DIAMOND BLADE PERFORMANCE LESSON 1:
The Science of Stone Cutting – Blade v Stone

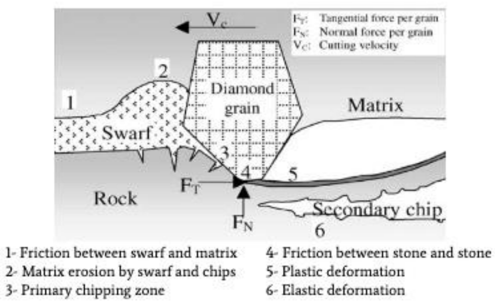
V

A. What is a diamond blade made of?

It is a metal alloy called the “matrix”, which is embedded with diamonds.

B. How does it cut?

The diamonds do the cutting. In simple terms the exposed diamonds crush the material in front of them, whilst metal matrix holds them in place. If a saw is run correctly, the metal matrix should wear just a tiny bit faster than the diamonds, so that the diamonds are always exposed just enough to come into contact with the stone and do the cutting.



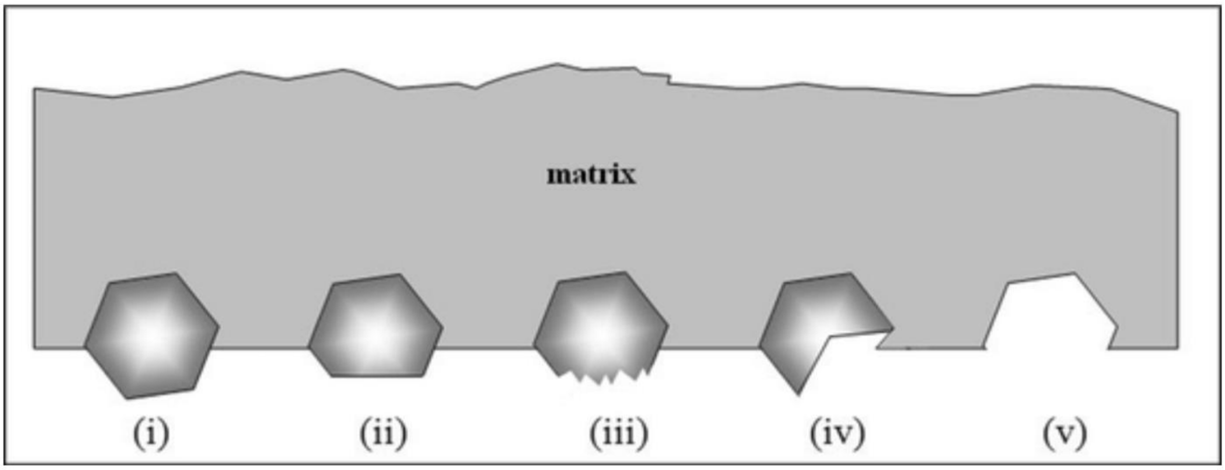
C. What happens if the metal matrix wears too quickly?

The diamonds will stick out too much and either will break off or fall out. The diamond should look darker in colour than the metal matrix. If the diamonds fall out, the holes fill up with stone dust which often looks lighter in colour. It is quite common, for some operators to think these lighter coloured dots are diamonds.

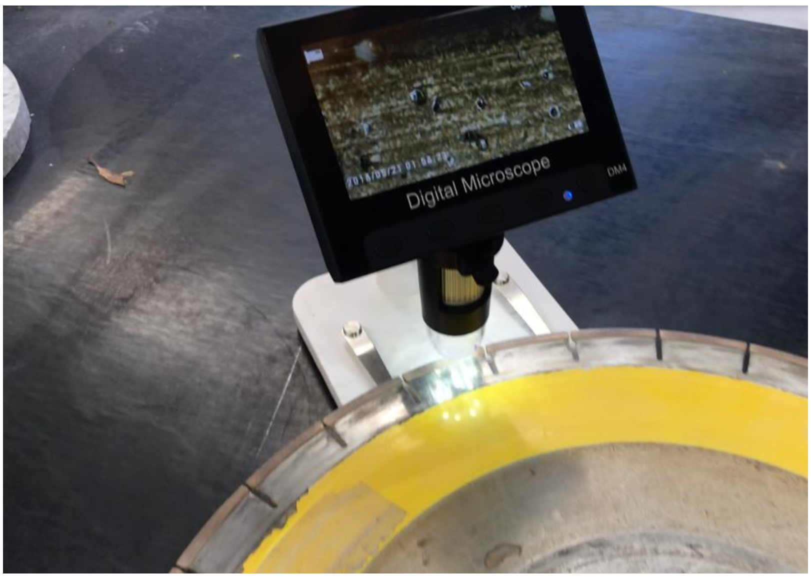
D. What happens if the metal matrix wears too slowly?

The diamonds are not fully exposed, they are protected by the matrix and <u>do not cut</u>. This is commonly referred to as “glazed over” or “closed”.

For optimal cutting performance, you want the diamonds to maintain sharp edges. Instead of flattening the edges, you want microscopic pieces of each diamond to break away, leaving fresh, sharp edges which will cut effectively.



States of diamond grains: sharp (i), flattened (ii), micro-fractured (iii), macro-fractured (iv), and grain pullout (v)



On the left we are seeing grain pull out, on the right we have freshly emerging diamonds

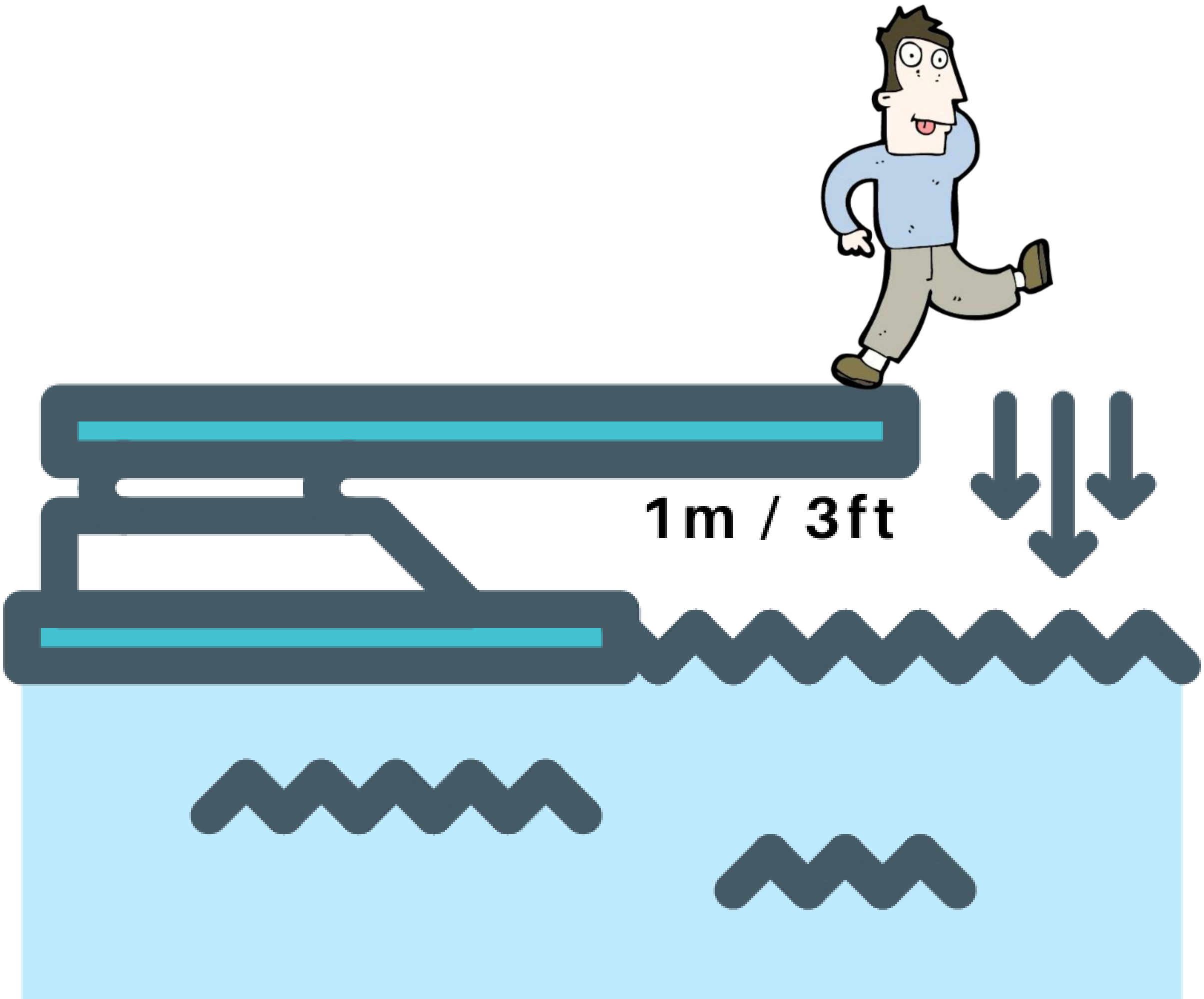
E. MAGIC QUESTION - how do you ensure that the metal matrix wears at the correct rate to:

a. Always have the diamonds slightly exposed? and

b. So, the diamonds stay sharp and don't "glaze over"?

To explain this, we're going to think about a person diving into water.

Meet Silly Billy! He is going to demonstrate.

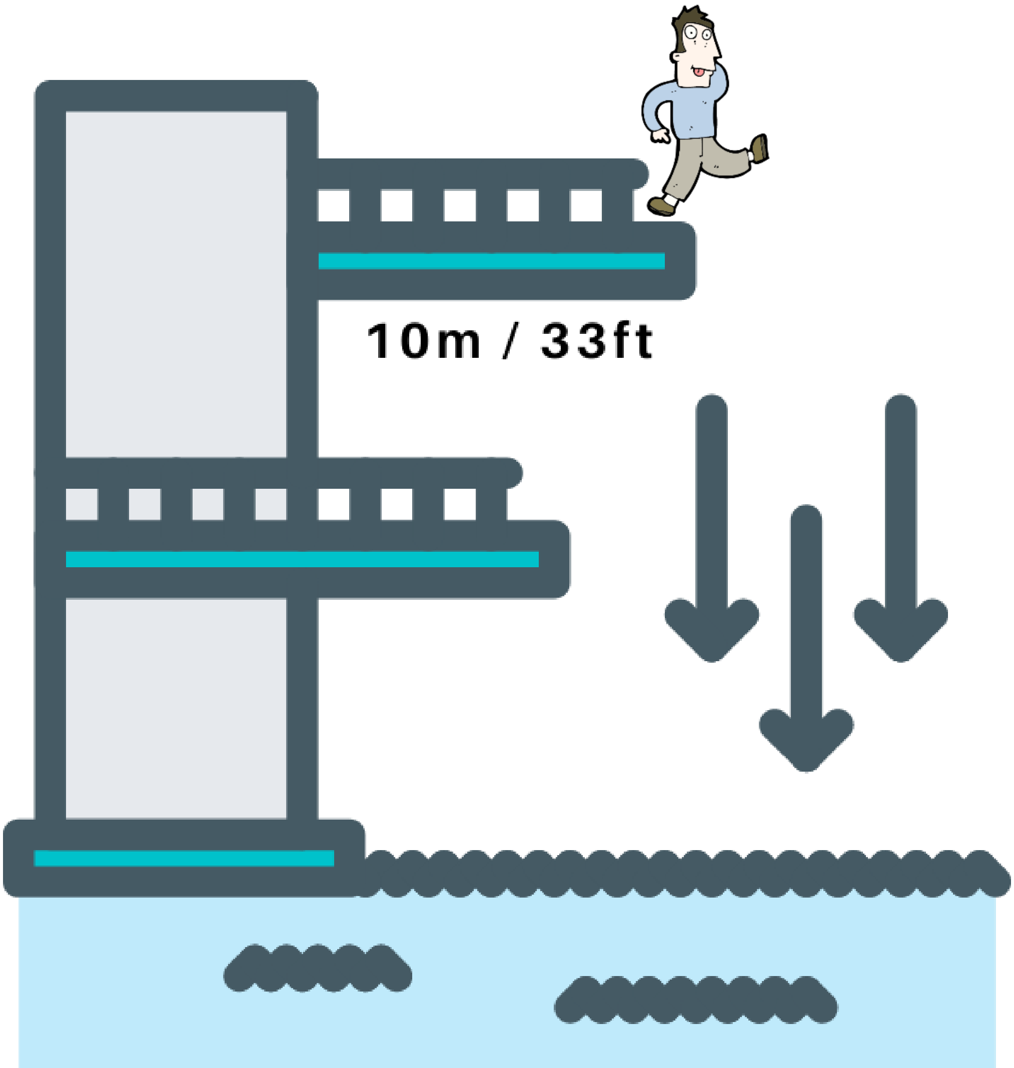


Olympic low diving board - 3ft /1m from the water. How fast will Silly Billy be falling when he hits the water?

$V_i = \sqrt{2gd}$

$= \sqrt{2 \times 9.8 \times 1}$

= 4.4m/s or 14.4 ft/s – quite slow – Billy will be OK



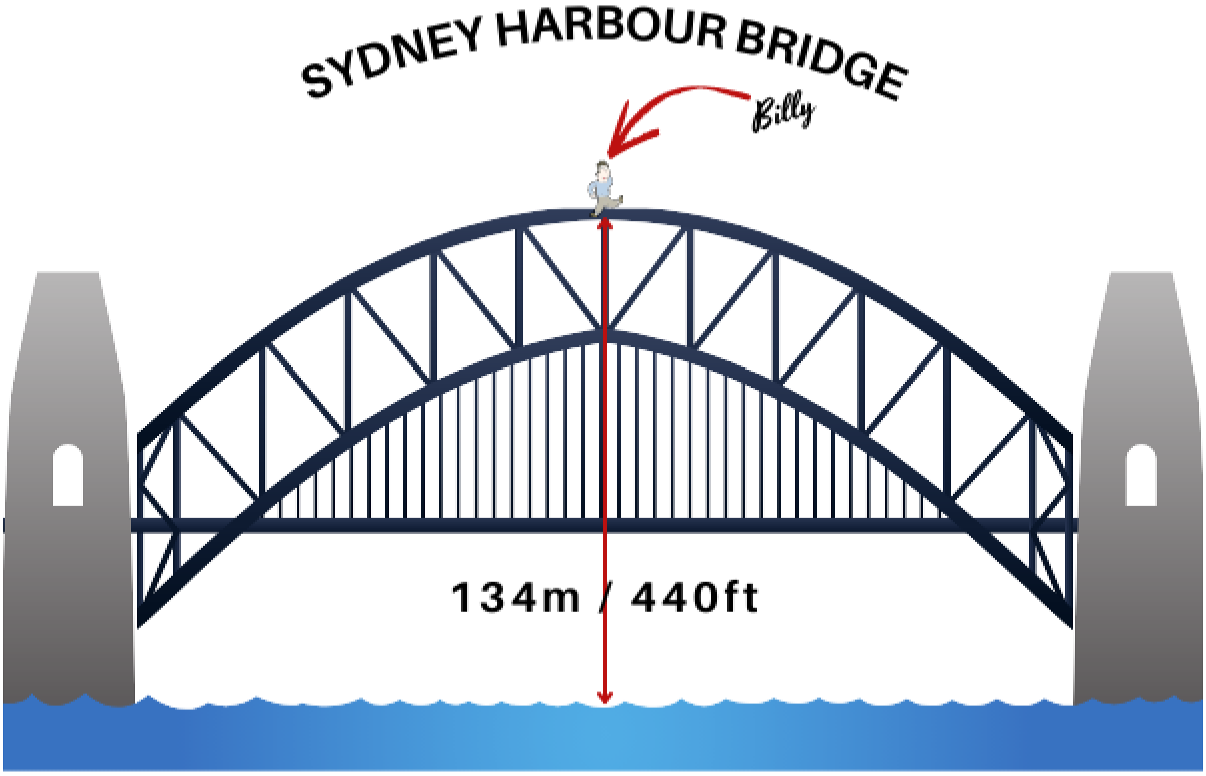
Olympic high dive platform - 33ft / 10m from the water. How fast will Silly Billy be falling when he hits the water?

$V_i = \sqrt{2gd}$

$= \sqrt{2 \times 9.8 \times 10}$

= 14m/s or 46ft/s.

Pretty quick! In fact, if you don't dive correctly, you can be seriously injured.



134m / 440ft High. How fast will Silly Billy be falling when he hits the water?

$V_i = \sqrt{2gd}$

$= \sqrt{2 \times 9.8 \times 134}$

= 51m/s or 167ft/s

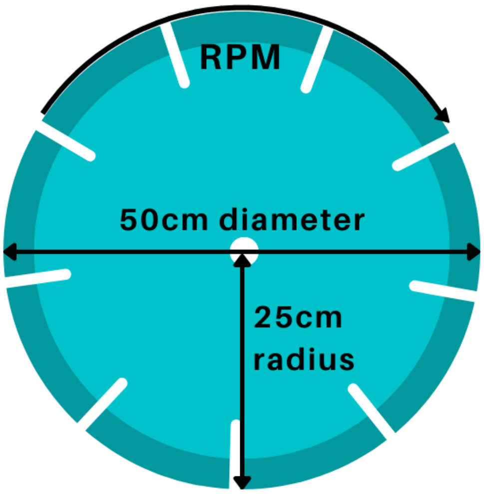
VERY FAST

When you hit the water at 51m/s the water feels VERY HARD - like concrete!

What does this have to do with a diamond saw blade?

EVERYTHING!

How to calculate the tip speed of your blade, using its diameter and RPM (Revolutions per Minute)



1. **calculate "C" - the CIRCUMFERENCE of the blade**

   C = 2 π R

   = 2 x 3.141 x 25

   ` **= 157cm or 5.15ft**

2. **Calculate "S" - the "tip speed" of the blade if it is travelling at 1500RPM**

   S = 1500 x 5.15ft

   = 7725ft or 2356.19m per minute

   Divide by 60 to get per second

   = 128.75ft per second or 39.27 m/s

A general rule of thumb for sintered diamond tooling is 20m/s to 25m/s for very hard material and 30m/s to 35m/s for softer material. – ALWAYS inspect the diamonds after the first cut and adjust accordingly. Each blade manufacturer will produce different hardness's of matrix.

GOOD NEWS - YOU DON'T HAVE TO DO THIS MATH!!!

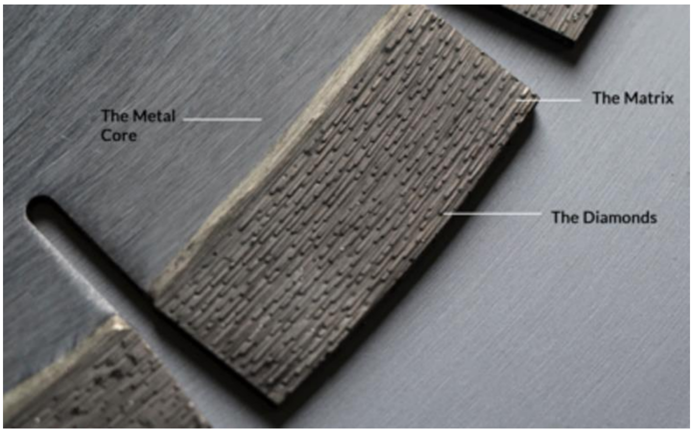
BAD NEWS – STILL NO BEER WHILE OPERATING MACHINERY!!!

ALL YOU NEED TO KNOW IS

the higher the RPM,
the faster the cutting-edge travels and
THE HARDER THE METAL MATRIX BECOMES

TOO SLOW <---------- SWEET SPOT – COMET TAILS **----------> TOO FAST**

Metal matrix is too soft:	Metal matrix is correct hardness:	**Metal matrix is too hard:**
Metal matrix wears too fast. Diamonds get exposed too quickly and break off in big chunks or fall out.	Metal matrix wears tiny bit faster than the diamonds Diamonds exposed the right amount to cut cleanly. Comet Tails visible behind each diamond	Metal matrix wears too slowly - same speed or slower than the diamonds are wearing. Diamonds are not exposed or become blunt – **Glazed Over**
Constantly have to stop and **dress the blade** to expose new diamonds. Cuts slowly. Wastes blade. Stops work.	Diamonds stay perfectly exposed and sharp. Cuts at optimal speed & never have to stop to dress the blade.	Constantly have to stop and **dress the blade** to expose new diamonds. Cuts slowly. Wastes blade. Stops work.



THE GOOD NEWS

With this new knowledge and a little practical training you can easily dial in the optimal RPM and feed rate for different materials.

NOW, with the help of S-Complex™:

Cut, shape and polish stone, sintered stone, quartz, porcelain faster than you ever thought possible:

- Faster cutting/polishing speeds
- No stopping to dress blades

Cleaner cutting:

- Perfect cuts = less hand finishing
- Fewer blowouts
- Cleaner mitre joints – for thin sintered stone and porcelain slabs

Longer blade life = more lineal feet / meters with each blade

Less Noise

WHEN YOU ARE AN EXPERT

YOU ADD VALUE TO THE BUSINESS

YOUR JOB BECOMES MORE INTERESTING & ENJOYABLE

CONDUCTING AN S-COMPLEX™ TRIAL

WHATEVER HAPPENS, DON'T PANIC. WHEN YOU START CUTTING AT MUTLIPLE TIMES THE SPEEDS YOU ARE USED TO, YOUR ADRENALIN WILL BE HIGH. IF SOMETHING UNEXPECTED HAPPENS CONSIDER THESE THINGS:

1. **The water feed**

   The faster you cut, the more important it is to get enough water into the cut. With very fast feed rates, it is also harder to force the water into the cut.
   It is the water plus the S-Complex™ that allows the very high cutting speed.

- SOLUTION
  Make sure that the water irrigating the blade are placed DIRECTLY IN FRONT of the blade and point DIRECTLY INTO the cut. Most fabrication shops have the water irrigating the blade from both sides and not directly in front of the cut. To get super high speeds you may have to use smaller aperture nozzles on the water jets so the water squirts harder into the cut, or even fit the saw or CNC with a stronger water pump. Larger feed lines is usually the easiest fix. Changing the inlet water hoses from ½" to ¾" (Larger if possible) will make an enormous difference.

2. The cutting bed needs to be in a reasonable condition

- If your blade looks great and sounds great and you are getting blowouts, it may be caused by cutting on top of a saw groove in the cutting bed.

- SOLUTION
  Ensure the stone is positioned so you are not cutting directly over a groove in the cutting bed. If the cutting bed has too many holes and groves to ensure this, replace the cutting bed.

  Make sure the cutting bed is stable
  An overused cutting bed might be in pieces, which means your slab might move during cutting = bad cut and danger.

3. Your cuts are not 90 °

- SOLUTION
  Ensure the cutting bed is PERFECTLY LEVEL

  Do you have a good enough spirit level? Have you been trained how to use a spirit level? There is a lot more to using a spirit level than you can guess!!

  Real life Example: During an S-COMPLEX trial while cutting sintered stone we were able to increase the feed rate from 75" per minute to more than 250" per minute.

  Someone noted the cut was skew - not a perfect 90°

  The operator assumed the super high speed was forcing the blade out of the alignment.

  So, we grabbed the off cuts from the original cuts we did at their normal speed of 75" per minute and checked them with a right angel.

  They were also not square! It turns out they had not been cutting square for a long time and had not noticed.

  As we said – when you cut at incredible speed, you look more closely, and you are more likely to notice when something isn't quite right.

DEKTON	- Baca Robot - Hard Rock Trial					
CUT	Inches / m	RPM	Amps	Milliamper	MM/Minute	RPM
1	75	1700	10	10000	1905	1700
2	85	1700	11	11000	2159	1700
3	85	1800	11	11000	2159	1800
4	95	1850	11.2	11200	2413	1850
5	95	1900	11.2	11200	2413	1900
6	105	2000	11.7	11700	2667	2000
7	115	2000	11.4	11400	2921	2000
8	125	2000	11.5	11500	3175	2000
9	135	2000	11.8	11800	3429	2000
10	145	2000	11.4	11400	3683	2000
11	155	2000	11.4	11400	3937	2000
12	165	2000	11.8	11760	4191	2000
13	165	2000	11.8	11800	4191	2000
14	175	2000	11.9	11850	4445	2000
15	185	2000	12	11950	4699	2000
16	195	2000	12	12000	4953	2000
17	195	2100	11	11000	4953	2100
18	205	2100	11.5	11500	5207	2100
19	215	2100	11.7	11700	5461	2100
20	225	2100	12.1	12100	5715	2100
21	235	2100	12	12000	5969	2100
22	245	2100	12.3	12300	6223	2100
23	250.39	2100	12.4	12400	6360	2100

Above is an example of the how we operated the S-Complex™ trial.

Over 23 cuts, we slightly change the saw parameters to eventually cut at the saws maximum feed speed. We started with a relatively blunt blade that we slowed the RPM down on, to “open” it up (Another silly term for a sharp blade). We then start to increase the feed speeds. Note that we were looking at the blade between each cut and were carefully listening to the sound of the saw. We also had to alter the feed of the water so that it was directly in front of the blade (Into the Kerf of the cut).

Things that can go wrong whilst cutting:

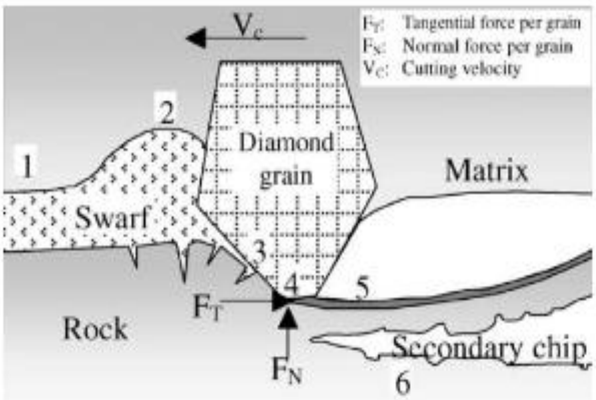
- It can go out of square - typically caused by the feed speed being too high.
- Chipping - feed speed too high, the blade is blunt (the most likely answer).
- If you ever see sparks or dust, you are not getting enough water into the cut and you will never achieve the huge increases in performance.

The fabricator had already gone to a lot of trouble to ensure that they had excellent high-pressure water to the saw blade. As we said above, larger hose diameters to the saw.

S-Complex™ Additional information:

The main function of wear in the diamond, is micro and macro fracturing, which is effectively thermal shock. One of the reasons for this, is rapid heating and cooling of the diamond grains - they reach a graphitization temperature and are significantly weakened. As the diamond is quenched with the lubricating water, micro fractures begin to propagate in the diamond, as the blade continues to spin you force more water into the micro cracks and when that water expands, (from the heat of the cut) a small chunk of the diamond gets blown out. - Macro fracturing. This is where the S-Complex™ magic happens - S-Complex™ is preferentially drawn in to the fractures and does not expand as quickly as the water and typically gives you a 30% increase in tool life.

The picture below illustrates how the diamonds actually cut the stone, the diamond acts as a plough and crushes the stone in front of it. The Rehbinder effect of the S-Complex™ occurs when you are forcing a tiny reaction to occur between the diamond and the material being cut. This can be described as a mechanochemical reaction. The force of the diamond pushes the S-Complex™ into the stone and significantly weakens is bond strength of the material at that interface. - Effectively softening the stone. At this point you yell at the customer - SCIENCE..



1- Friction between swarf and matrix
2- Matrix erosion by swarf and chips
3- Primary chipping zone
4- Friction between stone and stone
5- Plastic deformation
6- Elastic deformation