Comentários sobre o Desmonte de Rochas com Explosivos

Evaluation of the pre-split results

Por Bruno Pimentel.

Hello my friends, welcome to a new newsletter article on rock blasting, and I hope everyone is doing great!

As always, we leave here the links to the Portuguese and English versions so that those who haven't yet can subscribe and receive automatic notifications for each new article, as well as for you to check that you haven't missed any articles:

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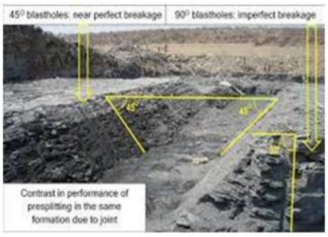
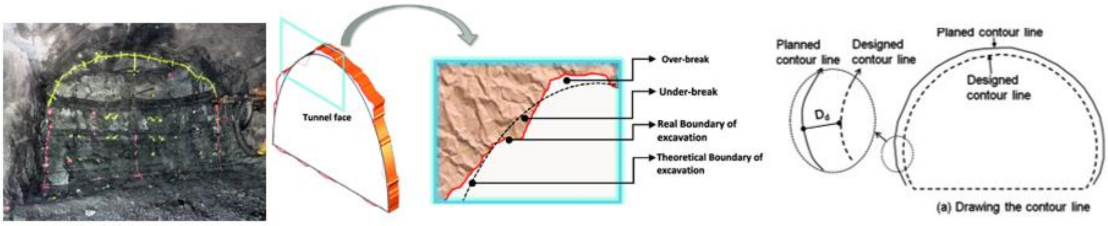
As we commented in previous articles, in the next articles we will try to bring a series of specific themes, which may not apply to all operations, but will certainly serve as a reference for several similar situations, as well as we are inviting some friends so that they can participate and contribute with some articles and case studies, because that way you can rest a little from my comments and we can have several other opinions and experiences to share. So, as we always say, if you have any suggestions or want to share an article, please contact us, remembering that here nobody pays anything and the idea is simply to share knowledge and experiences. But leaving the rambling aside, today's topic is related to a very well-known topic that I've been helping some friends and students in the last few months, which are the pre-split blasts.

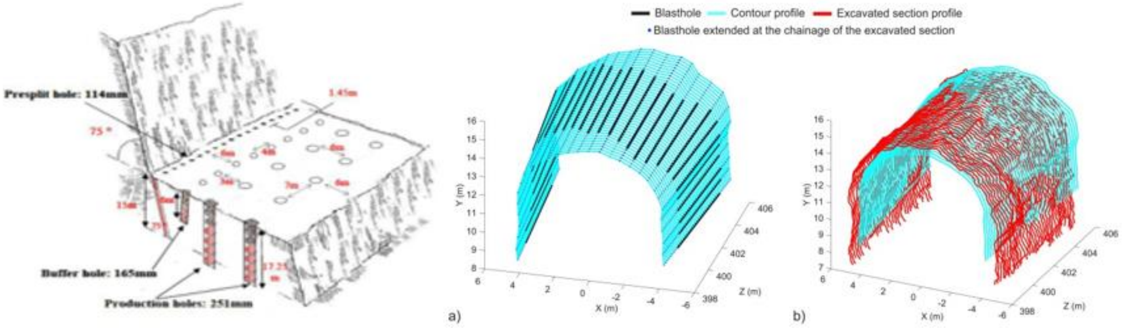
As simple as it may seem, pre-split blasts are among the most used and versatile blast techniques we have available, because despite being one of the main sculptural or finishing blasting techniques, which aims to cut the rock, for a better definition of the final wall, it also has several other applications among the control techniques, which are used for a greater preservation of the remaining massif, reducing the damage generated by the production blasts, as well as controlling the levels of the various impacts that can be generated by the blasts. Pre split techniques can also be used to reduce vibrations in a certain direction, secondary blasts, special blasts, and many others.



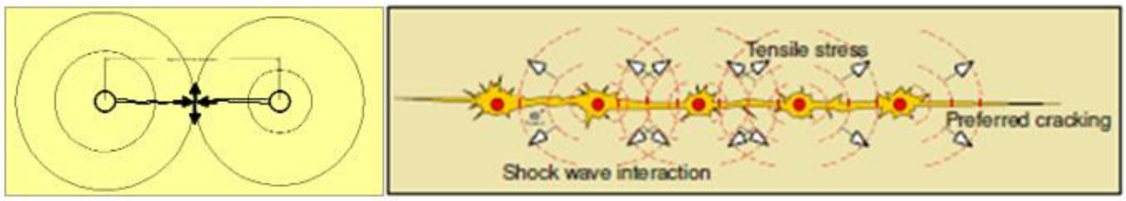
In addition to applications in open-pit blasting, pre-split techniques are equally important in underground blasts, but in this case they are better known as contour blasts, widely used to cut tunnels, control overbreaks and preserve the remaining rock.

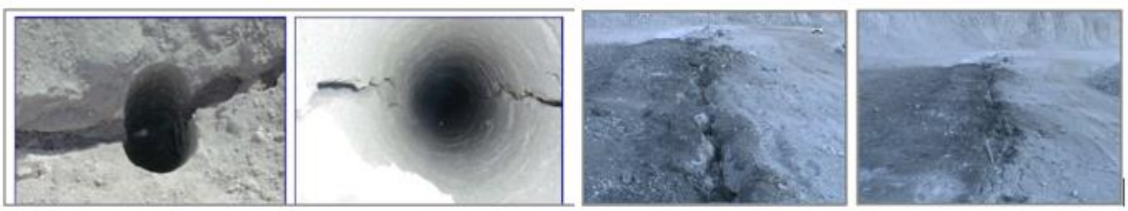


We can say that the pre split is the main preservation technique for the remaining massif, being the most used individually or in conjunction with some other technique, both in open pit and underground blasts. It is characterized by the opening of a crack in a rock mass to, in this way, separate the part that will be detonated (rock block to be fragmented) from the remaining rock that must be preserved.



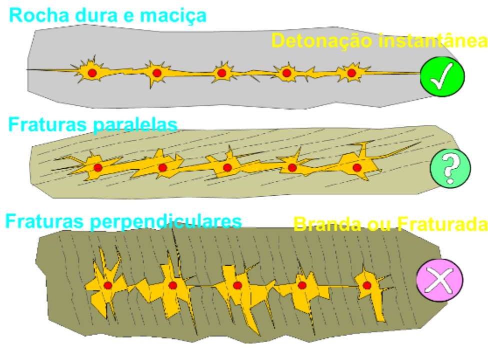
The theoretical definition will indicate that the pre split is nothing more than the instantaneous blast of a line of parallel and coplanar holes along the cut surface that one wants to create, with controlled explosive charge, to cause the least possible shocks or cracks in the remaining massif. Where the simultaneous blast of the holes produces a tension force that creates a cut in the plane formed by the several holes.



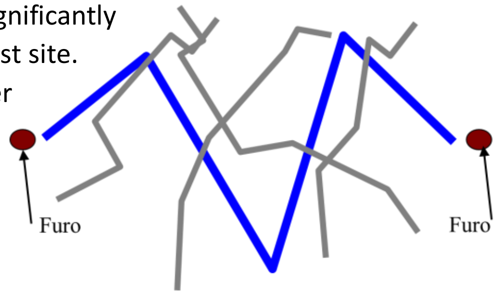


The cutting plane created by the pre-split creates a protective filter for the remaining massif, being able to reduce or even eliminate the blast effects of the production holes that are detonated after the pre-split. When compared to production blasting, the pre-split uses a very low amount of charge, normally uncoupled, as its objective is to cut the rock and not fragment it.

Pre-splits usually provide an excellent result in hard and massive rocks, leaving a smooth wall marked by the half-rounds of the holes, but the technique can be adapted for almost any type of rock, requiring an evaluation and adaptation of the parameters, so it is It is important to be aware that your results can vary significantly according to rock properties and load characteristics.



As well as the results, spacing and load can vary significantly according to the type of rock and its conditions at the blast site. We can say that the more fractured the rock, the harder the pre-split performance will be. We see this clearly when we have a change of characteristics in the same blast.



Despite the higher execution cost, mainly due to over-drilling and more work in loading and blasting, there are several reasons why pre-split is the most used technique:

- Improved cut definition for the remaining wall
- Better wall definition and appearance
- Greater slope stability
- Creates a greater sense of security
- Greater ease with different inclinations
- Works as a filter for blast waves
- Can be detonated well in advance
- Can be applied for dilution control
- Others.

When dealing with special blasts, as is the case with civil works, the better definition of the cutting lines combined with the possibility of preserving the remaining massif, justifies the almost mandatory application of this technique, mainly in more confined excavations, such as channels, foundations , structures for powerhouses and spillways, which will later be coated with concrete. The non-use of pre-split in the excavation of these structures will have as a direct consequence the appearance of overbreaks, increasing the consumption of concrete and producing situations of instability in the rock cuts, which in many cases will require the application of different treatments and even reinforcements in the concrete structures.

The quality and precision (direction, angle and parallelism) of the drilling are essential for a good performance of the pre split. The importance of drilling accuracy can often not be considered in the project, but it is of great importance due to the parallelism that must exist between the wells, since their non-parallelism can be the cause of irregular profiles. For as we have seen, the cutting mechanism needs the waves to collide to generate the fractures in the right directions and thus allow the gases to do the work of widening them creating the cutting plane.

The theme and versatility of pre split is very broad and we could use some articles to cover the theme more, but that will be for another time. We always get carried away and end up writing more than we intended, but let's try to focus here that our objective is to talk about the evaluation of the pre split results, so let's stop with the concepts and get straight to the point.

An important observation to be made is regarding the imperative need to carry out a careful evaluation before making any changes to the plans already in use, as it is very common to see people arriving at new operations and wanting to make numerous changes based on their past experiences, without have seen a few blasts and evaluated their performance. Because we need to understand that each operation has its particularities and they need to be taken into account, which is why we always recommend that before any modification an adequate assessment is made. It is important that before changing, we know why we are changing, what is justifying this change, and what we want to achieve, even to assess whether the new configurations will produce better results than the previous one.

Furthermore, there is an old saying that "the results speak for themselves", so the best way to evaluate a blast and identify what needs to be improved is when we evaluate its results and compare them with our original goals.

When it comes to evaluating the performance and the result of the pre split, there are two standard ways, which are based on visual evaluations, but which have a very useful practical applicability, both for evaluating the results and for evaluating the performance and behavior of the blast itself:

1. Quantitative: based on the visible half cast factor, which generally refers to the % of visible half casts after cleaning.

2. Qualitative: defines the quality of the blast, where the half cast is not an end in itself, what is needed is to obtain stable walls.

The first is the most conventional one, which despite being done through the same visual evaluation, it defines a quantitative parameter that can be easily measured, indicating a value in % so that we can compare the effectiveness of the cut, as well as the performance between different blasts. This parameter is commonly known as the “half cast factor”.

The half cast factor or index is the dimensionless ratio, or percentage, between the total length of half casts, observable on the remaining wall, after the blast, and the total length of holes drilled and blasted. It is an indirect indicator of the damage induced by the contour holes to the remaining wall.

This is the main factor used to evaluate the quality of the pre split, referring to the preservation of the remaining wall, as a high rate of half casts will indicate that the cut was effective and that the apparent damage caused by the blast was minimal.

It is important to highlight that the half casts factor only represents the possible apparent damage, not indicating microfractures in the rock or indirect damage, and does not represent the stability of the rock, only the level of apparent damage caused by the blast. But it is one of the most accepted methodologies for evaluating the result of the pre split, with regard to the quality and effectiveness of the blast.

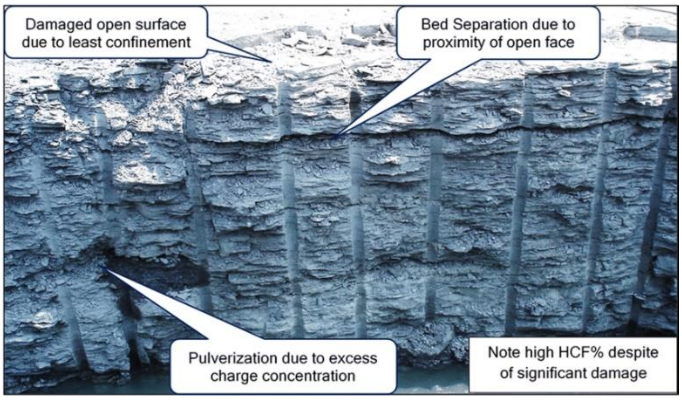
In the figures below we have an example of the result of two pre-split blasts, where we can assess that in the blast on the left side the wall is practically intact and we can observe all the half casts, so we would indicate that this blast or its result has a half-cast factor of 100%, that is, it would be a practically perfect blast in relation to this factor. With regard to the blast on the direct side, we can see that there are many fractures and loose blocks, and in a good part of the wall we cannot see the half-rounds, so I could say here that we will have an approximate half-cast factor of more or minus 40 or 50%.

An important point that needs to be made clear in this methodology is that it takes into account the visible half-casts, regardless of the reasons for the absence of the others, such as, for example, the blast may coincide with a fault plane or even the rock is already extremely fractured, and even though the “damage or lack of half casts” is not blast’s “fault”, it will receive a low evaluation score. So when we are using this factor to evaluate the pre split, it tends to evaluate the “cutting capacity” much more than the damage itself, but with experience and a lot of criteria we can indicate whether the absence of half-casts is due to the damage caused by the blast or whether it was due to natural characteristics of the rock. Therefore, when comparing different blasts, we should ideally compare them in groups according to the characteristics of the rock, because in this way we can effectively evaluate the result of the pre split in each type of rock.

On the other hand, we can evaluate the result of the pre split through a qualitative evaluation, where the fact of half casts is not the final objective, but evaluating the wall as a whole, seeking to identify points where the blast may have caused damage to the rock. , as well as points where it was inefficient in performing the cut.

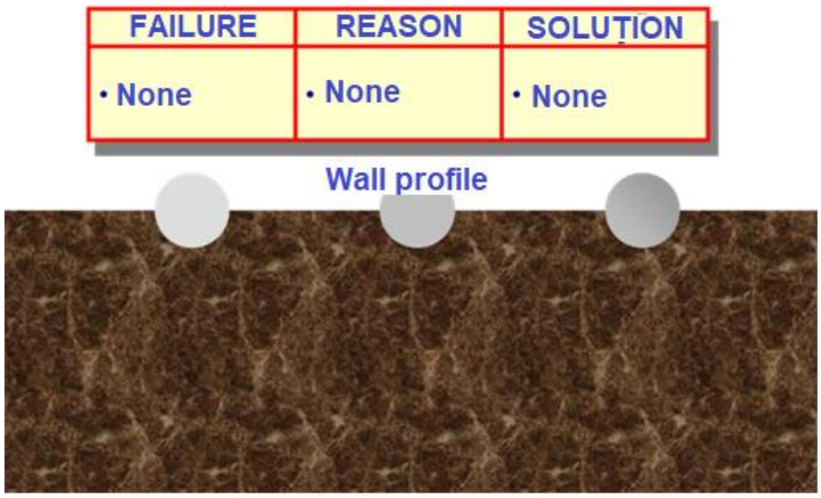
Qualitative assessment is very subjective, depending entirely on the experience and criteria of the person who will carry out the assessment, as well as the factors taken into account, but there are a series of basic principles that should serve as a guide for carrying out a good assessment, especially when the objective is to identify points of improvement in the blast plan.

In the qualitative assessment, we carried out a visual assessment of the remaining wall, to try to identify the state of the rock in the face of the pre-split action, evaluating possible damage to the hole wall, as well as the state of the area between the holes. Because there are several points, which when visible, can serve as an indication of how some elements behaved during the blast. That is why this methodology is usually used to evaluate the blast plan parameters, seeking to use these indicators as a guide to optimize the pre split settings.



We can say that the qualitative evaluation is like a general pre-split check-up or even like an analysis of your fingerprint on the rock wall, which allows us to evaluate the behavior of the blast and how it acted in the rock. So let's take advantage of this article to make some basic comments that need to be evaluated in this type of evaluation.

First, let's refer to the figure below, where we have the scenario that we consider perfect, where we can see the intact half-casts of all the holes, the cut between holes looks perfect and we don't see any evidence of damage to the wall. In this case, a good qualitative assessment would coincide with a half cast factor equal to 100%, as we have no anomalies in the pre-split result itself, just as we have no anomalies due to rock characteristics.



We don't want to go into too much detail here, but it's important to be clear that in addition to evaluating the cut and the existence of half-casts, it's important to evaluate the entire wall set, looking for signs that may indicate damage caused by the production blast, which go indicate that the pre split cut well it was not enough to filter all the damage, or even evaluating the integrity of the half cast itself, as it is possible in some situations, even with the perfect cut, we find half casts cracked or broken, indicating that locally the explosive is overloaded and therefore damaged the wall of the hole.

Another point to observe is the parallelism between the holes, to assess the quality of our drilling, seeing if we have errors in angle or direction, as well as the spacing between the holes. Because as we said at the beginning, drilling has a direct influence on performance and cutting.

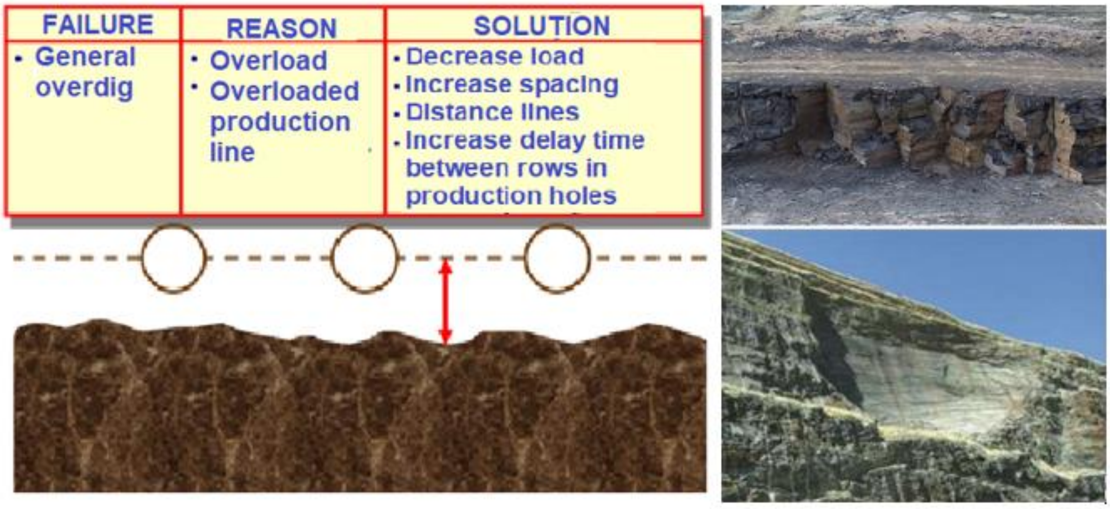
We can also observe the remaining crest, that is, the region close to the mouth of the hole, to see if we have damage at that end, which in most cases can be caused by the gases that come out at high pressures. So it may be necessary to use explosives with fewer gases, or a smaller amount, leaving the upper part with less charge than the rest of the hole. It is important that the cut takes place even at the mouth of the hole, but this is a critical point, especially on benches, as the rocks are naturally less trapped and more unstable.

Another important point is to observe the foot of the hole, both on a workbench and in a tunnel gallery, to assess whether the cut was effective on the foot, which is the most stuck and resistant part, so it is common to often have a remnant rock that it wasn't cut straight, indicating that it needed less spacing or more loads on the foot. Generally, a little more load is placed at this point, due to greater resistance, so it needs a punctual evaluation, so as not to put too much load and damage the corner, but also not to have leftover material, as it can make it difficult to insert the drilling of the next blast.

We can also look for geological structures and fractures, which can indicate a wedge or loose rock blocks, which can fall, aiming more at the stability of the wall, than at optimizing the design.

Some operations can create evaluation checklists, or even assign points to each of these details, and thus have a score for the pre-split result, but the most important thing is to understand what caused each of these details, so that we can go optimizing our blast plan, remembering the influence of drilling and rock characteristics.

Now that here we have a very different situation from the previous one, where we can see that we had an overbreak, where the cut is beyond the pre split line and we see evident damage to the rock, which can be along the entire wall or located in some region of the plane. In this stretch we will not find any half cast or we will have a very low index, because the damage went beyond the cut line.

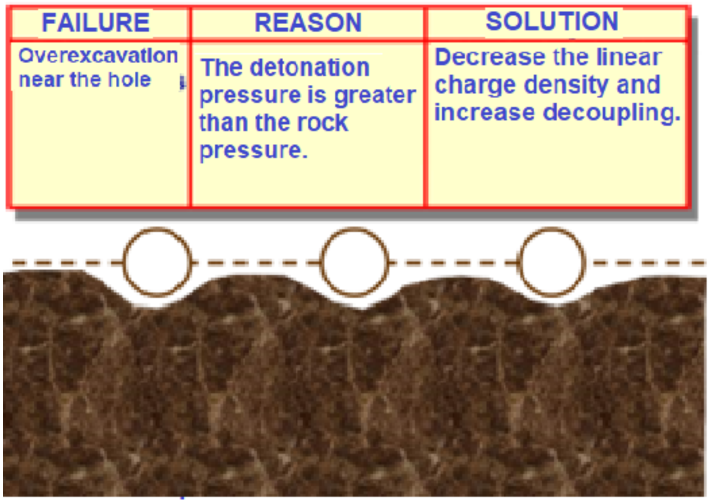


It is important to understand that the first indication of this situation is an excess load, which could be either from the pre split itself, which had too much load and damaged the rock, or in joint blasts, it could have been caused by the last line of the production holes, indicating that these holes have a high back overbreak and that the pre split is not being enough to prevent the damage. But there can also be a series of specific situations that can cause this, such as lack of relief (timing, stuck front, poorly sized mesh, etc) in the main blast, leading to greater confinement and thus causing an increase in tensions in the back , as it can also be due to punctual characteristics of the rock, as we see in the photos to the side, where we clearly see that there were faults and fractures in the rock, which caused the natural breakage at these points.

It is important to be clear that each situation like this can have a completely different explanation, so in addition to identifying the overbreak, it is important to carefully evaluate each scenario, seeking the real cause of the damage, because, for example, if it is a natural condition of the rock, it can be necessary to reassess the pre-split and production blast settings, or even adapt the cutting lines according to the structures of the rock itself, if it is a question of overload, you have to assess where it is occurring, whether it is in the pre-split or in production dismantling, and resize loads and holes to fit. Remembering that this can change from one sector to another of our operation, so an adequate assessment is important before carrying out the plan, to see if we are dealing with the standard case or if we have to adapt our plan to new conditions.

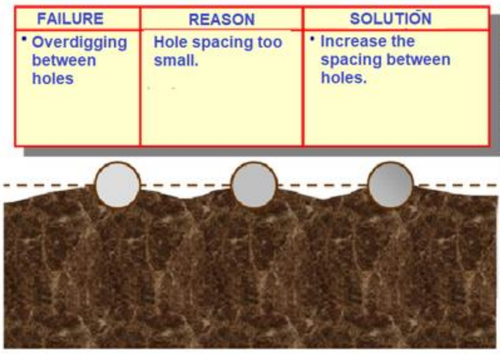
In some situations it may be necessary to completely resize the pre split, change explosives, detonate it in advance without the production blast, and in others it may just be to change the diameter or even increase the timing of the production blast to give more relief, as soon as the first step is to identify the problem, then what is caused, and finally what are the possible solutions, as it is possible that we can have more than one for each case, and of course we will choose the easiest and most economical.

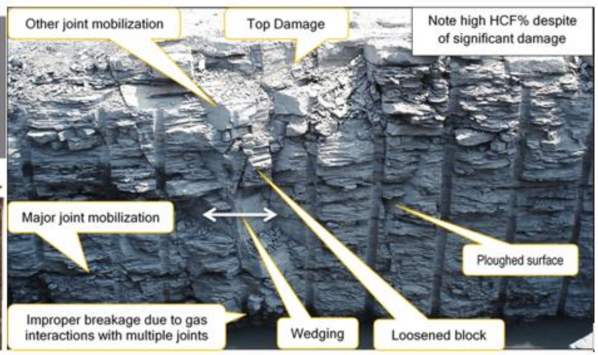
Another situation similar to the previous one, but with overbreaks located closer to the hole, may indicate that we have a very high linear power factor, that is, the blast pressure of the explosive is greater than the impact resistance of the rock, making causing it to suffer grinding in the vicinity of the hole. Where in many situations we can even see the half cast, but it will be all cracked and with damage indications, or when we use spaced charges, like in a barbecue, it is common to see the damage exactly where the cartridges are, indicating that they are punctually causing greater damage.



In most cases, the standard solution will be to reduce the charge, or better distribute it along the hole, when it is the case that we only have damage in the places of charge concentration, but we can also change the diameter or change the spacing between the holes . Also, when we use larger diameter holes, they may be serving as an auxiliary or cutting free face for the production holes, or even fractures may be leading the gases to the pre-split holes, so it is important to analyze whether it is a general case or if it is a specific situation. For example, when it is a situation of fractures, it is common to see pressure (water or dust) come out of other holes as we are drilling, giving a direct indication that this will occur during the blast, in the case of localized damage, we will see several marks spaced along the half cast, and it may just be reducing the diameter of the cartridge, and even using the same power factor, that is, placing more cartridges with smaller spacing, and we will have better results.

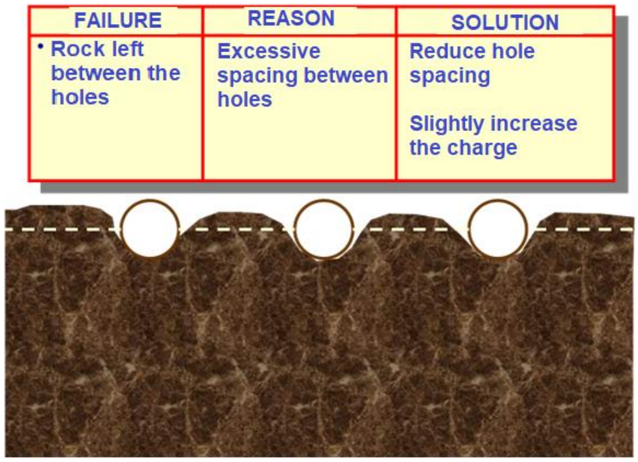
Now, instead of having the hole as the center of observation, we have the space between the holes, and we see that in this case we had an overbreak between the holes, which indicates that the explosive charge is well dimensioned, as it is not causing damage to hole wall, but that the holes are very close together, so when the waves from the two holes meet their joint force exceeds the limits of the rock. So many times we will have a high half cast factor, which can even reach 100%, but this damage between the holes will usually indicate that we can increase the spacing a little.





It is important to observe if this damage is not due to the breaking properties of the rock, which can sometimes have small or closely spaced fractures, but in any case, the ideal is to gradually increase the spacing, or even try a small reduction in the power factor. . Also in very specific situations it can be caused by the last line of the production blast, which finds relief in the holes, but not between them and thus ends up causing a little damage between the holes, and the standard solution would be to decrease the load a little or increase the distance between the pre split and the last line of production holes.

In the case below, we have the opposite situation, where we still observe the half-casts, which can have an index of up to 100%, but an underbreak between the holes, that is, an inefficiency in the break between the holes. Where the likely situation is that the power was insufficient to cut between the holes, so the standard recommendation is to decrease the spacing between the holes or else increase the linear load a little. But in the same way, we may have other specific situations, where, for example, we may have fractures that make it difficult for the cutting interaction between the holes, or even deviations and misalignment in the drilling, which can cause similar situations.



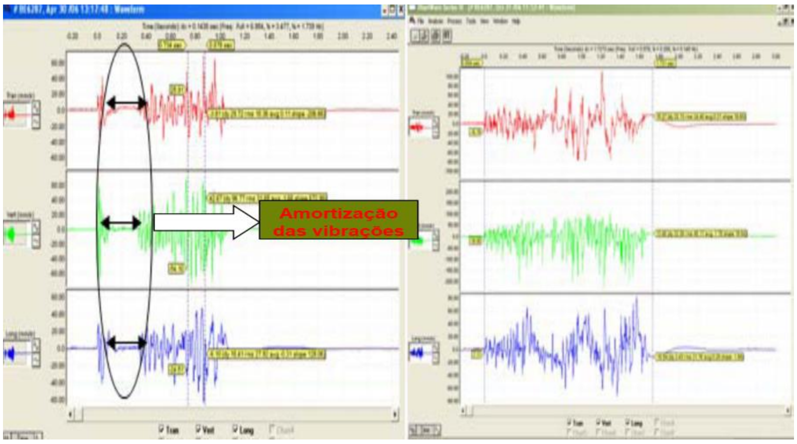
It is important to understand that these qualitative observations/evaluations of the pre-split wall are fundamental in the blast plan optimization process, and that they are indispensable for a correct evaluation and dimensioning. They are very simple and intuitive, where with good criteria and guidance, anyone can make assessments in day-to-day operations, I just try to be careful that there may be different solutions according to the characteristics of the rock and the blast settings, so that it is necessary to carry out the adjustment tests for each possibility until finding a more acceptable standard result.

As we said at the beginning, hard and competent rocks present a much more comfortable scenario for pre-splits, as the characteristics of the rock will influence less the probability of results, so normally they will express exactly the performance of the pre-split, facilitating its evaluation , while in soft or fractured rock scenarios, the wall can behave much more according to the characteristics of the rock, making the evaluation difficult, as well as the definition of the best alternative. Therefore, an assessment must be made according to each scenario.

We don't want to go on too long, but just so we don't miss out, there are also other ways of evaluating the pre split, which we can say are more technical or instrumental, and therefore are more used in specific technical evaluation studies, such as An example is the case of the pre split filter, which aims to evaluate the ability of the pre split to serve as a filter, preventing the passage of vibrations and shock waves that can be generated by the production blast.

In a summarized and simplified way, we can say that shock waves and vibrations will depend directly on the medium in which they are being propagated, so they will behave with different speeds in different types of rock, just as they undergo changes when they encounter a difference of medium during its propagation, and therefore, the pre split can act as a difference of medium, where the crack/cut created in the rock, and mainly when there is a surface separation, will cause a reduction of the waves transmitted from the block of rock being blasted into the massive remnant.

So in the pre-split filter test, what we do is make some holes in front and behind the pre-split, which will serve as observation points, and in them we place disposable sensors, which will measure the level of vibrations before and right after the pre split, and so we can determine how much the vibrations were reduced by going through the pre split, or as we say how much the pre split filtered out of the waves. In simple terms, we can say that an acceptable result is a reduction of at least 50% of vibrations, but in critical scenarios, where vibrations can compromise the stability of the rock, the goal may be greater than 80% of vibration reduction , to ensure the least possible impact.



That's it, let's stop here, we already have 12 pages and I'm writing on a Sunday afternoon... kkkkkk... As soon as another opportunity we'll delve deeper into the pre-split themes and bring some case studies about this whole thing evaluation process.

As always we hope you're enjoying it and we're doing our best to try to get more people involved so we can share as much as possible.

Yesterday I was thinking about how good blasts are beneficial, how they can save lives, bring savings to companies, generate profits, facilitate the work of all subsequent processes (excavation, transport, processing, etc.) and how important it is to know this. I wish I could go back 20 years ago, when I was still studying at university and have a conversation with myself, to be able to show from the beginning the importance and impact of what we do, and that when we do it well it can change the lives of people and operations. But well, since we can't, we hope to help some friends and contribute in some way.

As always, please comment and share, so that we have safer and better blasts!!

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