❖ OPENING SIZE AND ORIENTATION

In competent rock masses, where rock mass failure is not a dominating factor, failures are described by geologic structures. If the forces imposed on the block are sufficient to overcome the shear strength mobilized along the discontinuities, failure occurs. Whether these structural blocks are described by discrete structures or by families of structures, failure modes are similar.

➢ *Wedges and prisms*

By far the most common structurally defined failure in hard rock mining is the wedge or prism. In this case, either a wedge (three sided) or prism (4 or more sides) is defined in the excavation boundary by geologic structures.

Failure is by one of several modes. These are:

- unidirectional sliding along one plunge line (two faces);
- rotational sliding on one face, and;
- simple detachment under gravity action.

The latter is only applicable in the back (or crown) of an underground opening when the wedge or prism opens downwards.

Innumerable dissertations exist on the analysis of wedge failure. Hoek and Brown, Brady and Brown, and Goodman's work are all good references regarding this topic.

What is important when considering such failures is that:

- a good understanding of the potential shapes and forces involved is understood. An analysis as conducted in Figure H1 utilizing DIPS and UNWEDGE (RocScience) is highly recommended. In some cases, an adjustment of the opening shape is all that is required to reduce or alleviate problems with wedge failure;
- wedge failures increase in volume roughly as the square of the span, thus a minor increase in span can have a substantial impact on the volume of rock to be reinforced (Figure H2);

All of the above can be analyzed statistically in a fashion similar as that utilized for our slope stability designs. Rock mass designs can be conducted in a similar statistical fashion.

One useful diagram for determining maximum span is attached as Figure H3. Statistical analysis of the rock mass properties allows an estimate of the ranges of unsupported spans that may be attained.

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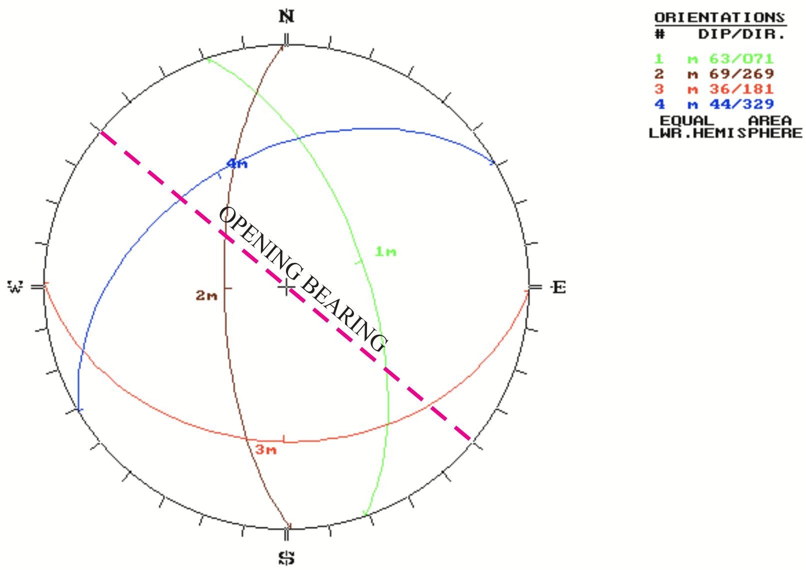
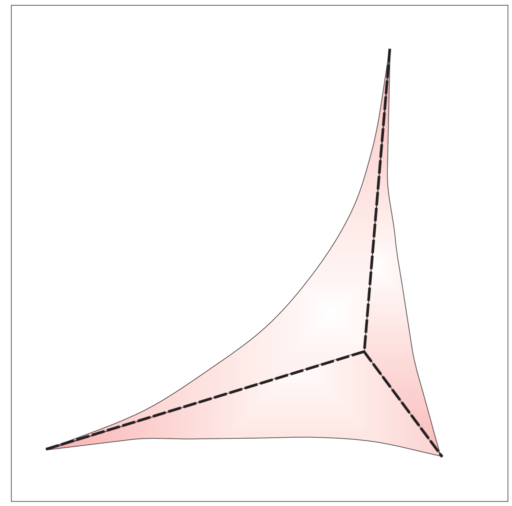
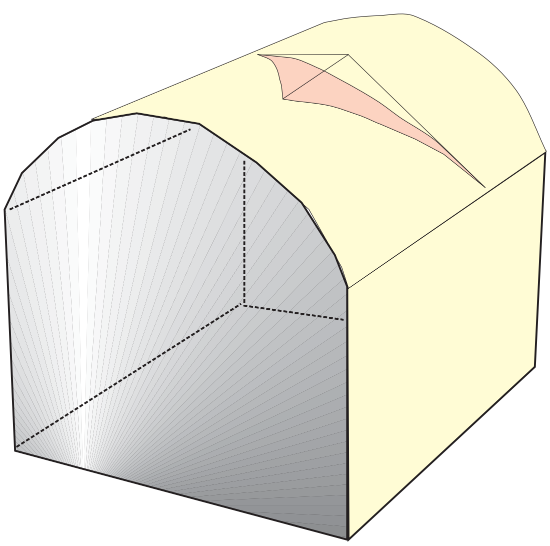


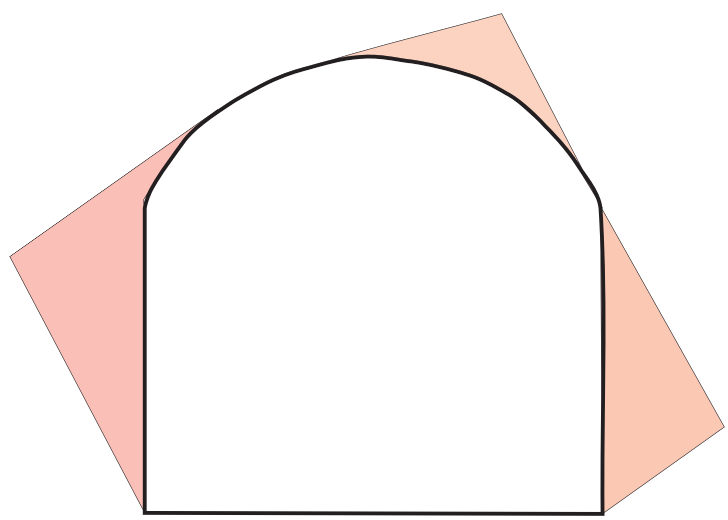
Potential structural orientations



Isometric of wedge, looking down



Isometric - back only



Section - looking along axis

Potential wedge failure geometries

FIGURE H1

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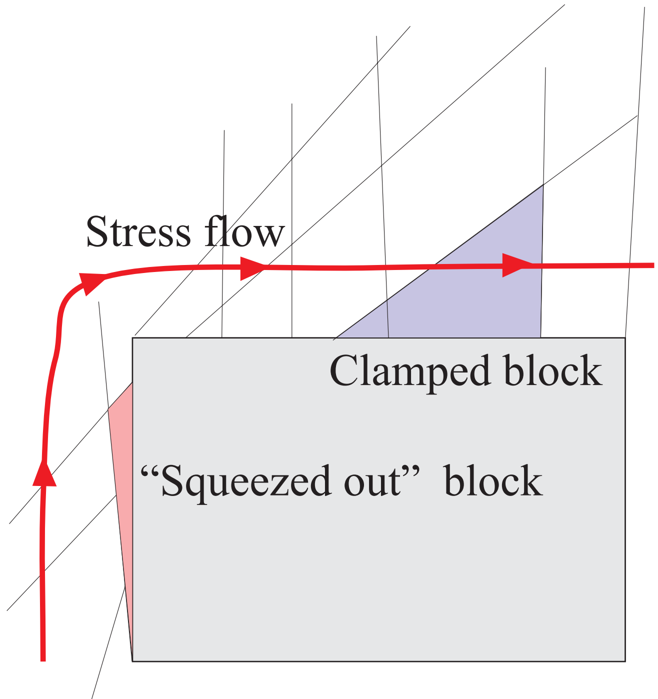
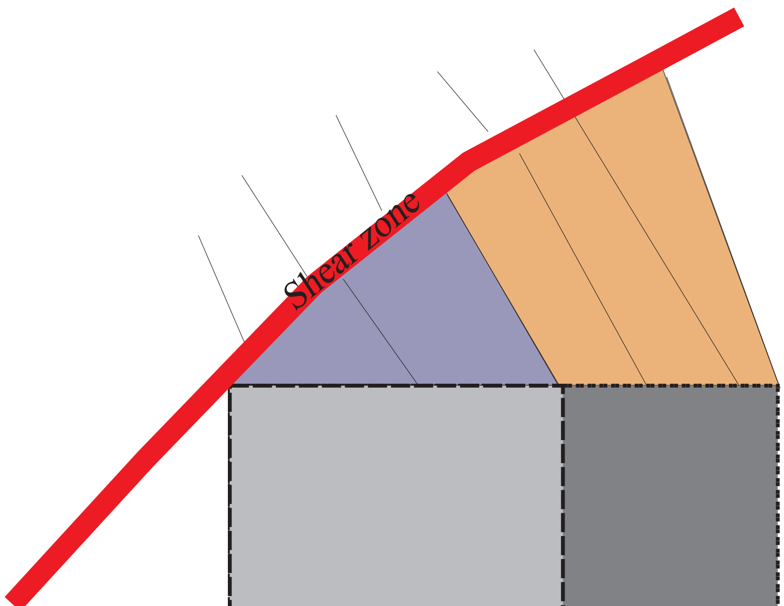


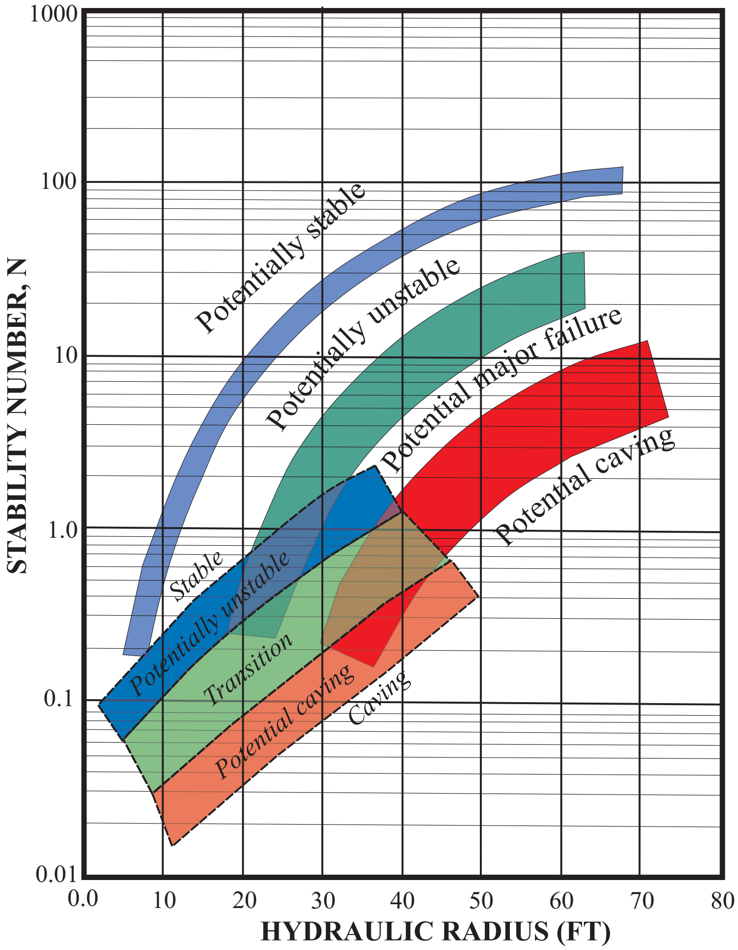
Schematic of clamping stresses



Increase of wedge volume
as opening size increase

After Hutchinson and Diederichs, 1996

FIGURE H2



TRANSITION ZONE KEY

- potentially stable - potentially unstable, modified Mathew's method
- potentially unstable - potential major failure, modified Mathew's method
- potentially major failure - potential caving, modified Mathew's method
- potentially stable - potentially unstable, Laubscher's RMR converted to N
- potentially unstable - unstable transition, Laubscher's RMR converted to N
- unstable transition - potential caving, Laubscher's RMR converted to N

Note:
This chart has been designed utilizing Stewart and Forsyth's modification of Mathew's method (CIM Bulletin, July 1995) as well as Laubscher's (1990) MRMR stability system converted to the Q system for comparison/useage. Both presented methodologies are limited for design in weaker rock masses.

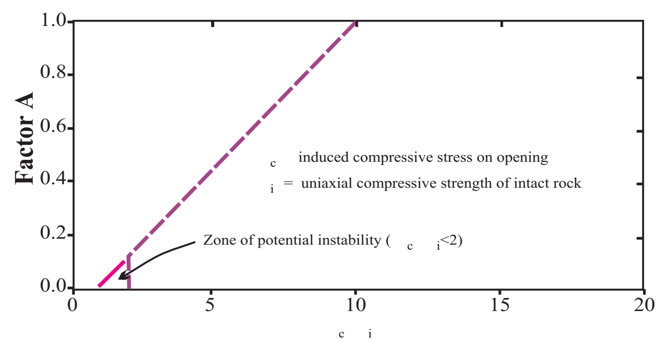
Laubscher's MRMR can be converted to Q', as utilized in N, the stability number by the following equation:

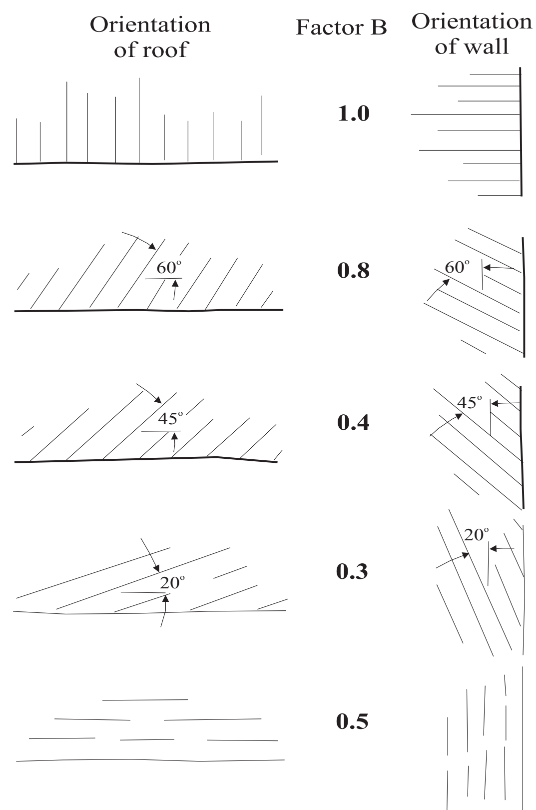
Q'=10^((RMR-42.52)/19.92)

The RMR used in this equation should not be adjusted to MRMR with the exception of blasting conditions. This is due to the fact that the orientation and stress adjustments take place within Mathew's graph. This is also the reason behind extracting the stress reduction factor (SRF) from Barton's Q value to obtain Q'. It must also be noted that the conversion equation given above is not the standard conversion from Q to RMR. It has been modified to compensate for the lack of an included SRF in Laubscher's RMR data collection.

Q' = Q*SRF

N = Q'*A*B*C





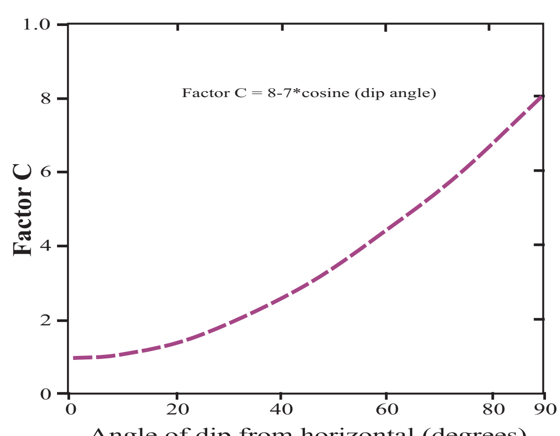


FIGURE H3

Diagrams taken from Stewart, S.B, and Forsyth, W.W; The Mathew's method for open stope design; CIM Bulletin, July-August 1995.

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