks generated by Discrete Fracture Network (DFN) software can be read as input

Secondary Fragmentation Inputs



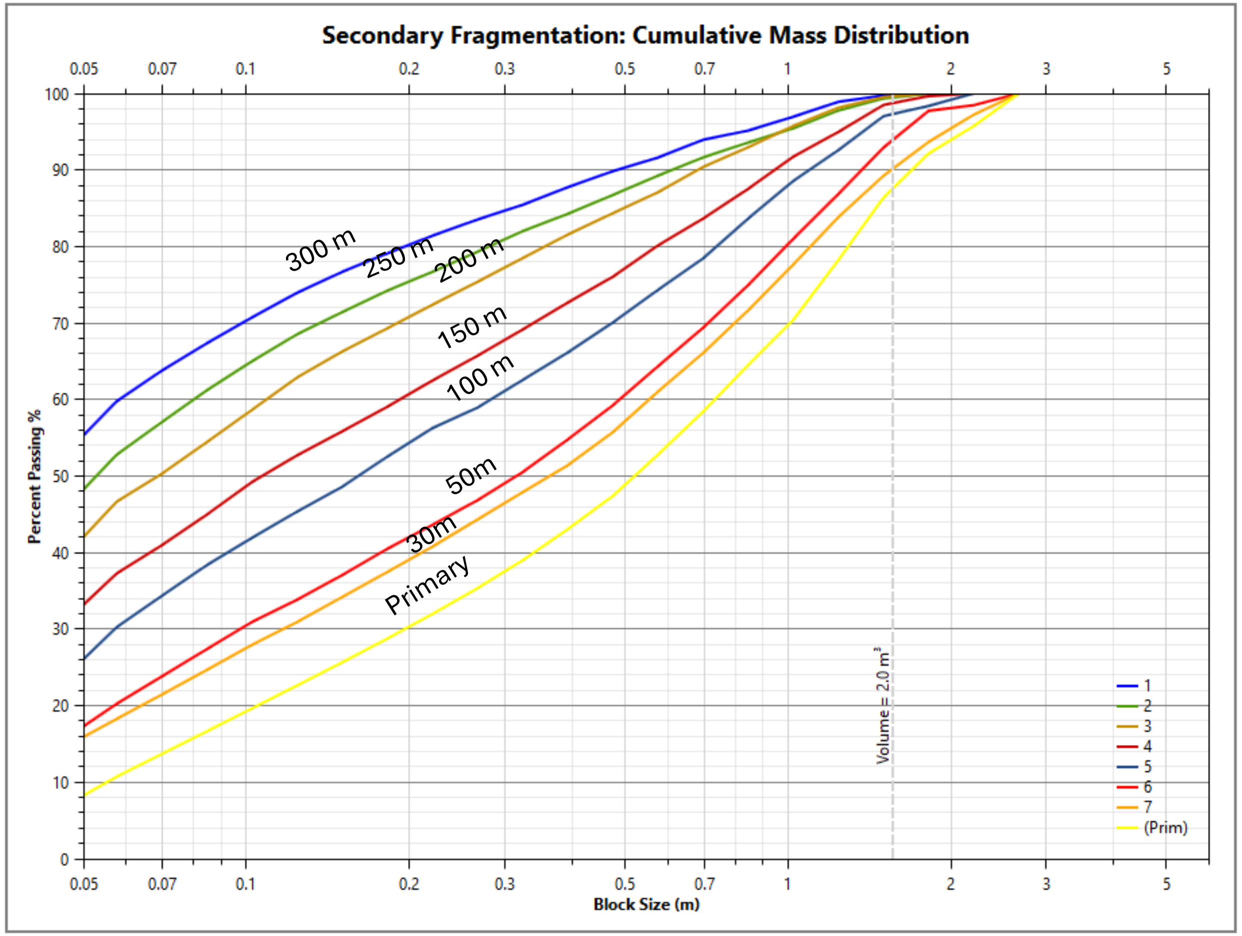
For secondary fragmentation analysis you must define the primary fragmentation file that will be used. The inputs requited are as follows:

- **Draw height:** The vertical distance through which the primary fragments moved to get down to the drawpoint. Different analyses can be run in which the draw height is modified. The draw height should generally be greater than 30 m because during initial draw the undercut-blasted rocks will be mixed with caved rock.
- **Max caving height:** This is the vertical distance from the drawpoint floor to the free surface – the natural ground surface or bottom of an open-pit etc. As the height of draw increases, BCF will calculate the height of caved material and will calculate the amount of subsidence of the ground surface occurs. As the surface subsides the draw column height will reduce.
- **Draw Panel Width:** The minimum horizontal dimension (span) of the area being drawn
- **Vertical ingress:** A percentage to account for the fact that small blocks and fine materials migrate faster than the larger blocks. Usually enter zero or maybe 5%.
- **Rate of Draw:** The rate at which the caved rock is drawn down in cm per day.
- **Air gap:** The air gap at the top of the draw column through which blocks will free-fall as they cave. Usually mine operators try to keep this at zero.
- **Draw point width**
- **Draw bell width:** The lesser of the width of the drawbell measured across the major or minor apex. Measured at the top of the apices.
- **Adjust weathering:** Weathering of the rock is specified in the Geotech data. You can modify it here to conduct sensitivity analysis of weathering effects on secondary fragmentation

Secondary Fragmentation – Results

Note: This graph shows secondary fragmentation results for height of draw (HOD) increasing from 30m to 300m. Primary blocks are from a random jointing case with joint frequency = 60 cm. Veins are present that reduce the block strength. Primary block FOS was 1.2 causing some block failures in the cave back. Air Gap & Ingress were both zero.

Project: Calibration2024 / Folder: BCF4Testing



Cumulative Mass

Mass distribution

Add V4 Results

Show Primary Curve

View Input Data

Shows a pop-up screen with all input data for the series shown in the graph, see next slide

Copy Graph

Copy x-y values

DrawPoint View

Shows three realizations of fragmentation in a drawpoint – see next page

Open Word Report

Current report name:

None

Heading text for report page:

Copy Results + Inputs to Report

Keep a log of your runs in a MSWord file which includes all inputs and results. Good for your final report.

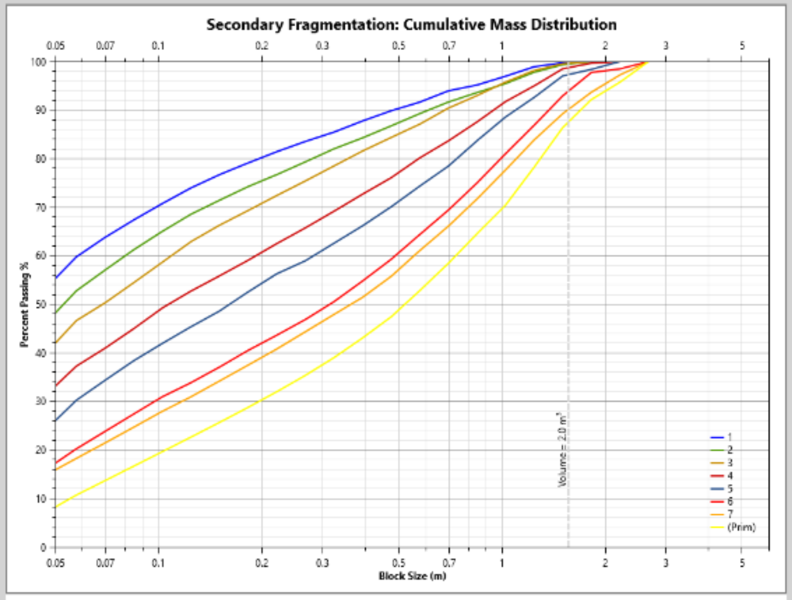
HOD = 30.0m (CSR321) Volume % at DP: Not Failed = 39.1 % Prim crushed = 34.0 % Sec arching = 0.0 % Sec splitting = 11.0 % Sec impact = 0.0 % TotFines = 15.9 % Round Fines = 6.2% Total Tonnage = 5031.0 T

Series	File	Domain	Fragments	HOD (m)	OvSize %>2m³	Num OvSize/Kt	Max Size(m)	HiHangups/Kt	LoHangups/Kt	Fines% <5cm	ResTime (weeks)	RBS (MPa)
1	Rand06m-sig48-HOD300m	Rand-only+veins	1169045	300.0	0.3%	1.1	2.00	0.0	0.0	55.3%	171.4	53.2
2	Rand06m-sig48-HOD250m	Rand-only+veins	1208371	250.0	0.7%	2.1	2.03	0.0	0.2	48.2%	142.9	53.35
3	Rand06m-sig48-HOD200m	Rand-only+veins	1254505	200.0	0.5%	1.7	2.00	0.0	0.0	42.0%	114.3	53.48
4	Rand06m-sig48-HOD150m	Rand-only+veins	1053011	150.0	1.5%	6.1	2.25	0.0	0.6	33.2%	85.7	53.65
5	Rand06m-sig48-HOD100m	Rand-only+veins	1025702	100.0	3.0%	6.6	2.62	0.0	0.6	26.0%	57.1	53.89
6	Rand06m-sig48-HOD50m	Rand-only+veins	1152452	50.0	7.1%	12.4	3.04	0.0	2.6	17.3%	28.6	54.30
7	Rand06m-sig48-HOD30m	Rand-only+veins	1057405	30.0	10.7%	12.9	3.04	0.0	2.4	15.9%	17.1	54.61
8	(Prim)Rand06m-sig48.prb	Rand-only+veins	7094353	-	13.6%		3.11			10.7%		57.6

Summary results associated with fragmentation curves plotted on the graph

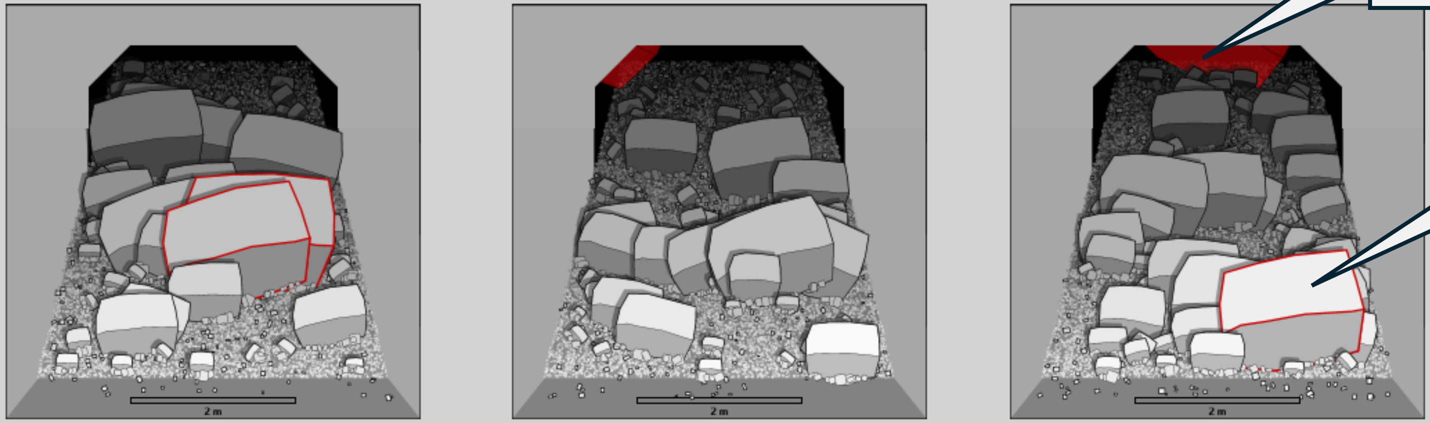
Secondary Fragmentation Run – Draw-Point View

Note: This view shows a representation of secondary fragments in three draw-points for any of the secondary result cases. This view shows blocks randomly drawn from the fragmentation distribution. Oversize blocks (> 2 m³) outlined in red.



Project : Calibration2024
Filename : Rand06m-sig48-HOD30m.sec
Domain : Rand-only+veins
Blocks : 1057405
Height of Draw : 30.0m
Oversize % : 10.7%
Oversize/1000t : 12.9
Max block size : 3.04m
Fines < 5cm : 15.91%

Drawpoint Realizations: File: Rand06m-RBS57-Sig48[1]-HOD30m.sec H.O.D = 30.0m



Blocks greater than 3 m length shown up here in red – potentially choked drawpoint

Oversize block > 2 m³ (length > 1.56 m) shown with red outline

Show miner | ReDraw rock fragments | Copy window to clipboard | Copy Drawpoints only

Secondary Fragmentation Run – Inputs View pop-up

InputView

Folder: C:\Users\gsest\OneDrive\Documents\BCFData\BCF4Testing

Primary data

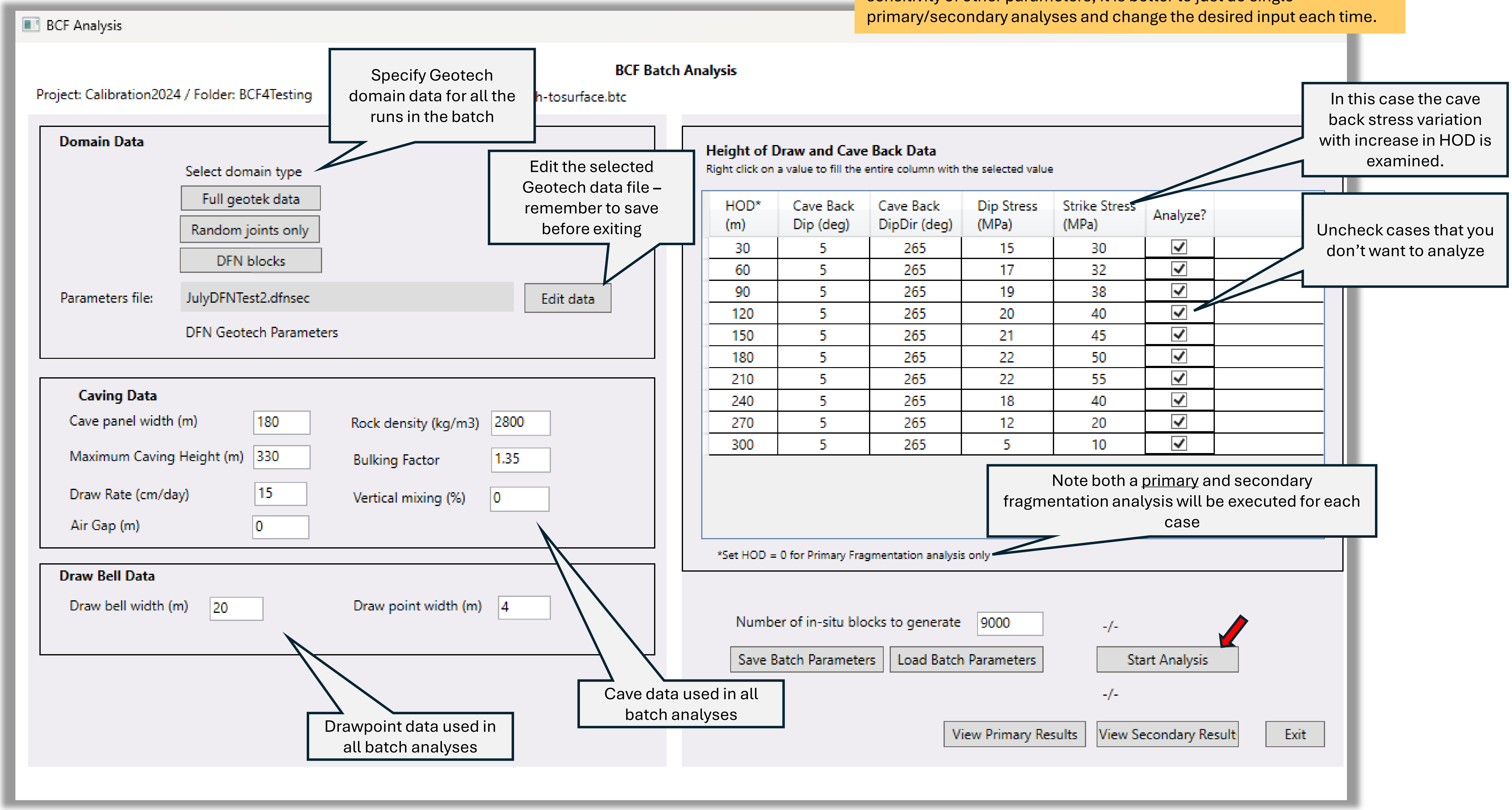
Secondary data

Scroll-Bar

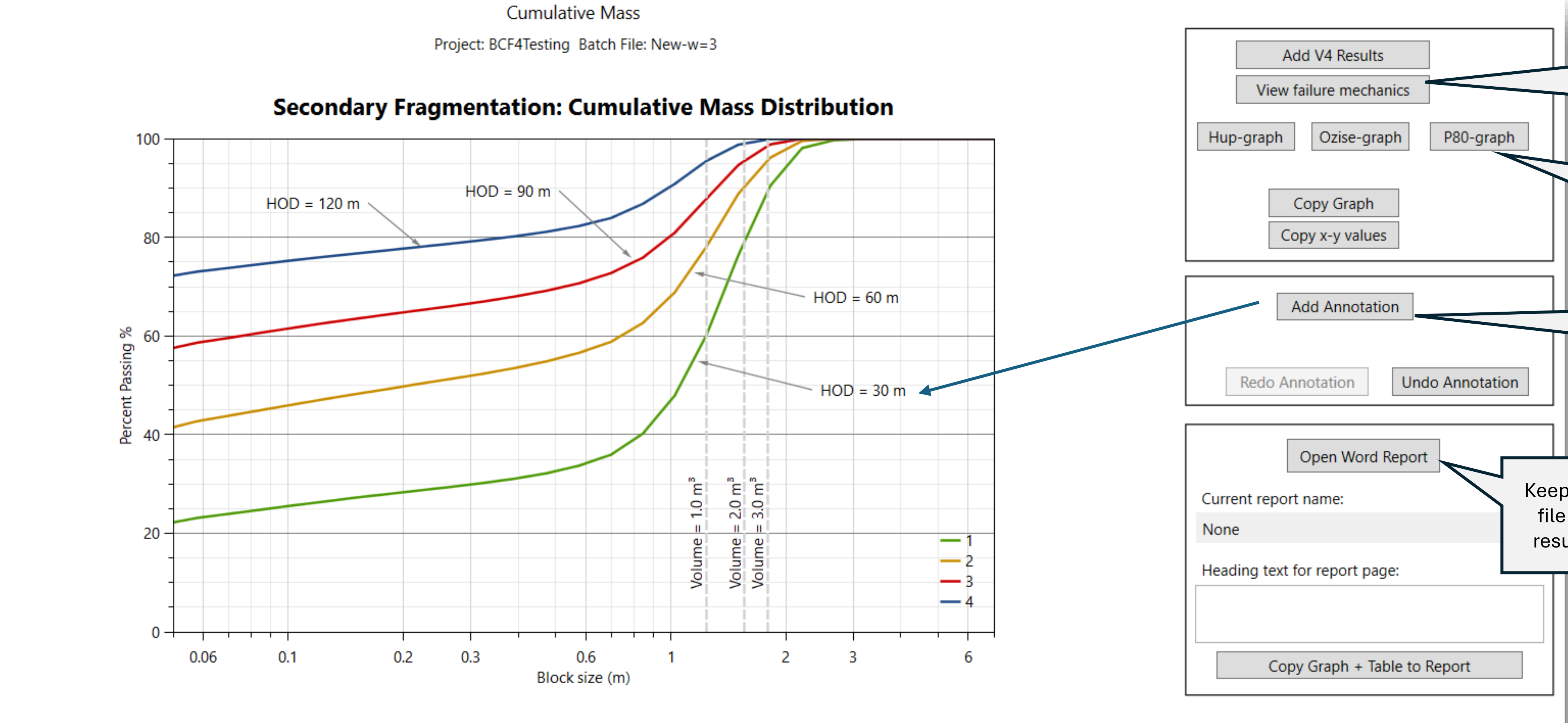
Rock Properties:	Domain	UCS	Veins/m	Veins Moh	RBS MPa	IRMR	Weath 1-5	MRMR	RQD	CoreLoss%
Series = 1	Rand-only+veins	87	4	3	57.6	60.4	5	60.4	100	5
Random Joints:	Mean Spacing (m)	Min Spacing (m)	Maxspacing (m)	Jcondition						
	0.6	0.05	5	25						
Cave Face Stress:	Dip stress	Strike stress	Normal stress	Face Dip	Face Dipdir					
	20	48	0	13.0	165.0					
Sec Frag Inputs:										
HOD (m)	Max Cav Height	Panel Width	Swelfactor	Dens	Ingress%	Drawrate	Air Gap	DPwidth	DBellWidth	
300	1500	150	1.45	2800	0	25	0	4	12	
+										
Rock Properties:	Domain	UCS	Veins/m	Veins Moh	RBS MPa	IRMR	Weath 1-5	MRMR	RQD	CoreLoss%
Series = 2	Rand-only+veins	87	4	3	57.6	60.4	5	60.4	100	5
Random Joints:	Mean Spacing (m)	Min Spacing (m)	Maxspacing (m)	Jcondition						
	0.6	0.05	5	25						
Cave Face Stress:	Dip stress	Strike stress	Normal stress	Face Dip	Face Dipdir					
	20	48	0	13.0	165.0					
Sec Frag Inputs:										
HOD (m)	Max Cav Height	Panel Width	Swelfactor	Dens	Ingress%	Drawrate	Air Gap	DPwidth	DBellWidth	
250	1500	150	1.45	2800	0	25	0	4	12	
+										
Rock Properties:	Domain	UCS	Veins/m	Veins Moh	RBS MPa	IRMR	Weath 1-5	MRMR	RQD	CoreLoss%
Series = 3	Rand-only+veins	87	4	3	57.6	60.4	5	60.4	100	5
Random Joints:	Mean Spacing (m)	Min Spacing (m)	Maxspacing (m)	Jcondition						
	0.6	0.05	5	25						
Cave Face Stress:	Dip stress	Strike stress	Normal stress	Face Dip	Face Dipdir					
	20	48	0	13.0	165.0					
Sec Frag Inputs:										
HOD (m)	Max Cav Height	Panel Width	Swelfactor	Dens	Ingress%	Drawrate	Air Gap	DPwidth	DBellWidth	
200	1500	150	1.45	2800	0	25	0	4	12	
+										
Rock Properties:	Domain	UCS	Veins/m	Veins Moh	RBS MPa	IRMR	Weath 1-5	MRMR	RQD	CoreLoss%
Series = 4	Rand-only+veins	87	4	3	57.6	60.4	5	60.4	100	5

Primary & Secondary Fragmentation Batch Run

Note: Batch runs are useful for looking at HOD and cave-back stress variations on fragmentation of a specific Geotech domain. For sensitivity of other parameters, it is better to just do single primary/secondary analyses and change the desired input each time.



Batch run results



Plot a bar chart showing failure mechanics of blocks in the draw column for each HOD in the batch run

View hangup/oversize/80% passing size for each HOD in the batch run

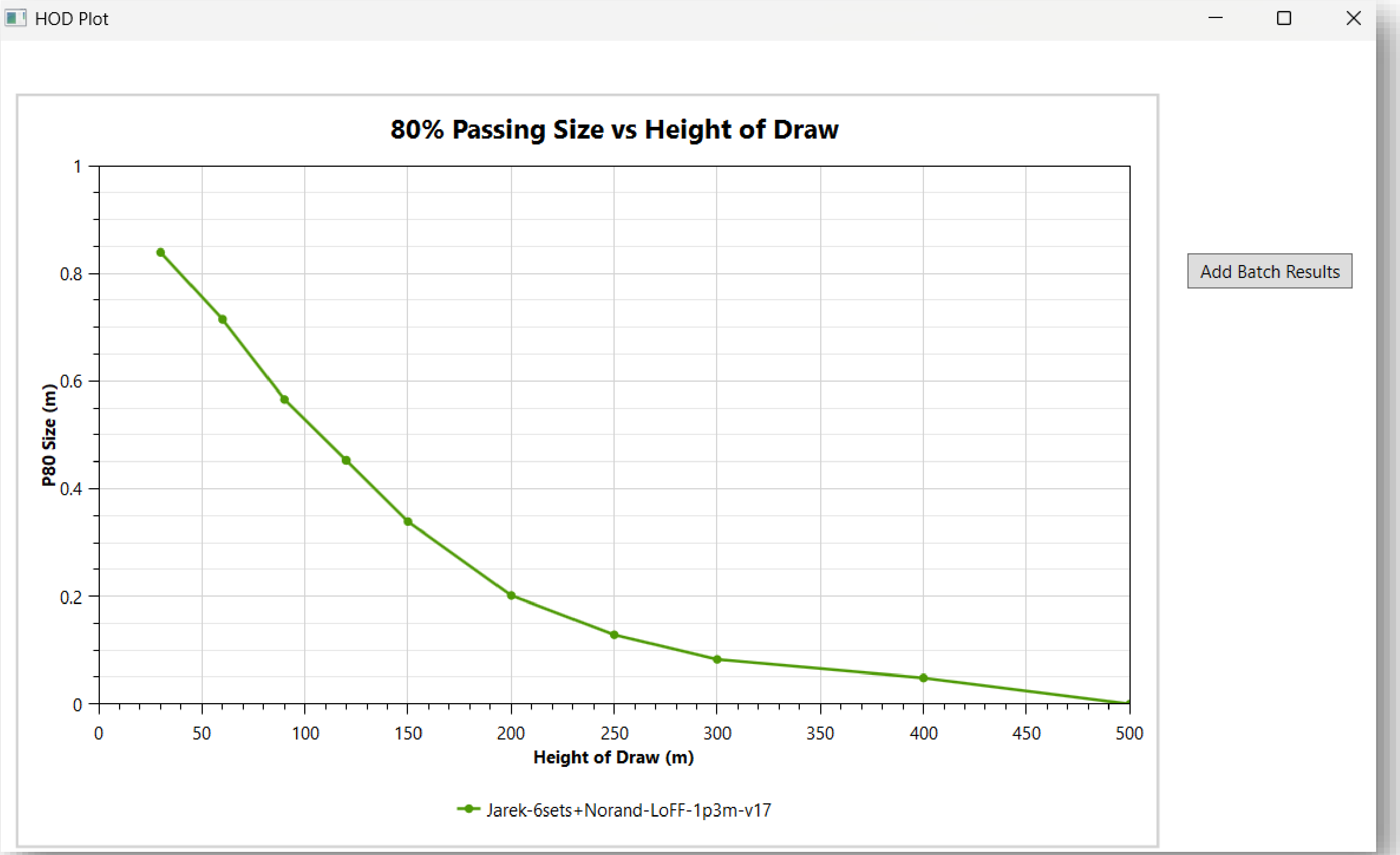
Annotations can be added to any result graph.

Keep a log of your runs in a MSWord file which includes all inputs and results. Good for your final report.

Series	File	Domian	Blocks	HOD (m)	OvSize% >2m	Num OvSize/Kt	MaxBlock size(m)	HiHangups/Kt	LoHangups/Kt	Fines% <5cm	ResTime(weeks)	RBS (MPa)
1	New-w=3[1]-HOD30m	New	1660115	30.0	23.6%	35.4	3.35	0.0	6.7	22.21%	17.1	28.1
2	New-w=3[2]-HOD60m	New	2426312	60.0	11.1%	20.8	2.82	0.0	2.4	41.50%	34.3	24.5
3	New-w=3[3]-HOD90m	New	2479469	90.0	5.3%	11.8	2.55	0.0	0.9	57.59%	51.4	22.5
4	New-w=3[4]-HOD120m	New	1726102	120.0	1.2%	4.9	2.34	0.0	0.3	72.25%	68.6	21.3

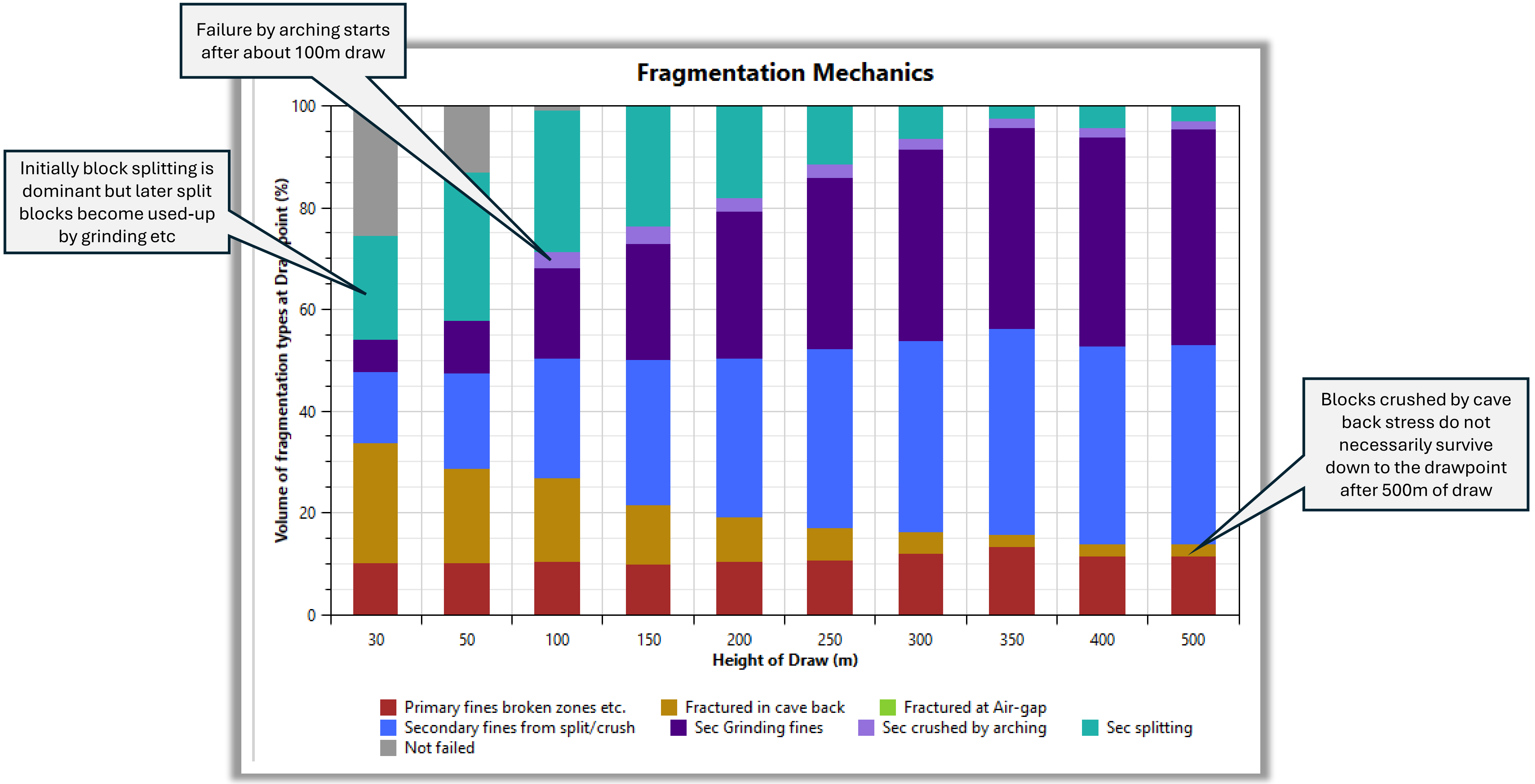
Summary results associated with fragmentation curves plotted on the graph

Batch Analysis: Change of key parameter with Height of Draw

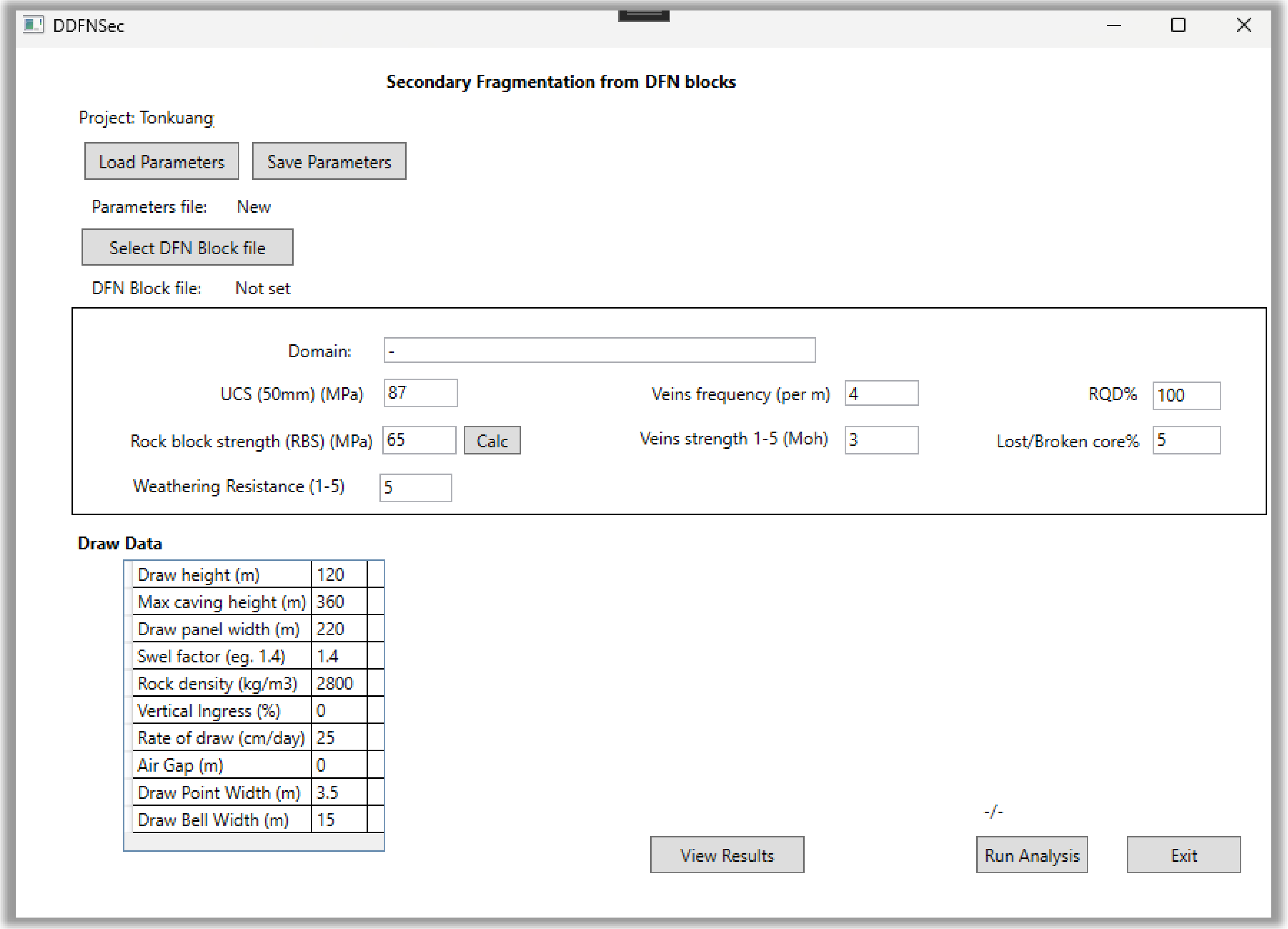


Failure Mechanics Plot

Low strength Volcanics – RBS 40 MPa with weak veins –lots of grinding



Secondary Fragmentation using DFN generated blocks as input



You can use DFN generated blocks as input. The DFN blocks must be generated and written to a text file in a specific format. The MxRap software can produce blocks with the required format.

In this screen you must define the rock mass parameters as well as the secondary fragmentation parameters. That will be applied using the DFN blocks.

Output will be a standard BCF secondary results file with associated plots.