To use or not to use inclined holes in open pit blasting?

By Bruno Pimentel.

Hello my friends, I hope you are all well!

In our last publication we brought an article by our friend Laercio Morais, so I confess that my fingers were already itching to write for you again, I wish I could do it more often!

For those who haven't seen Laercio's article or haven't signed up for our newsletter, just click on the link below:

Português

https://www.linkedin.com/newsletters/desmonte-de-rocha-c-explosivo-6941709482355748864/

English

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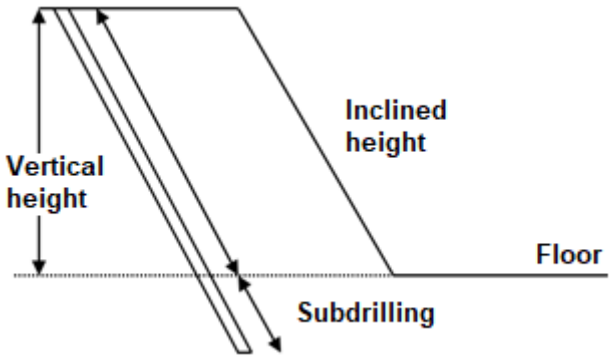
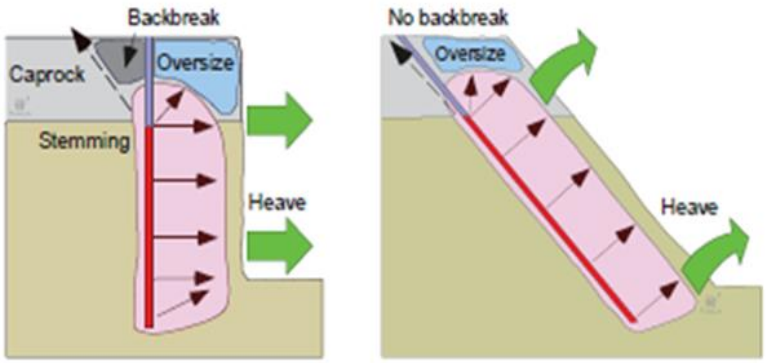
In today's article, we are going to talk briefly about a topic that always generates a lot of discussion, which is the possibility of using inclined holes in our blasting operations, because although for some operations this may seem like standard practice, others are constantly questioning whether the benefits are really worth it. the penalty in the face of operational difficulties.

Before entering the subject, it is important to warn that here we are not going to dictate rules or say what should be done, but rather we are going to raise the main points that must be observed in each operation so that it can be assessed whether the benefits found are greater than the difficulties for its realization.



In general, both theoretical concepts and practical applications have indicated that the use of inclined holes in open-pit blasting, mainly in benches, produces better results, where the main reasons for this would be:

- Charge distribution is more uniform;
- Better direction of energy to the stemming region;
- Greater foot relief;
- Better movement of material;
- Better angle definition.

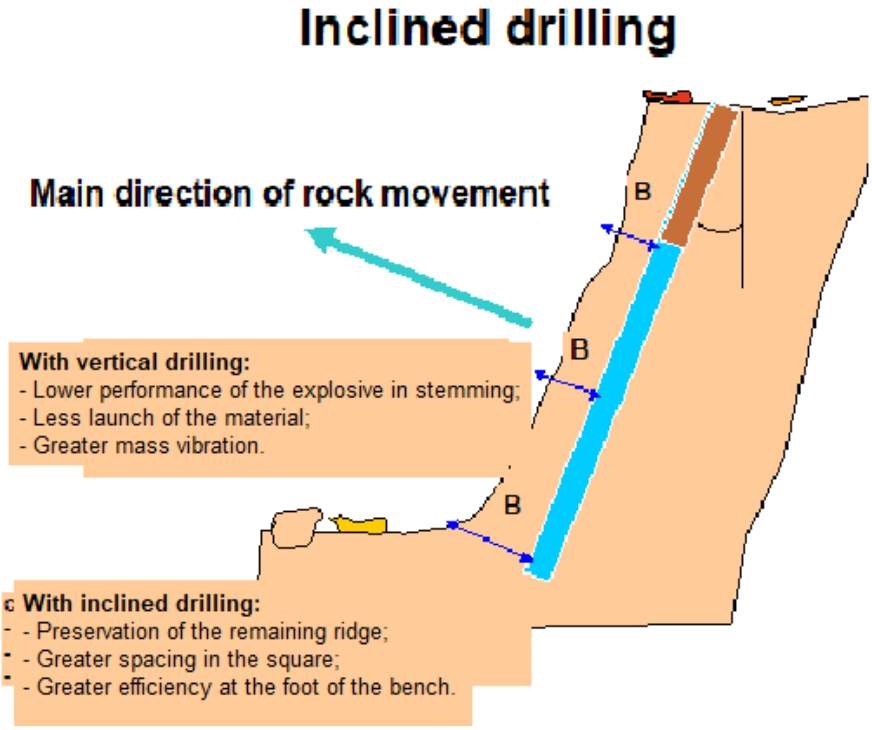


These reasons imply a series of possible advantages that will vary according to the other blasting configurations and mainly with the characteristics of the rock, and this is a very important point, since the characteristics of the rock can completely change the results. For example, even if the blast plane settings and the hole inclination are the same, we will have a completely different result if we have a change in the direction of the rock structures, in the same way that in friable rocks we will benefit much more from the greater relief and greater release of the material, while in hard rocks we will make much more use of the energy of the explosive. Therefore, it is important that, when analyzing the performance of inclined holes, we consider the characteristics of the rock, which is why the design configurations must be tested and adapted to each type of massif and scenario.

But in general, we can say that the main advantages of using inclined holes can be:

- The better distribution of the explosive throughout the rock volume contributes to a better and more uniform fragmentation, reducing the coarse fraction;
- With better use of the energy of the explosive, we also have a decrease in the possible impacts caused by energy losses, mainly a reduction in vibrations;
- The inclination of the holes also allows a greater actuation of the explosive in the stemming regions, and this not only immediately above the hole, but mainly between the holes, improving the fragmentation in this region, even reducing the number of blocks;
- The arrangement of the inclined holes and the greater relief generated in the blasting allow for greater efficiency in pulling the foot out of the bench, enabling reductions in under-drilling and the generation of feet. In many cases, the reduction of subdrilling helps to justify part of the increase in hole length;
- Increased cutting efficiency at the base of the bench also allows preservation of the bench top from the next level down;
- We have greater control over material release, with better formed piles and looser material, facilitating its excavation;
- In several situations it is possible to take advantage of the benefits generated to open a drill pattern, mainly in friable rocks and thus reduce the specific consumption of explosives;
- As the inclination adapts to the rock cut angle, we will normally have an adaptation of the spacing of the first line, as well as a better arrangement of the remaining slope;

- As the holes move more easily forward, generating greater relief along the blasting, we have a smaller action of their energy on the remaining massif, reducing overbreaks, damage to the crest and to the remaining slope;
- Inclined walls allow for greater stability than vertical ones, especially when the inclination of the holes coincides with the accommodation angle of the massif.



On the other hand, despite the many advantages, we also have a series of disadvantages when using inclined holes, and that is why it is necessary to make a careful evaluation of its use, because in some situations the disadvantages can bring much more harm than good, making so that the cost/benefit ratio can be very high. But in summary we can indicate the main disadvantages as being:

• Increase in the amount drilled, which will be directly linked to the chosen inclination, where the greater the inclination, the greater the amount perforated, which of course implies an increase in drilling costs;

• The inclination of the holes causes greater operational problems in the execution of the drilling, normally generating greater difficulties in aligning, positioning and inserting the holes;

• As a result, greater supervision, follow-up and control of the execution of drilling and loading activities is usually required, to ensure that it is following the appropriate parameters;

• In practice, despite using inclinations of up to 45°, most of the time there are several limitations and operational difficulties for inclinations greater than 20°, both for drilling and for charging with explosives, which need to be carefully considered as they can increase in much lead time and quality;

• Inclined holes are more difficult to load with explosives, especially in manual loading or when there is water in the holes;

• Most drilling rigs will experience a reduction in feed force lowering production levels and increasing costs;

• We will also see an increase in drilling tool wear;

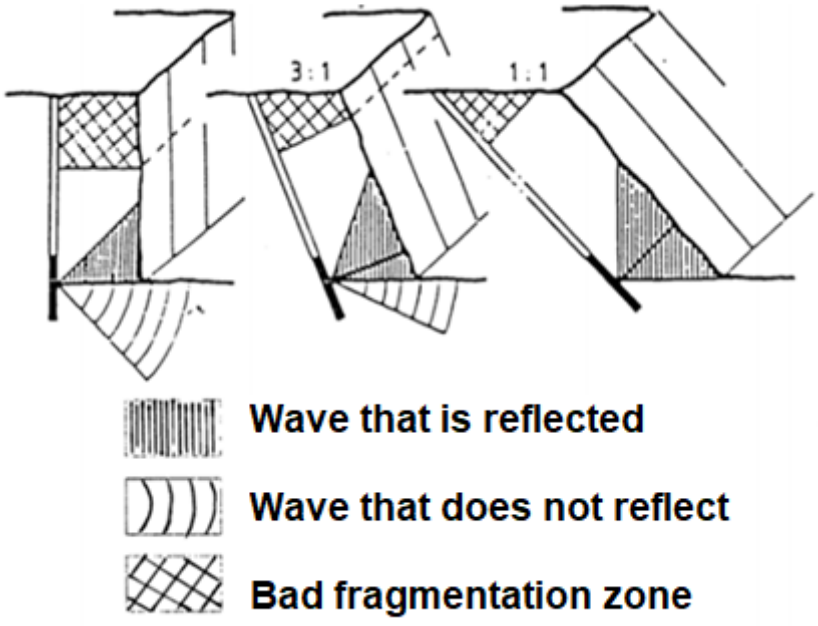
• Inclined drilling tends to present greater deviations, and this is one of the biggest problems, as deviations and errors in drilling will result in differences in the mesh and distribution of the explosive, which can impact the results and also greatly increase the potential for risk of detonation;

• Greater release of material or slope errors in the first line may imply a greater risk of flyrocks;

• Greater difficulty in exiting drilling debris, causing a greater amount to remain inside the hole, thus losing part of the depth;

• A crucial point is that the inclination of the holes must be perpendicular to the hole sequence line (note that the drilling line can be different). Ideally, the time sequence line should be the same as the drilling line and parallel to the free face;

• It is also important that the inclination follows the inclination of the bench or make adjustments in the first row to avoid large or very short burdens, in the same way it must adapt to the intended slope angle.



Along with the disadvantages, it is worth emphasizing the operational difficulties in using angles greater than 20°, because although in specific scenarios they can be circumvented, in large operations these difficulties can represent a great impact on the productivity and performance of the operation. Therefore, we need to consider the following points:

• Operational Limitations of Drilling Rigs: Most drilling rigs will decrease in efficiency as you increase the slope, increasing deviations, possibility of errors, running costs, time, etc.

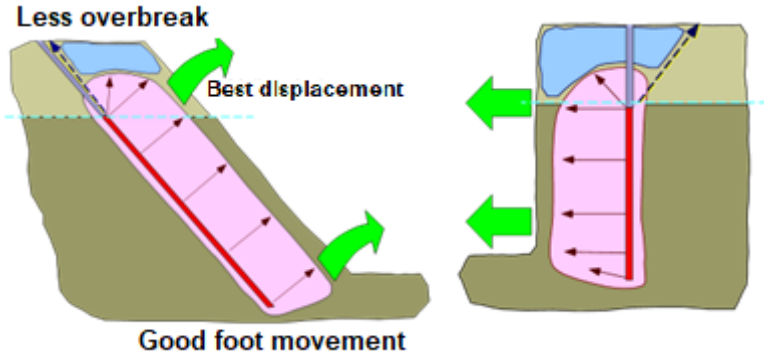
• Greater difficulty in drilling and aligning the holes: and this point intensifies as the bench conditions are not ideal, so that in uneven areas this can represent a situation with a high probability of errors and deviations.

• Inclined holes cause more wear on rods, bearings, couplings and stabilizers: this will imply both costs and the possibility of greater errors.

• They generally cause a higher level of deviation: errors and deviations should be the biggest concern in inclined drilling, as their impact can generate much more damage than potential benefits, so a basic parameter that must be analyzed with great care for the Determining whether or not to use slope in holes is the ability to maintain accuracy.

• Slanted holes are more likely to collapse: this intensifies with the angle, as the upper part of the hole wall loses its natural support, and especially in friable or fractured rocks, it is common for material to fall off the hole walls , causing depth loss as well as creating larger voids along the hole.

• Difficulty in manually loading very inclined holes: the greater the inclination of the holes, the greater the difficulty in carrying out loading, where it is often necessary to use guide rods to take the explosive to the bottom.



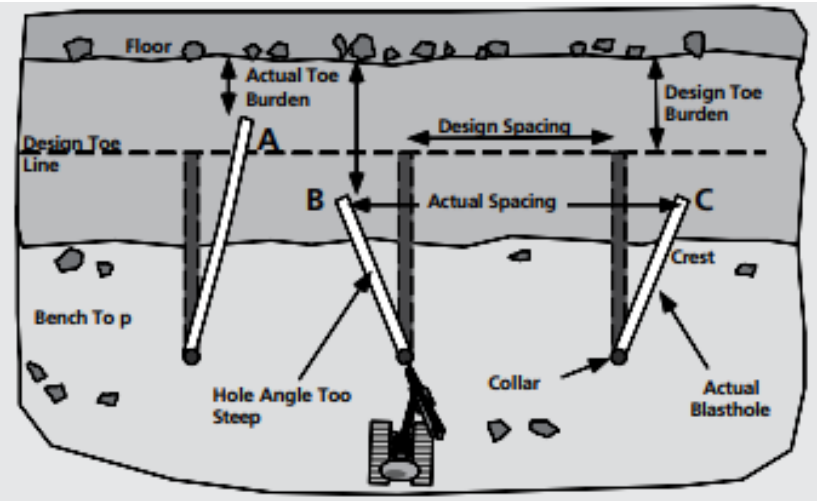
Another point that we need to be very attentive to when using inclined holes is their alignment (direction), as a wrong alignment will eliminate any advantage of the inclination, and most of the time will create a scenario of losses much greater than any potential benefit. . That's why it's important to be mindful of the fact that angled holes require an accurate and reliable drill alignment system to ensure the hole is going in the right direction.

In the next figure we see some possible alignment errors:

• Hole A with very small spacing on the foot;

• Holes B and C with very large spacing in the foot;

• Hole A and B too close, and holes B and C too far apart.

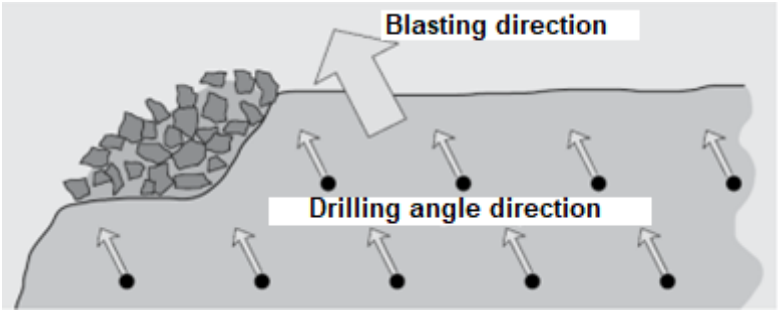


It is very important that the sloped holes are clearly oriented with proper alignment, following the slope of the free face or more precisely the material release direction.

Imagine the scenario that we have the hole aligned forward, and we are going to direct the detonation to one of the sides, what will happen is that the hole will exit laterally, completely losing the advantages of the frontal inclination, so we need to draw the alignment oriented according to the sequencing of holes and that this should be a constant direction throughout the entire blast.

Ideally, the direction of the holes should be defined in advance, together with the design of the blasting sequencing, and although in practice in most operations the sequencing is determined after drilling, in these cases it is recommended to make a timing following the alignment, otherwise we lose the advantages of the slope and we can have very unpredictable performance.

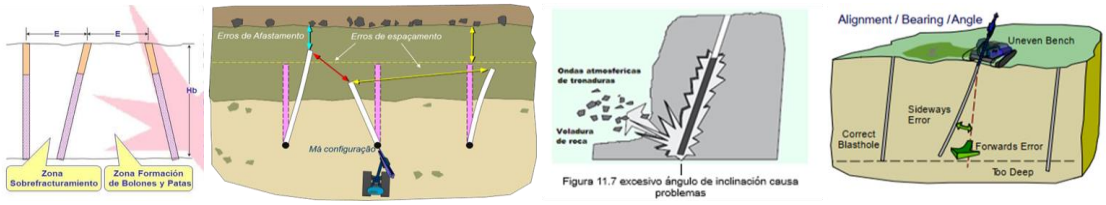
When the alignment and sequencing of the holes follow the free face direction we generally have better results, as we take advantage of the draft along with those provided by the existence of a good free face. On the other hand, when the sequencing does not follow the free face or the alignment of the holes, we will have holes completely out of direction and the results can be very unpredictable, increasing the risk of impacts and worse results.



As we have already mentioned, the greatest concern with inclined holes is precision, as errors can be much more harmful and dangerous, and for this reason the practice is often avoided, and this is without a doubt the first point that must be considered before taking measurements. any decision. Because if we cannot guarantee the accuracy and quality of the inclination and alignment of the holes, it is better not to test it, as this is a basic prerequisite for making any decision in this regard.

For example on a bench with a height of 15 m, errors of 1° in the slope can result in errors of 0.5 m in the foot, and can mean a great impact in the detonation, mainly in small holes or when they are in the first line next to face free. Likewise errors in alignment, and it is very common to find errors well above 1° and this implies huge deviations for any scenario.

It is important to take into consideration that the main causes of errors are associated with rock characteristics, operational errors and equipment conditions, so we need to evaluate each of these points very carefully.



So, as we commented, our objective today is not to reach any conclusion, just to raise the main themes regarding inclined holes, but to finish our article today, we leave here some final considerations that we believe are important:

• It is generally agreed that when it is possible to perform a quality inclined drilling, it brings more benefits to the results, and in some occasions it can be used as a way to improve results or to lower costs by optimizing some other element of the plan, for example use a bigger stemming, increase the mesh a little, decrease subdrilling, etc.

• Inclination is more commonly performed in smaller diameters, due to the flexibility of the equipment, but it can be used in any conditions, as long as the equipment has this function and possible improvements are identified that justify its use.

• The inclination can also be used in blasting without free face, seeking the possibility of a greater vertical release of the material. Even some bank opening techniques will suggest an initial opening inclined to open a first free face to be used during the detonation.

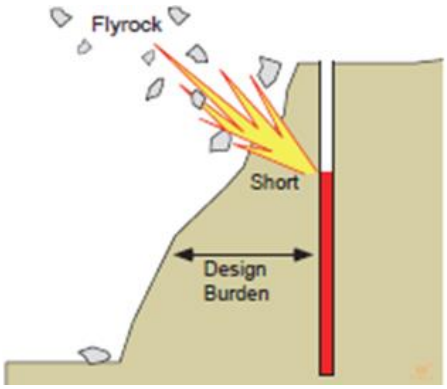
• We must not forget to analyze the characteristics of the rock, because, for example, on one side of a mine shaft, the inclination and direction of the holes can coincide with the rock structures, while on the other side, they can have opposite directions, and this will directly impact blasting results and slope efficiency, so we may use slanted holes on one side and the other vertical, or we may have to change the direction of the holes.

• It is worth remembering that we always have two options with regard to the benefits, it is to continue with the configuration to take advantage of the advantages obtained or to optimize other parameters, such as expanding the drill pattern or reducing the sub-drilling, seeking savings and maintaining the same standard result, for this, it is necessary to weigh the extra costs of inclined drilling against the savings generated by optimizing the plan.

• Some operations will use inclined holes to follow a better inclination of the angle of repose or breakage of the rock, either to adjust the holes in the first line to the free face or to ensure the cut at the angle of repose of the remaining slope.

• Also some operations may use only a few lines close to the free face or slope to achieve this, leaving the rest of the blast with vertical holes.

• In situations where the free face can be very irregular, the inclination of the holes in the first row, or in some rows, can help adapt the load, avoiding large distances at the foot of the bench or even situations of potential risk due to premature escape of gases on the face.



Well that's it my friends, let's stop here, the idea was just to arouse curiosity and leave the topic up in the air, so that you can assess the characteristics of your operations, as well as for those who are not in the day to day to have a better idea clear understanding of the complexity of the subject, since many of the advantages and disadvantages cannot be easily measured, so this is usually a difficult decision to be taken and needs to be well evaluated, followed by several tests, so that an adequate decision can be made for each scenario.

I've seen some operations that used inclined holes, but that were causing much more damage to the operation, as well as others that would clearly benefit, but they didn't because they never considered the possibility, so there are many opportunities for improvement, what we need is to identify them and analyze each one of them properly.

As we always ask, please comment and share, so that we have increasingly safe and quality detonations!!!

We hope that these articles are being useful and that if you have any examples to share or any comments that please do so, that way we all contribute together!

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