GEM4D Creating geotechnical block models

Geotechnical block models could consist of many components, with geotechnical block and structural models arguably the most important. This tutorial discusses the creation of geotechnical block models in GEM4D Version 1.8.2.3 (which was published on 12 June 2019), and the creation of structural models will be discussed in a future tutorial. GEM4D is currently free of charge and available from the BasRock website www.basrock.net.

Although many software packages could be used for block model creation, GEM4D simplify the process for geotechnical engineers with functions explicitly tailored to our needs. However, the basic principles discussed in this tutorial is directly transferable to other software packages should that be preferred. At this time, the options for block model creation in GEM4D is more limited than commercial mine design and geological software packages, but many aspects automatically managed. The background knowledge required by the user is low, and models can be created in a fraction of the time compared to other software packages.

Figure 1 shows the naming convention of the different objects required to navigate the GEM4D interface.

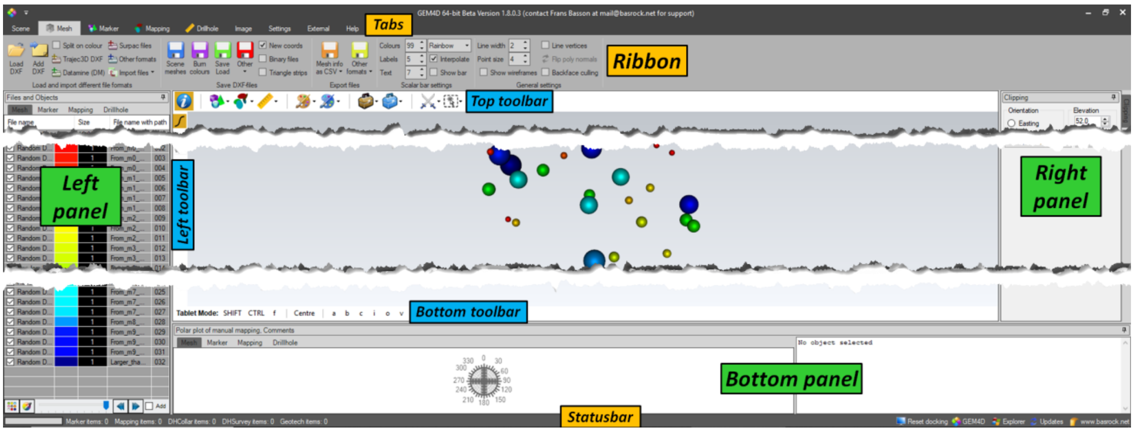

Figure 1: The GEM4D interface objects naming convention

Geotechnical block model basics

In the most simplistic form, a block model is a regular grid of coordinates with values associated with each point. Each point in the grid then represents typical values at the centre of a rectangular volume surrounding the point. In geotechnical engineering, the typical values could be obtained by interpolation from nearby data points, or manually added based on rock type properties.

The conceptual process to generate basic block models is thus a simple two-step process:

1) Create a regular grid of coordinates points around the volume of interest.
2) Assign values to each coordinate point that represent typical values for a small rectangular volume surrounding the coordinate point.

A few fundamental decisions are required when creating block models:

1) Block size and shape, which determines the number of coordinate point for the regular grid. Block model blocks can also be subdivided into smaller blocks.
2) Block model rotation to align to the orebody, as the mine does not necessarily align with the coordinate system.
3) Choose a value assignment method; which could be by interpolation of existing nearby values, or a manual assignment based on rock type or geotechnical domain.
4) The results communication method; which could be in a statistical format, or by visualisation such as isosurfaces or colouring meshes on their interpolated values (see Steps 6 and 7).

In some technical fields, much effort and consideration go into these decisions, but for the majority of geotechnical application areas, these decisions can be simplified. For example, in the current GEM4D version; the block shape is always a cube, block models cannot be rotated, and the interpolation method either inverse distance squared or nearest neighbour. All three result communication methods (statistical, iso-surface and coloured meshes) are automatically and immediately available in GEM4D when the block model is generated.

Note that block models are volumetric, and the model size is increased eightfold when the distance between points is halved, as the number of points doubles in each dimension ($2_x \times 2_y \times 2_z = 8_{xyz}$).

Step 1: Select the most comprehensive dataset

Load the values of the most comprehensive dataset from a comma delimited (CSV) text file with "***Ribbon => Marker => Load files => Text (CSV)***". The required data format of the file is **Easting, Northing, Elevation, Data1, Data2, …**, thus coordinates with associated values. In mining, this is often the geotechnical (or RQD) logging from drill core. GEM4D can solve the logging data from Collar, Survey and Logging files and extract the composite values, but drillholes are outside the scope of this tutorial, and a discussion available on the GEM4D Blog https://www.basrock.net/single-post/2017/01/06/GEM4D-Version-1740-available-for-download. If drillholes are of interest, let me know, and I can do a more comprehensive tutorial.

The values from the most comprehensive dataset form the backbone of the geotechnical block model. See Figure 2 for an example of the required format for the CSV-file, which was exported from Excel with "***Ribbon => File => Save As => Save as type => CSV (Comma delimited) (*.csv)***". GEM4D automatically adds the numerical values in front of the columns from **Elevation** onwards, and the reasoning discussed later in this tutorial.

Easting	Northing	0_Elevatic	1_Sets	2_JCond	3_JCond	4_Alterati	5_Alterati	6_Roughn	7_Roughn	8_Roughn	9_RQD	10_Q'
59928.6	9123.7	460	2	r	2	una	1	R1.5	R	1.5	70	17.5
60113.2	9105.2	340	2	r	2	sli	2	R1.5	R	1.5	80	10
59936.8	9122.2	460	2	r	2	sof	4	S1	S	1	70	2.9
60020.2	9153.5	500	2	r	2	una	1	R3	R	3	70	35
59938.8	9156.4	540	2	r	2	sof	4	S3	S	3	70	8.8
59731.5	9201.4	740	2	r	2	una	1	R1.5	R	1.5	90	22.5

Figure 2: Required format for the comma-delimited CSV-file for Marker-data

Step 2: Filter the values for the area of interest

GEM4D can filter values in two ways:

1) In the data grid; when hovering the mouse cursor over a column header, a dropdown arrow appears which allows for filtering options similar to Excel.
2) Scene filtering; "***Ribbon => Marker => Marker filters => Manual***" has a multitude of manual filtering options, for example by mouse selection in the scene, of relative to loaded mesh objects and surfaces.

An easy way to filter out the relevant data for a regional block model is by loading the meshes in the area of interest with "***Ribbon => Mesh => Load and import different file formats => Add DXF***" (if the meshes are in a DXF-file). When the meshes are loaded, the mesh bounding box could be used for data filtering with "***Ribbon => Marker => Marker filters => Manual => Mesh bounds***". The "***Mesh bounds***" is a rectangular volume aligned with the coordinate system that encapsulates the visible meshes, often called a bounding box.

This method extracts the data within the mesh bounds, and the extracted data saved as a separate data file by selecting "***Left panel => Marker => Mouse right-click in the data grid => Save data as CSV-file***" from the context menu.

Step 3: Create a regular grid

Load the filtered data file from the previous step with "***Ribbon => Marker => Load files => Text (CSV)***". By checking "***Left panel => Marker => Iso-surface and Colour mapping => Iso-surface***" or "***Colour meshes***", a regular grid with 'best-guess' parameters is automatically generated. The 'best guess' parameters are selected based on the data density and spacing and normally a good starting point. The regular grid and interpolation settings could be changed with "***Left panel => Marker => Iso-surface and Colour mapping => Settings***".

After the regular grid is generated, it can be visualised by checking "***Left panel => Marker => Iso-surface and Colour mapping => Show regular grid***", and the grid point transparency and size can be changed with the slider and numeric box to the left of the checkbox. These point settings are essential, as explained in later steps.

When you are satisfied with the regular grid and interpolation settings, save the coordinates and data as a CSV text file with "***Ribbon => Marker => Save and export files => Other options => Regular grid points (CSV)***".

Step 4: Add additional values to the model

Load the file created in the previous step with "***Ribbon => Marker => Load files => Text (CSV)***". This is the basis file for the geotechnical block model, and additional columns can now be created in GEM4D or Excel. Use GEM4D for allocating parameters based on spatial domains (see Step 5 on data filtering), or use Excel to generate new columns from calculations based on existing parameter columns.

Add new data columns to the grid with "***Left panel => Mouse right-click in the grid => Add blank grid columns***" and select the number of columns to add in the "***InputBox***". Add a default value to any cell in a new column by mouse left clicking in the cell, enter the default value, and press the keyboard "***Enter***" to accept the value. Move the mouse cursor back to the same cell, and a mouse right-click in the cell activates a context menu. Select "***Copy to visible column cells***" from the context menu, which copies the default value to all the visible cells in the selected column.

Step 5: Filter data to assign values

Different values can be assigned to spatial areas of the mine by data filtering. As mentioned in Step 2, the data can be filtered in the data grid (Excel-style), or manually from the scene with "***Ribbon => Marker => Marker filters => Manual***". The available options for the manual filters are:

- "***Mesh bounds***": See the discussion in Step 2, where this method was used to extract the data around a mesh object.
- "***Relative to meshes***": An collection of advanced, but very powerful, filtering techniques that allow the filtering of data relative to mesh objects. The first two options require the correct normal orientation of the polygons in the mesh, and the third option expands the form with many more filtering options.
- "***Pick box***" and "***Pick sphere***": Define the filtering size in the pop-up form, and mouse pick on any location in the scene. The data within the defined square box or sphere is extracted, and all other data are hidden.
- "***Remove inside selection***" and "***Remove outside selection***": Selecting one of these options changes the mouse cursor to a cross. Pick anywhere in the scene (open space or on an object) for a starting point, drag the mouse to create a lines box covering the data of interest, and pick a second point anywhere in the scene to either remove or retain the data within the rectangular lines box.

An in-depth discussion of the filtering options will follow in a future tutorial if requested, and descriptions are available from the following links https://www.basrock.net/single-post/2018/10/28/GEM4D-Version-1802-available-for-download and http://basrock.co/pdf/201703%20BasRock%20Newsletter.pdf. Filter the data from a specific domain, and assign a new value to the domain by:

- Mouse left-clicking on any cell in the relevant column.
- Add a value to the cell, and press the keyboard "***Enter***" to accept the value.
- Move the mouse cursor back to the same cell; mouse right-clicks in the cell to activate the context menu and select "***Copy to visible column cells***", which copies the default value to all the visible cells in the column.

By repeating this process, values can be assigned to all domains.

Step 6: Statistical Distributions

After the relevant parameters are assigned to each column, extracting the statistical distributions are simple and quick, as GEM4D automatically calculates the value distribution and statistical parameters of the filtered data, as shown in Figure 3. Mouse right-click in the textbox, and the statistical parameters can be copied to the clipboard and pasted directly into Excel. The relevant information can thus be filtered Excel-style from the data grid, or by making use of the manual filters, and the histogram and statistical parameters directly copied across to Excel.

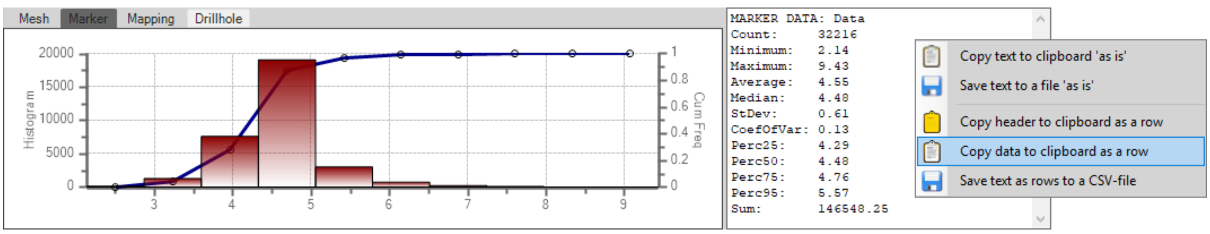

Figure 3: GEM4D automatically calculates a histogram and statistical parameters of the filtered data

Step 7: Visualise model results

All visualisations are started by selecting the relevant column number with "***Left panel => Marker => Colour mode => DataColumn***". GEM4D automatically adds the column number to the column name in the grid, for example, "***0_Elevation***", "***1_RQD***" etc. The default mode is to display the range of values from the minimum to the maximum values in the selected column, but the range can be changed by selecting "***Left panel => Marker => Colour mode => Mode => Manual***", which activate the "***Value start***" and "***Value end***" to the right for manual selections.

The results can be visualised in various ways, as displayed in Figure 4. Each visualisation method is briefly discussed below.

- **7A: GSI-observations**
  The image displays the raw observation data, but use a regular grid to colour the development meshes. Change the data markers to spheres with "***Left panel => Marker => Marker type => Shape => Sphere***", and colour the meshes on the interpolated values by checking "***Left panel => Marker => Iso-surface and Colour mapping => Colour meshes***".
- **7B: Anticipated stress conditions**
  A block model was used for this image, and the values are thus already interpolated. To avoid a second interpolation, change the following setting "***Left panel => Marker => Iso-surface and Colour => Settings => Nearest neighbour***". Colour the meshes as normal by checking "***Left panel => Marker => Iso-surface and Colour mapping => Colour meshes***". Make the regular grid fully transparent with "***Left panel => Marker => Marker type => Drag the slider bar to the far left***".
- **7C: Logged RQD-values as drillholes (left) and coloured stopes (right)**
  Creating Marker-data from drill holes collar, survey and logging data is outside the scope of this tutorial. Composites were created from the drill hole data and displayed with the stope meshes in the left image. For the image to the right, the data of the shown meshes was filtered with "***Ribbon => Marker => Marker filters => Manual => Mesh bounds***", the meshes then coloured as normal by checking "***Left panel => Marker => Iso-surface and Colour mapping => Colour meshes***". Make the regular grid fully transparent with "***Left panel => Marker => Marker type => Drag the slider bar to the far left***".
- **7D: Plan view of a single transparent grid layer**
  For this image, the data was horizontally clipped with "***Right panel => Clipping => Orientation = Horizontal***", and pressing the "***New clipping***" button. Make the data of the regular grid semi-transparent with "***Left panel => Marker => Marker type => Drag the slider bar partially to the left***", and adjust the Marker point size to fill the space between points with "***Left panel => Marker => Marker type => Shape size***".
- **7E: Volumetric display of the data**
  For this image, display all the regular grid points and play around with the point transparency "***Left panel => Marker => Marker type => Drag the slider bar partially to the left***" and point size "***Left panel => Marker => Marker type => Shape size***" until achieving the desired effect.

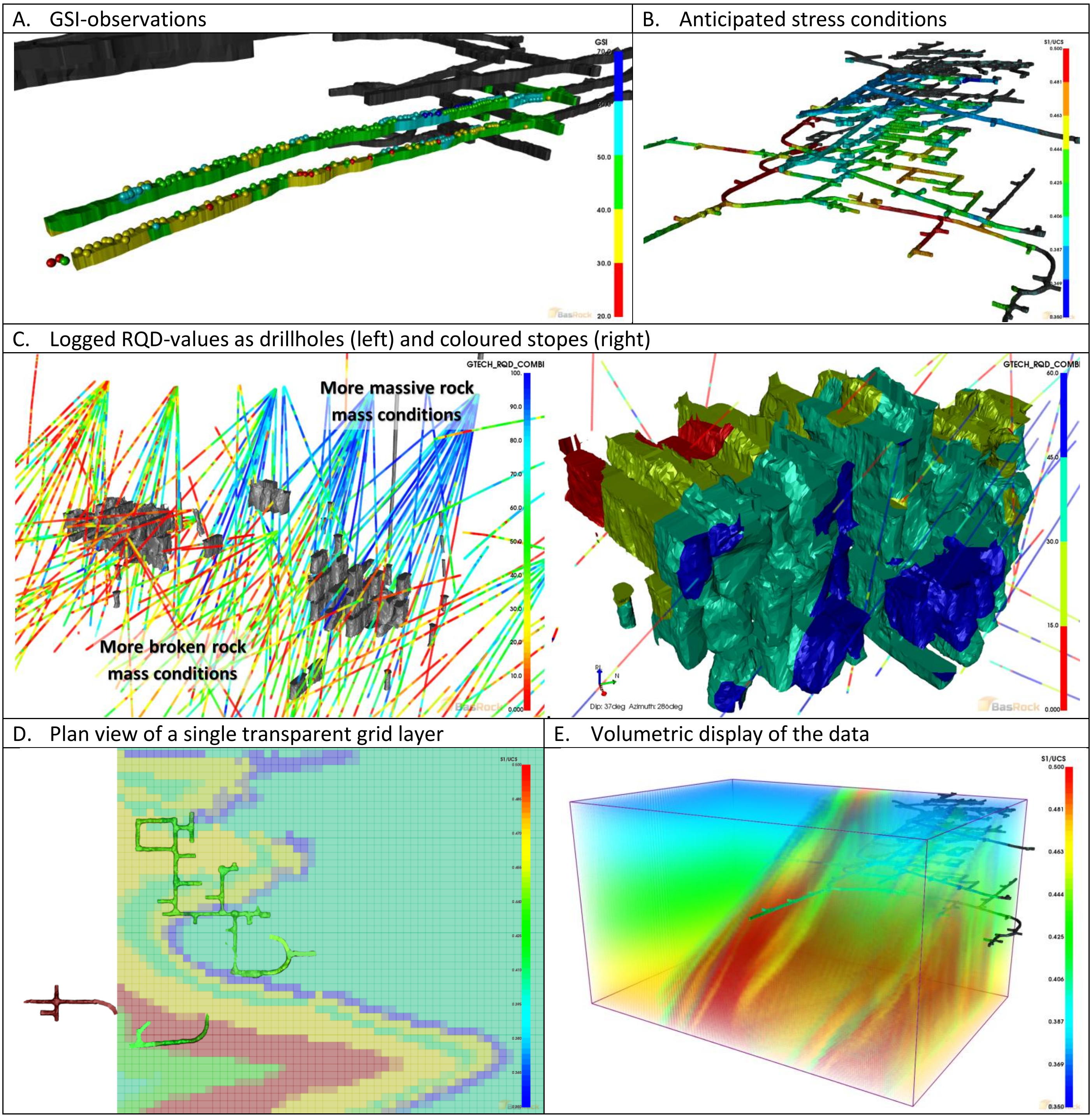

Figure 4: Different ways to visualise geotechnical data and block models