Open Pit reconciliation

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1. Introduction

In mining, reconciliation refers typically to a comparison between an actual outcome against a planned design expectation. The usual purpose is to either learn from the comparison to improve the outcome, or to quantify the deviation and determine if the result is within acceptable limits. A few examples where reconciliation could assist are:

1) Evaluate an extraction quality.
2) Highlight deficiencies in a process or process execution.
3) An objective review of conditions, outcomes, or impacts from a process change.
4) Compare areas with different processes, rock types, structural influences, time periods, stress conditions.

This discussion is focussing on reconciliation from a geotechnical perspective to determine the amount of cress loss, toe flare, and catch berm capacity. At KCGM and Boddington, the achievable wall angles are mainly dictated by rockfall management, and reconciliation a vital aspect to ensure sufficient catch capacity is maintained. Figure 1 shows the definition of crest loss and toe gain (or toe flare), which impacts on the surface area of the catch berm.
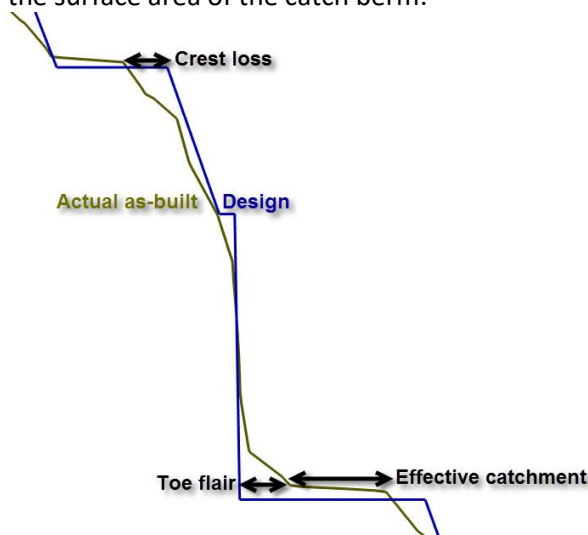

Figure 1 Schematic cross-section to define crest loss and toe flare

2. Qualitative reconciliation

Qualitative reconciliation is quick and easy to evaluate in GEM4D (www.basrock.net). Load two meshes and colour the as-built mesh with "*Top toolbar => Yellow colour palette icon => Colour on distance from mesh*", with the results shown in Figure 2A. Wall sections can also be superimposed to compare the outcomes qualitatively as shown in Figure 2B.

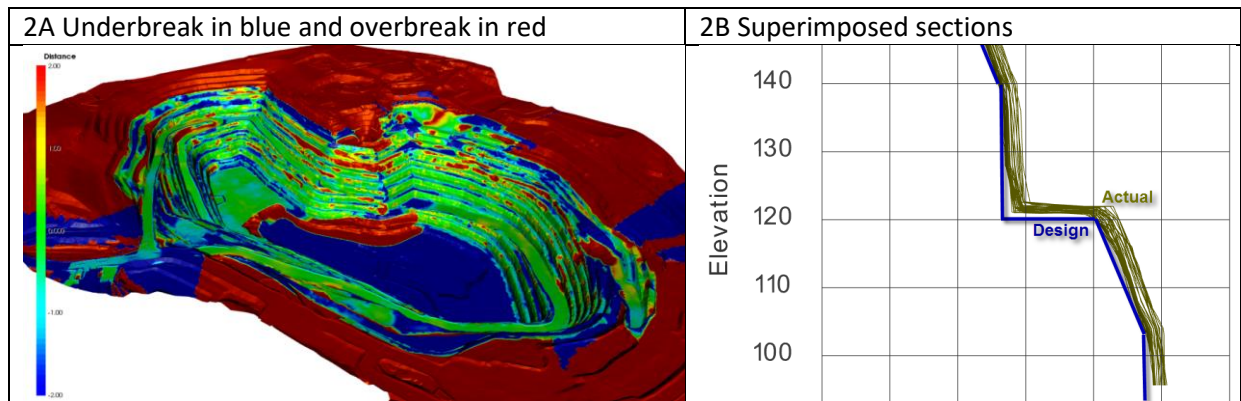| 2A Underbreak in blue and overbreak in red	2B Superimposed sections

Figure 2 Distance comparison between design and actual meshes

Much can be learnt from the visual variability techniques, but quantifying the deviations provides further benefits.

3. Quantitative reconciliation

The basic concept is to calculate a statistical distribution of the crest loss, toe gain, and achieved catch berm widths. This apparently simple task requires a number of manual steps and highly time-consuming in mine design software. A basic outline is discussed under "Traditional method" below, as the automated method will be easily understood afterwards.

3.1 Traditional method
The traditional method can be described in the four steps discussed below.

Step 1 – Select individual straight domains along a wall
The mesh has to be sub-divided into straight wall domains to enable the orientation of perpendicular sections.
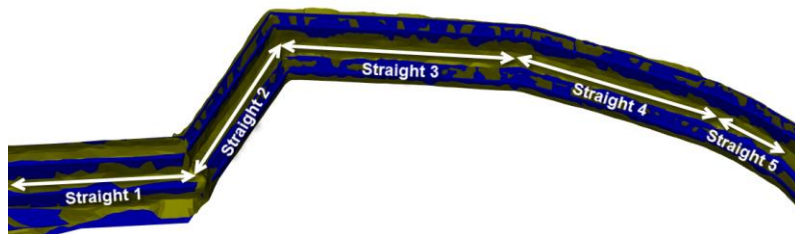

Step 2 – Create perpendicular sections for each straight domain at a set interval
Sections are created at set intervals for every straight domain. A typical interval selection is 5m, as a representative sample can be obtained and large areas covered without too many sections.
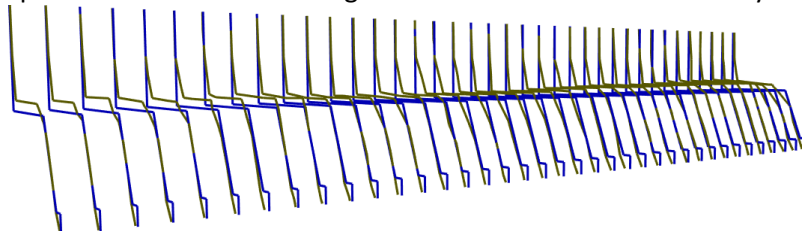
Step 3 – Mouse pick four points on every section

Mouse pick four points on each section in the exact same order; for example design toe, actual toe, actual crest and design crest.
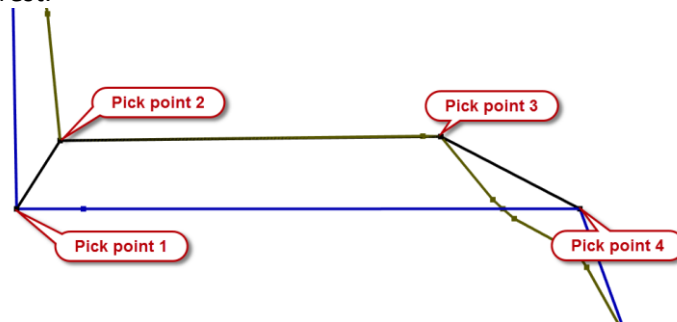
Step 4 – Manually calculate and graph the parameters of interest

From the selection point coordinates, all required distances can be calculated, and the results either graphed or spatially displayed.
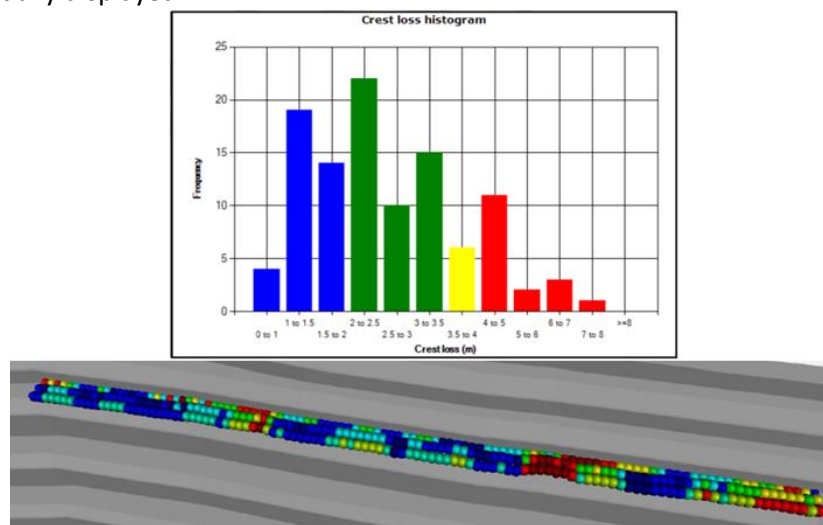
3.2 Automated method

The above method was reconsidered, and a simple solution found that automates the reconciliation process and still provides sufficiently accurate results. The automated solution was coded into GEM4D, as we have the luxury of full access to the source code with no reliance on third-party vendors.

The automated process can be done on a selected area, or a whole pit can be done simultaneously with little additional effort. The principle of the automated method is summarised in Figure 3. The actual and survey lines are subdivided into points; the design lines points are selected very close together, and the survey line points at the interval of interest, 5m for this example. The shortest distance to the design line points is then calculated for every survey point, and the value stored at the survey point location. The shortest distance will automatically be near perpendicular to the two lines, and the error can be minimised by selecting very short intervals for the design lines.
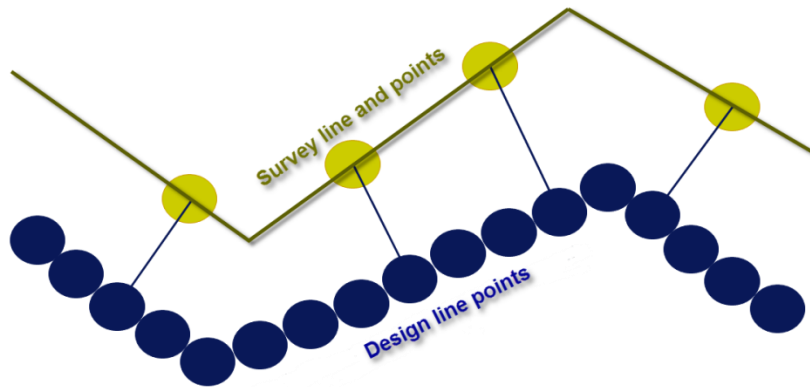
Figure 3 Principle of the automated reconciliation method

The automated method takes a few steps, but each step is quick to perform, and the whole process can be completed in a few minutes.

Step 1 – Obtain the design and survey strings
Obtain the design and survey strings for an area (or even the whole pit) and clean up the survey strings at the locations of interest.

Step 2 – Subdivide the design and survey lines
Sub-divide the design line into tiny segments, say 5cm. Sub-divide the survey lines into the interval distance of interest, say 5m. This is done by selecting the "Split lines into fixed length segments" as shown below.
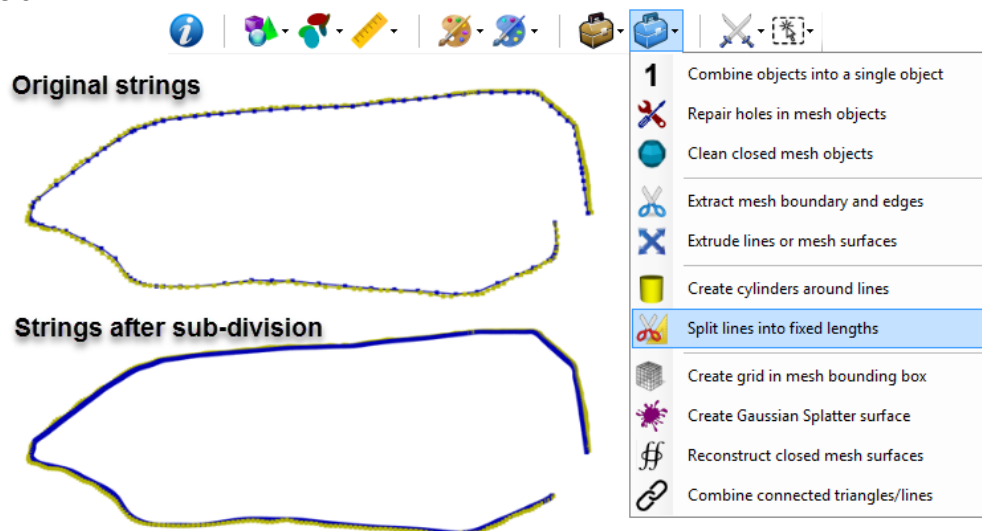
Figure 4 Strings before and after sub-division

Step 3 – Write the survey points out as a CSV-file and load as Marker-data
Hide the design string and write the survey points out as a CSV-file with "**Ribbon => Mesh => Export files => Mesh info as CSV => Poly, Line and Point vertices**".
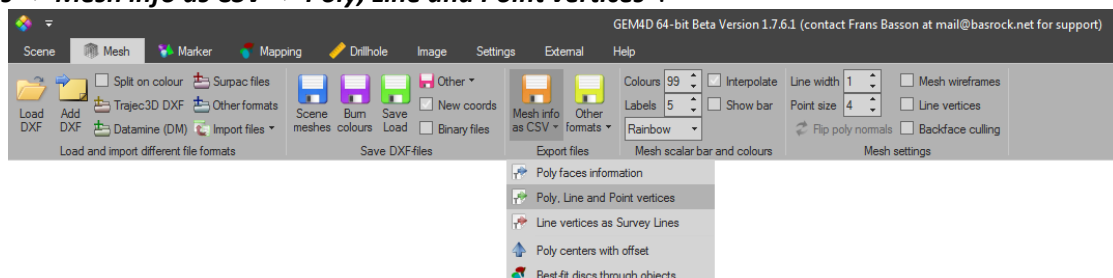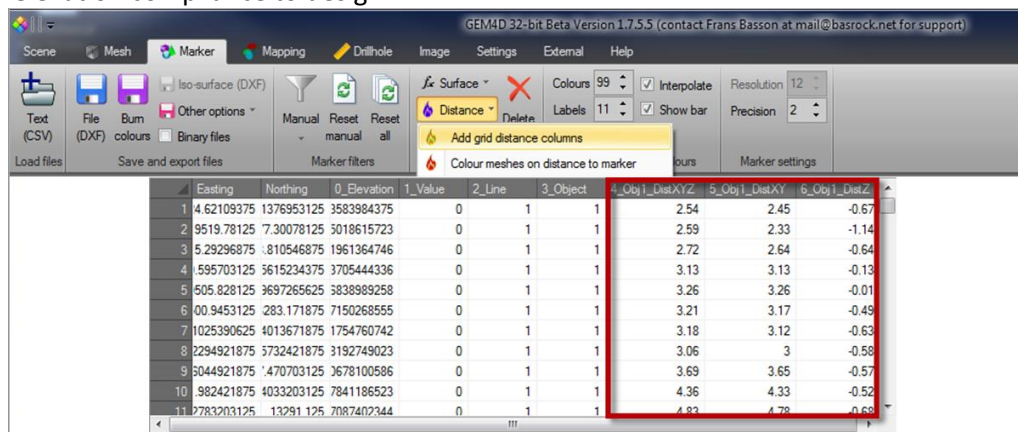
Hide or delete the survey string object, and load the CSV-file as Marker-data with "***Ribbon => Marker => Load files => Text (CSV)***"

Step 4 – Calculate the shortest distances
Select "***Ribbon => Marker => Marker actions => Distance => Add grid distance columns***", which calculates the shortest distance between each marker point and the design points and adds three columns to the Markers grid:

1. Obj1_DistXYZ – 3D distance between the two points.
2. Obj1_DistXY – 2D distance between the two points. This is the plan view distance and of interest for our discussion.
3. Obj1_DistZ – Z distance or elevation difference. This can be used to assess the bench elevation compliance to design.

3.2.1 Post Processing of Data
The histogram chart and statistics of each selection is automatically updated with the filtering within GEM4D, and the spatial colour coded spheres could be generated as shown in Figure 5. The data can also be exported as a CSV-file to be analysed in greater detail.
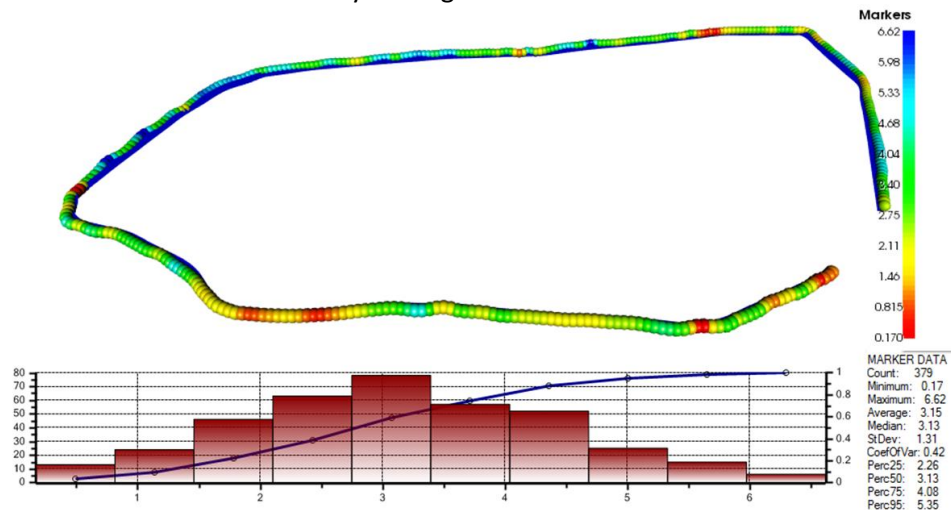

Figure 5 Result from the GEM4D interface

Data can be manually filtered within GEM4D for a more detailed assessment. Examples currently employed at NBG include lithology, design angle, shot number and wall domain.