❖ CATCH BENCH DESIGN

No wall design is complete without a catch bench. A catch bench is simply a cut bench on the rock slope. Its sole purpose is to "catch" rocks so that they do not continue unhindered to the toe of the slope or away from the base of the rock cut. The bench is designed with a specific width relative to its height so that rocks will come to rest before falling off the next crest. In addition, a "backbreak" distance is incorporated into design as the bench crest will often fail from its (usual) vertical position. The design catch bench width is thus always wider than the bench width required for safety (Figure C1).

How do we determine the profile and design width of the catch bench? As was mentioned in the introduction of this article, this specific topic has been the subject of theses. To attempt to completely cover the topic here would do injustice to the complexities of the design process. However, we have more information at-hand regarding the actual bench face profile than would normally be available. This gives us a tremendous advantage in terms of designing an effective catch bench.

Our information database includes:

- the complete bench face angle distribution;
- the amount of material lost off of the crest at any one point, including the backbreak into the catch bench as well as the profile down the slope, and;
- if desired, the block size distribution of the rock mass.

➢ Catch-bench profiles

The catch-bench profile is what determines the runout distance of rock falling from the bench face above.

A multitude of catch-bench profiles are available to the designer. For example, some bench profiles, listed in order of maximum to minimum expected bench runout, are:

1. Horizontal, run of mine clean-up (no retarding material on bench surface) This has the longest runout and is the widest bench. This is typically what is encountered in mining applications;
2. Reverse incline (dipping back from face towards toe) with run of mine cleanup. This is a relatively novel design. It would probably not be a good choice in areas experiencing high rainfall as it may channel water into the bench. However, for some areas it is quite useful. An incline of about 1m vertical:10m horizontal provides a substantial reduction in rolling rocks escaping the catch bench;
3. Horizontal, with a catch berm near the crest of the required catch bench (see Figure 9.1). This is functional if no cleanup is required on the benches. However, backbreak through the crest

can lead to the berm being a source of rocks falling to the bench below. It also hinders face scaling and bench cleanup at later dates;

4. Horizontal, with retarding surface overlay (loose gravel, etc). This, too, hinders cleanup and scaling. In addition, in areas experiencing winter freeze, the energy dispersing properties of the loose gravel are lost if the bench ices up;
5. Horizontal, with a catch fence near the crest. These are only practical if major cleanup is not expected and is relatively expensive.
6. Horizontal, with a mesh draped slope (shortest runout = narrowest bench). Draping the face works wonders to reduce the runout zone. Once again, a costly measure. In areas of winter snow and ice, ice loads must be factored into the design. In some instances, though, it is very effective. Where little loose rock is expected, for relatively short overall slope heights, and where the steepest bench controlled slope is desired, this is probably the alternative desired.

➢ Catch bench widths

Once a bench profile is chosen, then the required catch bench width can be determined. Two methods of determining the catch bench width are recommended by the author. These are:

▪ *Ritchie's rolling rock criteria*

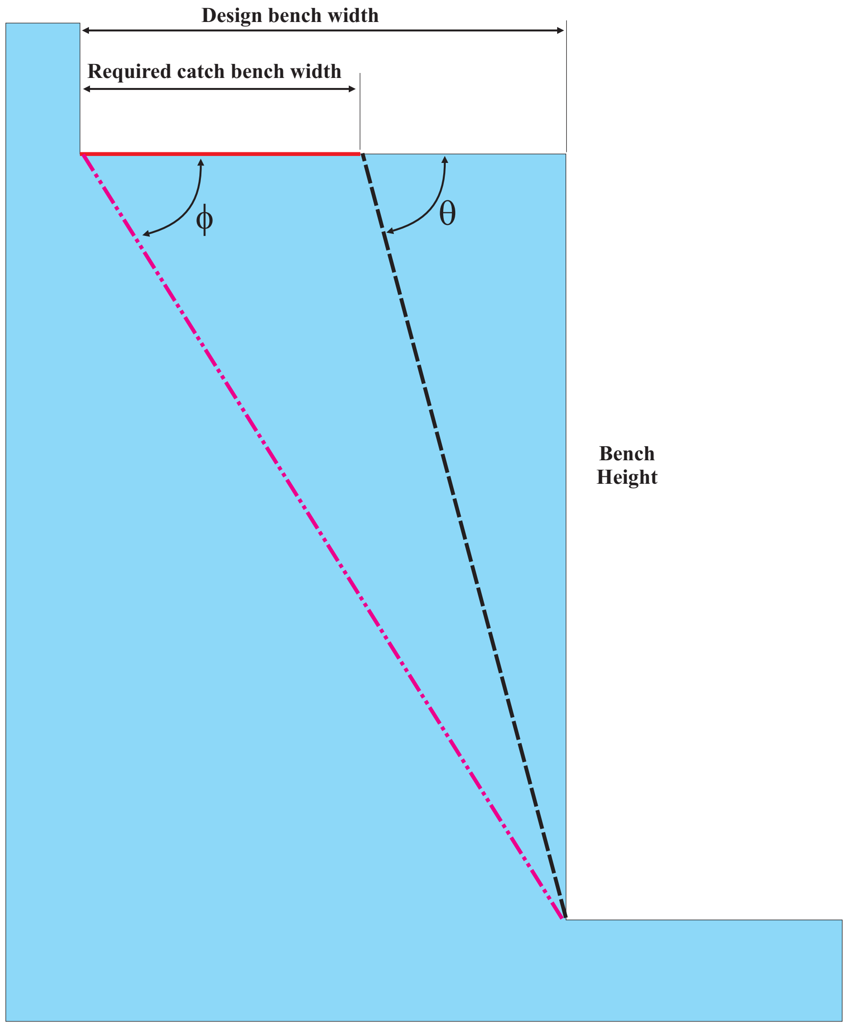
One of the first, if not the first, major efforts in determining the required catch bench width was conducted by Arthur M. Ritchie, of the Washington State Highway Commision, in the early 1960's. The study was ahead of its time. It utilized many novel concepts including video recording of rock trajectories and the rotational behavior of rock in flight between bounces. Most importantly, hundreds, if not thousands of physical tests were conducted to determine the actual run-out distance of rock traveling down a variety of slope angles with varying slope conditions.

▪ *"Bouncing" rock programs*

With the advent of computer programs that simulate bouncing/rolling rock on a slope, the ability to statistically design the required bench width took a major step forward. Of course, one of the base requirements is that the software simulating such rockfall actually models what occurs in the field. This is at times still somewhat questionable. However, rough checks can be made based on field experience and corresponding adjustments made to modeling parameters.

Given such software, we can include the actual bench profile as well as the variability of the bench crest as determined by our statistical bench face design process. While this doesn't include every lump and bump on the actual bench face that may affect the final trajectory of an individual rock, it goes a very long ways to allowing optimization of the design catch bench width.

An example is given in Figure C2. Here, the difference is shown between a horizontal bench, a horizontal bench with a berm and a reverse inclined bench.



Useful equations:

$$\phi = \tan^{-1}(h/W)$$

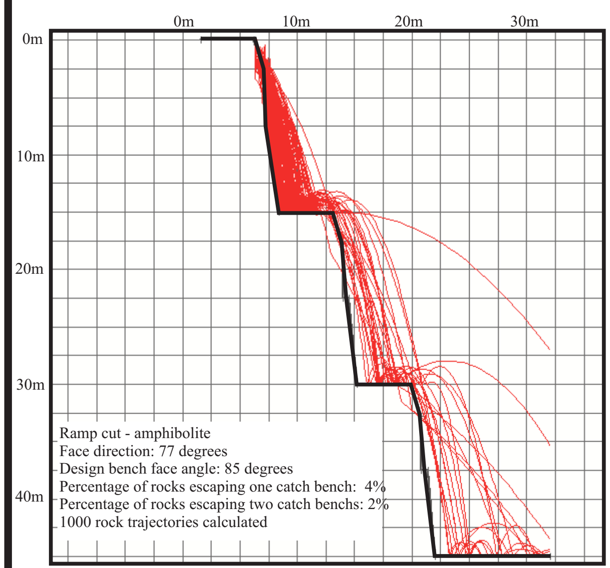
$$W = w + (h/\tan\theta)$$

Where:

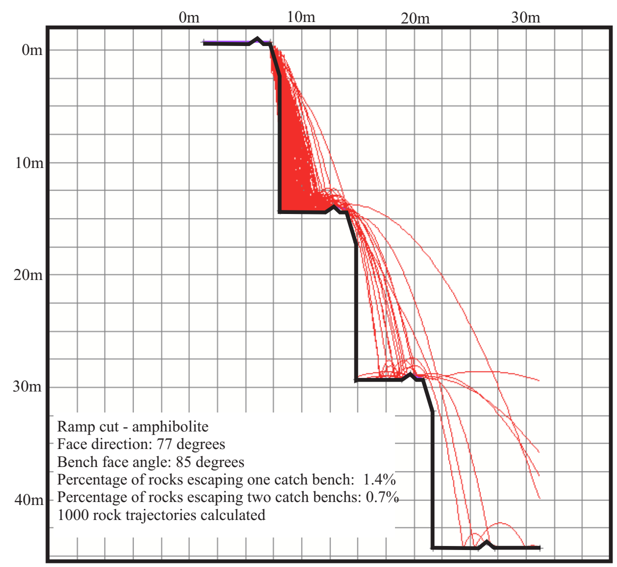
- ϕ = bench determined slope angle
- W = design catch bench width
- w = required catch bench width
- θ = design bench face angle
- h = bench height

Bench/bench face relationships

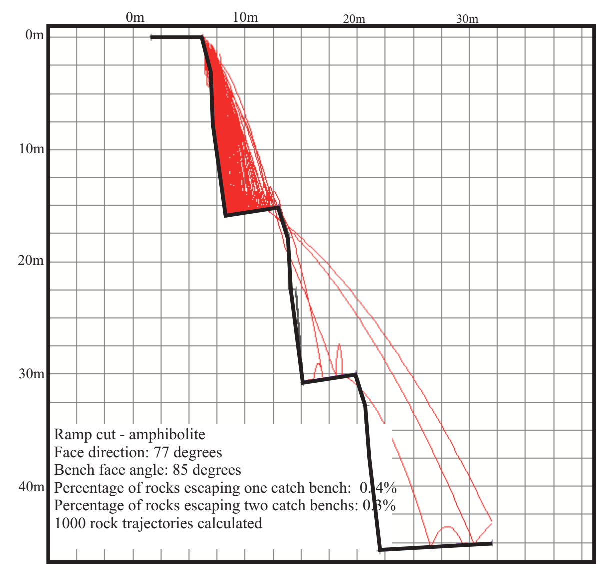
FIGURE C1



Flat bench



Crest berm



Reverse incline

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FIGURE C2

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