Epoxy vs. Polyurethane Crack Injection - how to choose?

Concrete Injection Made Easy

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SUMMARY KEYWORDS

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SPEAKERS

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This is the concrete Injection Made Easy podcast, session No. 14.
And I'm Mateusz Furs, your host.

And since it's a concrete injection podcast, I have a question: what do we use most often on our job sites to inject the cracks?

This simple question leads me to present to all of you the short comparison between polyurethane and epoxy crack injection. What does it take to run this remedial work? How to prepare oneself to be able to fill and seal the crack? Why do we use PU or EP resin? And when?

Ok, so In today's episode, we compare Polyurethane resin, PU, and epoxy resin, EP.

We'll look at the main similarities and key differences and which are used when. I'll give you an insider's take on my experience using both.

The cracks in the concrete are the subject of remedial works. This is a problem that has to be solved, meaning sealed. This is exactly where the

injection industry starts playing its role. This is also exactly the place, where my own business starts. I consider myself a problem solver.

A topline similarity of PU and EP is that both will fill and seal cracks and thus make them watertight. Both prevent concrete and reinforcement corrosion. But epoxy has the added feature of structurally bonding the concrete sections together and can restore the strength and structural characteristics of the concrete. At least every single TDS I have read says so.

This last factor often guides the decision making process on the part of engineers designing the remedial documentation to go for epoxy rather than for polyurethane solution.

So the big question is when the main objective is to restore the strength of the cracked slab, and when it is only? to seal it? Because in both situations the slab is destroyed. Then we chose different solutions, and after the job is done we say that it is solved. So, what the heck? How does it work?

So after the time, I have spent on the job site and after I had all these conversations with engineers and designers, I think I know their way of making this decision.
And this episode is truly about when to use which resin and how to do it correctly and in line with the best industry practices.

Remember, there are three parties involved in any structural repair. The Investor, designer, and applicator. And in any repair, everyone must be on the same page and if they work together smoothly and intelligently, that will be of ultimate benefit to the structure.

Keep in mind, that any repair is not only up to the applicator. The aim of the repair is specified in the remedial documentation prepared by the designer, especially when it comes to strengthening the structure. So you need to bear in mind that an applicator is always bound by the repair brief and that plays an important role in the choice of resin.

Having that said let’s dive into the topic.

Most often I use PU-based resin. Especially when comes to inject wet cracks and stopping the water. Why?
Because of the leakages that happen below the ground in the constructions such as tunnels, subways, garages. When there is leaking water, no-one waits long, the decision to stop the water is made almost instantly.

If the main objective is solely to make a crack watertight, then PU based material is the one of best choice, and I'll get into the particulars of why that is later.

Whereas if designers are concerned with restoring the original structural characteristics of the substrate, then they will often choose epoxy.
And yeah, as an applicator, I often draw on my experience to advise the other parties that when a repair is in construction above ground and the construction has a roof over it and there will be no water on this particular slab, then I suggest epoxy, because this will not just provide an effective barrier against moisture and CO2 infiltration and prevent corrosion, mostly carbonization, but it will also restore the original characteristics of the structure.

So generally speaking we can say, that we go for PU in the underground, wet situations, whereas we choose the epoxy solutions above the ground where our biggest concern would be restoring the strength of concrete and corrosion protection.
Perhaps it would be a surprise but carbonization does only happen to concrete that is above the ground because of CO2 presence that can get into the crack (inside the concrete) more easily, deeper and faster.
We use epoxy resin when we can meet the requirements that the crack will not change its width over time. This statement is also taken from the TDS.

Both resins make the construction better, but differently. I like to say that since EP has a higher viscosity (resembles honey, not water), has a lower bonding ability to wet concrete than to dry surfaces, to me, all this makes EP harder to apply than PU and is potentially not as effective. So when the water is present in the crack, and I know that the structure will not collapse (it is not in all cases I have ever seen) I easily choose PU resin, run my injection and I know that the structure is watertight and safe.

Also, PU reacts when in contact with water and so the presence of nuisance water in the crack actually can be good for the water-tightening as a whole. Problem water not only does not exclude the PU resin from being used but also take advantage of its presence, isn't that cool?

So in situations where you can't or don't need to use the structural bonding enhancements of epoxy, then polyurethane resin, with lower viscosity, ability to bond to wet surfaces, reacting with problem water, and overall greater ease of application, make this product a better choice than EP.

And EP products are not for injection of the structure under hydrostatic pressure at the time of application. This one statement alone is almost an answer to the whole episode when to use what.

Ok, let's have a look at a detailed comparison of PU and EP across several categories.

And by the way, do you remember what Chris Coderre, guest of 11th episode says about using TDS? If not, well, you know what to do right?

I used several different TDS to prepare myself for this session. And now, as I will compare some characteristics of resins, I'll be using this free information every resin manufacturer provides to all of us.

Uses:

Both are used to fill and seal voids and cracks in structures such as bridges and other civil engineering buildings, industrial and residential buildings, including columns, beams, foundations, walls, floors, and water retaining structures.

Both PU and EP provide good adhesion to concrete, mortar, stone, steel, and so on, but the key difference here is when comes to wet conditions. Almost all of the modern EP resins are capable of bonding to wet concrete, but also all of these materials prefer to be used in dry conditions, let alone standing water or crack filled with water. Most of the TDS reads the same. So my advice: if there is water and you do not have to use EP, stay with PU because you will not use all the EP advantages anyway, the injection process will be a real nightmare, and the success poor.

Characteristics / Advantages

Key difference between PU, which is also known as elastomers, because they're highly elastic and retain their elasticity over time, and EP, which are duromers, forming a rigid structure when fully set. Both PU and EP form an effective barrier against water infiltration and corrosion. But only epoxy resins structurally bond the concrete sections together and so can restore the original characteristics of the structure. Again, this happens mostly in dry conditions

All of modern both PU and EP resins are solvent-free and should not be thinned.
All of the TSD reads that we can use the resins at low temperatures starting from +5C in most cases. Some of them are ready to be used around 4.

Remember that the viscosity of resin at this temperature is much higher than at 25C. Almost all producers present the viscosity at this high 25C. Why? Because at this higher temperature the viscosity is lower than at the lower temperature :)

Ok, since I started this topic. Viscosity. What does it meal low? Let's compare it! The viscosity of water is 1 mPa*s. The viscosity of PU based resin I use to real hairlike cracks is around 50 mPa*s. And now, the lowest viscous EP resin I compare is around 150 at the temp of 25.

So now, at the temp of 4C how high it is? Does it is still a liquid?
And even more important questions? If there is 4C of ambient temperature, it means that our substrate is also 4. So imagine how easy (or hard) it is to injecting as thick as honey resin into a hairlike 0,1 mm crack that is even more open due to the low temperature of concrete. I would like to leave you with this thought for a second.

Ok, I'm back.
Most of the crack injection we do, we use 1 K pump with pre-mixed resin that we pure to the pump's hopper. Both, PU and EP, same kind of pump no matter if it is a piston or a diaphragm one. This is a sort of common denominator of these systems.

But for EP I prefer to use piston one because it doesn't heat the resin.
The pot life varies among the producers, and products but my general principle here is to mix as small as a possible portion at one time. Why? Because you do not want to have the resin to get hardened in the pump or a pump's hose.
The more you mix, the faster it cures. Easy!

Ways of application

Generally speaking, we use 2 ways of application: one being gravity feed other one being pressure injection.
We can use both ways only to epoxy based resins. Why?
We don't do such pouring with PU based resins because PU in contact with moisture will produce foam and this foam blocks resin from filling the void or from penetrating the crack, so the crack will not be filled, which is why we use pressure when applying PU based resins.
We can use the gravity feed method only in one situation - a horizontal slab crack and the reasons are obvious.
Here it is good to remember that cracks penetrating slabs to their soffit should first be sealed on the underside otherwise some resin may fall out before it will cure, and we do not want that.

With epoxy, you often make an incision into the top of the crack to create a vessel or a void and pour the epoxy into it and it begins to fill the crack underneath, and it's topped off with more epoxy as needed. While doing this, you'll see air bubbles coming up through the resin, meaning the crack is de-airing and is proof that the resin is filling the voids in the crack. This is a good moment to go and check what is going on underneath the repaired slab.

Injection packers

For some reason, the TDS of nearly all EP resins mentions surface packers only. But we know for sure, that if there is a need to use higher pressure, the surface packer will not stay glued to the concrete surface. So either you will not fill the crack completely with too low pressure, or you will lose your packer. How to solve this?
In this particular situation, you simply drill additional boreholes and place steel packers. In fact, if you see that the crack is really fine, do not even try installing surface packers because there is no chance you will fill this small crack with this honey-like resin. Perhaps you will not achieve it when using high pressure as well!
Surprisingly TDS of PU-based resin does not force anyone to use surface packers. So it seems that when the main objective is solely to make a crack watertight we are allowed to drill as much as we want. It's almost like saying: do whatever it takes to stop the water!
But when comes to epoxy filling it should look like the best surgery, nice and clean.

When using surface packers crack should be sealed at its surface with an epoxy paste (another product). You use this paste also to attach the surface packer remembering not to close the connection underneath the packer so that the resin may penetrate inside the crack while injecting. You can place a nail inside the packer and the crack to make sure there will be a connection after gluing.
Remember to remouce this nail before the resin cures.
All of the epoxy TDS says to remove the thin layer of epoxy paste (after the injection is completed) by grinding.
However, if you decide to apply the epoxy paste thicker, and you do it in between two strips of paper masking tape, then you can get a distinct edge of the epoxy paste.
After the injection is completed, this edge allows you to remove the paste by chiseling and cutting off the concrete surface.
It's a much faster way of removing this covering layer of epoxy paste. The decision is yours.

Injection packers, little bit more.

If the crack is wide, you may expect to be using lower pressure on your pump (in both PU and EP cases) so it is an opportunity to use plastic packers (again both, surface and hammer ones).
But if there is a fine crack, you should stay with boreholes steel packers only no matter the resin type.

Injection pressure

Make sure that your 1K pump can remain given pressure level all the time the same. There are drill-pumps which, after pressing a button, still increase the working pressure as long as the drill works, instead of keeping it at the preset level. What it means you can not control the injection process over time and you can easily destroy concrete rather than repairing it. Actually I do not recommend this kind of pump at all, because they are very dangerous both for you and the repairing substrate.

Injection direction

Vertical cracks should always be injected from the bottom upwards. Make sure you see the lower beginning of the crack. It may be hidden underneath the bottom slab if so, you need to drill the hole in the wall downward.
As soon as injection resin oozes out of the adjacent packer, the first one is sealed and the injection process can be continued from the next one.

Mixing ratio A : B see your TDS, it may be 1:2 or even 1:4, who knows what you have got there? No matter if it is PU or EP, you simply have to know it before mixing.

So as you can see, we can say that, in most cases, you would use PU based resins in the underground situations, where we deal with water under high hydrostatic pressure at the time of application (we can not use EP in such circumstances) and epoxy above the ground where the second biggest issue is the strength of the concrete.
Both of them allow you to fill the crack, making it water-tight and preventing any corrosion processes to both concrete and steel.

If you are equipped with a 1K injection pump, boy, you are ready to go for those two most common injection systems already!

From what I just told you we can get the general overview that the PU based injection seems to be much dirtier. I associate the struggle with the water element with polyurethane injection.

Ok, I guess that’s it!
I just compared two 1K crack injection systems.

I listed the goals standing behind each of them.
Now we know when to use which kind of repairing material.

One last piece of advice: always read the technical data sheet before you use a new kind of resin so you know how to use it. It will also give you a good overview of some kind of unexpected situation that may happen when using a given type of epoxy or polyurethane-based resin and how you can handle the situation.

I hope that you will find this PU&EP injection episode interesting. Share this with your co-workers and friends from our injection industry.
Thanks for listening and I hope you tune in next time!