Understanding the different formulations used in resin bonded anchors.

An article for the CFA website

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It is often difficult for someone new to resin anchors to understand the difference between the array of resins available. For those who specify anchors it is also important to understand this difference to ensure any specification changes are to truly equivalent products. In this article Matthew Cleaver gives an overview of the types available and the applications for which they are best suited.

INTRODUCTION

The resins used for anchoring purposes are usually composed of several ingredients; the main ones are listed below with the primary reason for their incorporation:

- A polymer, which gives the basic properties of the resin and binds it together – like cement in concrete.
- One or more monomers, these liquids are used to give a workable product.
- Mineral additives, to give extra strength to the cured resin – like aggregates in concrete.
- A curing agent or hardener, mixing this in starts the chemical reaction to harden the resin.
- Other additives, added to give the correct consistency, colour etc.

It should be noted that there are variations in the composition of the resin and additives used. These variations give rise to the differences in performance of the products available on the market.

All of the resin types described below are available as injection anchors for cartridge based delivery. The information is valid for all delivery systems but each resin type may not be available in all delivery formats.[1]

Unsaturated Polyester

This was the first available polymer type and has been available for many years with styrene monomer. Although styrene is still widely used for injection anchors and in many other industries, concerns over its safety both for transport (it is flammable) and for health (it is classified as harmful) have led to the introduction of “styrene-free” variants, the difference being the liquid monomer used in the manufacture of the resin. The use of alternative monomers enables lower health and transport classifications but increases the cost of the resin.

It should be noted that when installed in accordance with the manufacturer’s recommendations, including precautions for health and site protection, styrene based resins can offer negligible health hazard.

This type of resin gives a reasonable strength performance for the majority of applications and is best suited to fixings into hollow blocks or masonry.

Styrenated (styrene-containing) resins have been around for many years and have become well known for glass reinforced plastic manufacture and their use in automotive body filler. They are used because of their low cost and fast cure.

Styrene-free resins are a relatively new development (since the late 1990’s) and they use acrylic or vinyl monomers.

These are more expensive than styrene, but as they can be selected from a greater range of different monomers they can give an improved performance over the styrenated resins.

Polyester resins cure by what is known as a "free radical" curing mechanism in which the resin is catalysed by a peroxide. This mechanism is characterised by a fast reaction and good low temperature cure, which means that the product can give short loading times, even under low temperature conditions.

Epoxy acrylate

Also known as Vinyl ester, these resins (which should not be confused with pure Epoxy – see below) offer improved properties compared to polyesters although they cure in the same way, and therefore show the same fast cure and good low temperature performance. Due to the different polymer they generally exhibit improved strength and importantly better chemical resistance.
Styrenated and styrene-free versions of epoxy-acrylates are available and again, the styrene-free products have the advantage in terms of better health and safety classifications.
Epoxy acrylate resins are mainly used for high strength fixings into concrete, and their good chemical resistance gives good performance, even in damp concrete.
Epoxy acrylate styrene-free products offer an excellent level of performance and many anchors using this type of resin are available with European Technical Approvals (ETAs).

A special type of polymer similar in performance to Epoxy acrylate is a Urethane acrylate. Typically, this type of polymer tends to give a tougher material but may have reduced chemical resistance.

Pure Epoxy

Pure epoxy products are made from an epoxy resin and a hardener (usually amine based). They cure by a different "addition cure" mechanism from polyester or epoxy acrylate and as a result they lend themselves particularly to slightly different applications. Complete mixing of pure epoxies is vital, this is easily achieved with the mixer nozzles of most proprietary systems but more difficult with bulk mixed types [1].
Due to their different nature they are often supplied at closer to equal mix proportions e.g.1 to 1 to 3 to 1, compared to Polyester or Epoxy acrylate which are usually 10 to 1 through to 3 to 1. They tend to be slower curing and exhibit virtually no shrinkage, which typically gives them considerably better load performance. The low shrinkage also makes them more suited to use in a diamond cored hole, or for a fixing with a large annulus. The slow curing can also be advantageous in hot climates and also for reinforcing bar, where the slow cure gives more time for the injection of material and placement of the bar.
There is even more choice when selecting the materials used in pure epoxy formulation and the expertise of the manufacturer becomes even more important.
Pure epoxy products typically have good chemical resistance and excellent adhesion, and can be more versatile than polyesters. Their low temperature curing tends to be worse and although some formulations are capable of slightly lower temperature curing they are generally not recommended for use below +5°C.
In terms of health and safety, the resins and hardeners used generally give the products a higher risk rating.

Hybrid systems

Some manufacturers market blended 'hybrid' systems which use cement as an additional component. The incorporation of cement in one component and water in the other may increase performance.

CONCLUSION

The informed selection of resin anchors is very important to ensure safe and long lived fixings. This selection can be difficult when the properties of the different types of resin are not fully understood. Once this is clear however it enables the best and most suited product to be used. Once a particular type has been selected it should only be changed if the key application characteristics are still satisfied by the proposed alternative.

[1] See an article, also on this page of the website, "Delivery Systems for Resin Bonded Anchors."