PROCEDURES

Crack Repair

INJECTION METHOD

Injection Method

APPLICABLE FOR BLUEY TECHNOLOGY PRODUCTS:
BluRez Carbostop W, BluRez Crackseal NV, BluRez Crack Seal 150 and BluRez Epoxy 111.

INTRODUCTION

Injection is “the pumping of a stable fluid generally named ‘injection grout’ into rock and soil to fill completely all cavities, voids and cracks, creating a solid sealed mass” (Volpi, 1998).

Injection grouts aid in waterproofing and corrosion protection and are useful for structural purposes. With such varied uses, different grouts with different properties and characteristics are necessary for the different purposes. In general, though, grouts for crack repair should have low viscosity, low shrinkage, high bond strength, and high stability at the repair temperature

We at Bluey Technologies here summarise the main grout product groups used for injection. A particular grout could be perfect for one application but totally inappropriate for another. It is therefore particularly important to understand the specific characteristics of any grout before applying it. Detailed technical data sheets (TDSs) are available for each product in the Bluey Technologies range; you can find these on our website (www.bluey.com.au). In order to select the correct category of injection grouts, please refer to the following summaries of the relevant information about each.

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EPOXY RESINS

Epoxies are a combination of resin and hardener that react to form a non-foaming elastic grout that bonds poorly with water. The reaction dissipates heat, which causes the evaporation of the solvent and consequently allows the resin to cure. Epoxy resins' general characteristics include (a) good adhesion to metals, concrete, and ceramics, (b) little volume change during and after curing, (c) high tensile and compressive strength, and (d) high resistance to chemicals.

POLYURETHANE RESINS

Polyoil and isocyanate react to form a high-strength adhesive material with the flow characteristics of a resin. Polyurethane is versatile, which makes this type of resin particularly flexible for application. These resins can show such different properties, in either their liquid or hardened phases, as viscosity, thixotropy, foaming reaction in the case of hydrophilic resins, and mechanical strength. Their general characteristics include notably low viscosity, rapid curing, and flexibility.

Polyurethane resins can be separated into the three main categories of (a) hydrophobic and hydrophilic water-reactive polyurethane grouts, (b) two-component foaming grouts, and (c) two-component polyurethane elastomers.

CEMENTITIOUS GROUTS

These grouts are composed of a combination of cement and water with the addition of admixes or additives to alter their characteristics and properties. They are classified in the three categories of (a) pure cement mixes (PCMs) composed of cement and water, (b) admixed cement mixes (ACMs) composed of PCM and admixtures, and additive cement mixes (ADCMs) composed of ACM and additives.

Admixes include plasticisers and superplaticisers to alter the cement's viscosity, and accelerators to alter the curing time. ADCMs are usually composed of an ACM plus Bentonite, and may contain such other kinds of fillers as pozzolanic or non-pozzolanic additives.

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ACRYLIC RESINS

Acrylic resins are the result of a polymerisation reaction that occurs when resin and hardener combine to form a permanent gel. The grout formed in this way has low adhesive and compressive strength but considerable tear strength. Various additives can be added to speed up or slow down the reaction.

BLUEY TECHNOLOGIES GROUTS AND RESINS

For mixing and injection purposes we have separated our injection grouts into three separate categories to aid our clients through the process. These categories are dual component, single component, and catalysed.

DUAL COMPONENT

Injection material supplied in a dual cartridge or in ready-mixed form needs no pre-mixing, allowing you to go directly to the injection stage. For two-part products supplied by Bluey Technologies please refer to the mixing guidelines on the product's specific TDS to ensure the correct mixing procedure. Please note that some grouts require the complete mixture of both parts of the grout, but you can mix others based upon the required volume for the application.

We at Bluey Technologies recommend that you use a product-specific Bluey application gun and high-static mixer if the injection material is in dual cartridge format. The pressure the gun exerts is limited to the force the operator's hand applies. The application gun also delivers even pressure to both cartridges, which inject the correct ratio of the ingredients into the static mixer. Upon entering the static mixer the two ingredients become mixed through the helix nature of the inside of the tube. This ensures that they constantly move when passing each other, creating shear throughout the entire length of the mixer. The end product is a homogeneous grout that the gun injects.

SINGLE COMPONENT

Single-component cementitious grouts only require the addition of water to form a pumpable grout. In this case the mixing process and successful injection depends on the water-to-powder ratio. We at Bluey Technologies recommend that all our clients consult the product-specific TDS to ensure that correct ratio.

We also supply single-component injection resins ready for injection. They require no mixing.

CATALYSED

Some injection resins require a catalyst to initiate the reaction. The catalyst is usually in the form of an additive that requires mixing in the correct ratio with the main component. It is important to adhere to the exact mixing ratio as specified on the TDS. The end mixture should be a uniform, smooth liquid.

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INJECTION PRODUCT SELECTION

Having come to understand the different characteristics of injection grout groups, you then need to find out which type of grout is best suited for your proposed repairs. In order to achieve this, we at Bluey Technologies recommend that all our clients produce selection criteria to aid them in selecting the correct grout. You need to base these selection criteria on the application's essential parameters. This is often the difference between a successful and unsuccessful application. Below are some important points to consider during the selection criteria process.

First, you need to consider the permeability of the soil or the width of cracks in the substrate. Each grout has a different permeability rating and crack-width limit. It is therefore important that you select a grout with the correct characteristics to ensure a successful application. You can use the diagram in Appendix A as a guide.

You then need to consider the presence of moisture or water. It is important to identify the amount of moisture and water in the substrate. Hydrophobic grouts do not bond or cure in moist conditions or where water is flowing. However, hydrophilic grouts require water to catalyse the reaction and only bond or cure in wet conditions.

Water pressure, or the hydraulic gradient, is another important consideration. Grouts for injection into running water have a limit in regard to the pressure under which they can be injected. From >2 bar to ≥7 bar is classified as high pressure, and >7 bar as very high pressure. It is necessary to record the water-pressure reading for comparison when reviewing the relevant grout or grouts' technical data.

Compressive strength also requires consideration. Identifying the compressive strength the grout requires ensures that the product you select is capable of withstanding the forces to which it will be subjected. Low compressive strength requires <10 MPa, medium compressive strength ≥10 MPa and ≤35 MPa, and high compressive strength >35 MPa.

You also need to know how much adhesion to the surface the grout requires. It is important to understand the degree of strength the repair requires to dissipate the applied forces successfully so the repair and substrate can work monolithically. The strength of the repair is directly linked to the adhesion of the repair material to the substrate. Low adhesion is <1 MPa and high is >1 MPa.

Furthermore, you need to determine whether you require the grout to expand to fill a void. The answer is either yes or no.

Then determine the reaction speed required. This is the speed at which the grout must harden and set, and depends on the presence of moisture or water and the water pressure. As a rough guide the speed of reaction can be categorised as slow (>24 h), normal (>6 h), accelerated (>15'), fast (>1'), or very fast (<1').

The next thing you may need to consider is the press-filtration limit, which is specific to cementitious grouts. Unlike the homogenous nature of epoxy and polyurethane resins, the components of cementitious grouts can separate during the injection process if the ratio of water to solids has not been balanced well (see Figure 1). This separation is known as press filtration. It is important to take the injection's press-filtration limit into consideration when selecting the correct cementitious grout for a job.

You can calculate the press-filtration limit using such specific data related to the grout as its viscosity and the grading curve of solid particles and the data from a geological survey of the substrate. Machon (1999) recommended that the diameter of the biggest particle within the fluid should not be more than one-third to one-fifth of the crack-width or porosity's diameter. This is to ensure that

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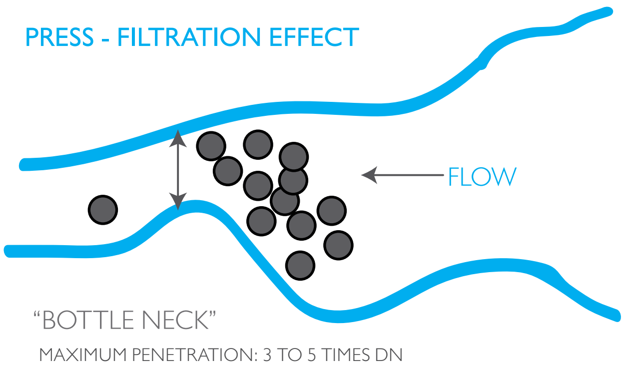
the grout's components stay together throughout the injection process.

Once you have established the selection criteria you can use the TDS's that accompany our grouts to select the right formulation for the job. If you need further help or guidance our experienced engineers would be pleased to help.

Figure 1: Schematic diagram representing the effects of press-filtration

PRESS - FILTRATION EFFECT



PREPARING THE SUBSTRATE FOR INJECTION

Crack-injection techniques are generally indicated for repairing cracks as narrow as 0.05 mm. Due to the cracks' narrowness the injection material needs to have low viscosity to penetrate and seal them. Injecting epoxy or polyurethane requires the drilling of access holes close to the crack being repaired. It is important to pay particular attention to the drilling, as doing it incorrectly can cause further problems. We recommend that you drill the holes at 45º to the crack line and at least 100 mm away from the crack (figure 2a).You should also drill the access holes approximately 200 mm apart along the full length of the crack (see Figure 2b).

100mm

45º

Figure 2a: Cross-section view showing the correct drilling of holes when preparing for crack injection.

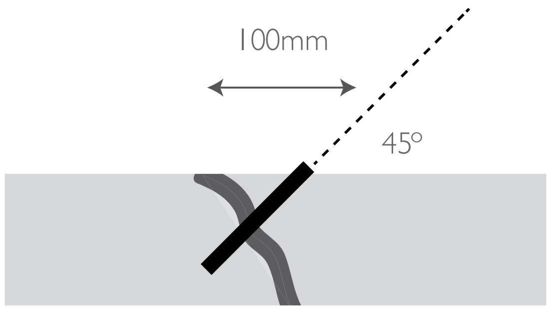
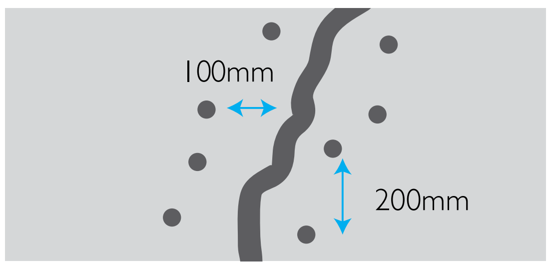


Figure 2b: Vertical view of a crack showing the ideal positioning of the drilled holes when preparing for the injection of crack filling



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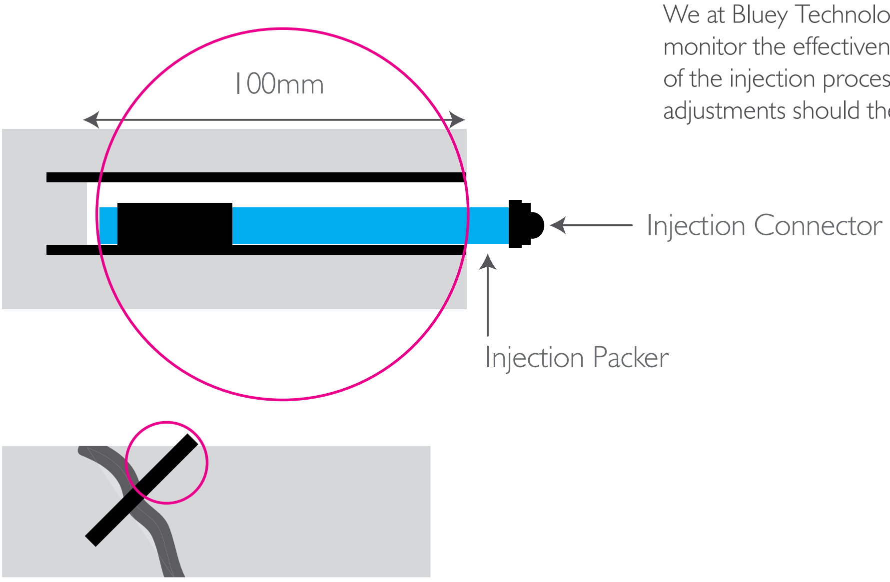
Once you have drilled the holes you need to clean the crack to remove any of such contaminants as oil, grease, or fine particles of concrete, as these may inhibit the effectiveness of the bond. We recommend vacuuming or flushing with water or cleaning solutions. If the injection material requires a dry environment for application it is important to consider this prior to cleaning.

You should seal all drilled holes with either a Bluey knock-in (12 mm ∅) or mechanical screw-in (13 mm ∅) injection packer. Having installed the packer to a depth of 100 mm, you need to attach the appropriate Bluey injector connector to fit the pumping system you are using (see Figure 3).

INJECTION PACKER

Figure 3: Schematic diagram showing the insertion of an injection packer and the injection connector



THE INJECTION PROCEDURE

The injection process requires a pumping system to apply pressure to the injection material. These systems include hydraulic pumps, paint pressure pots, air-actuated caulking guns, and hand-operated application guns.

Once you have chosen the pumping system you should start pumping at the widest part of the crack and proceed outwards along its length in each direction. Turn on the pump and slowly increase the pressure to a maximum of 30 bar, or as the product's TDS advises. Stop pumping for every litre injected and allow one to two minutes for setting. Start and stop the injection until the packer no longer accepts material or you have reached the specified pressure.

Then move to the next packer and repeat the injection process. Continue until the crack is full and adequately sealed. Allow the material to settle for two to three days before returning to the site and completing any additional injections that may be necessary. Figure 4 provides a schematic representation of the setup.

We at Bluey Technologies advise all applicators to monitor the effectiveness of the work at each stage of the injection process and to make any necessary adjustments should they be required.

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FACTORS TO CONSIDER WHEN INJECTING

It is important not to exceed the manufacturer's guidelines for the maximum pumping pressure to use when injecting a product. We at Bluey Technologies have specified the maximum pumping pressure for each of our products. Exceeding the recommended pressure can aggravate existing cracks and cause additional damage.

It is important to undertake extensive cleaning procedures before injecting grout in order to remove dirt and fine particles. Flush with water and then dry with compressed air unless you are using a hydrophilic injection resin. These cleaning techniques require a high degree of skill and specialist equipment to ensure their effective execution.

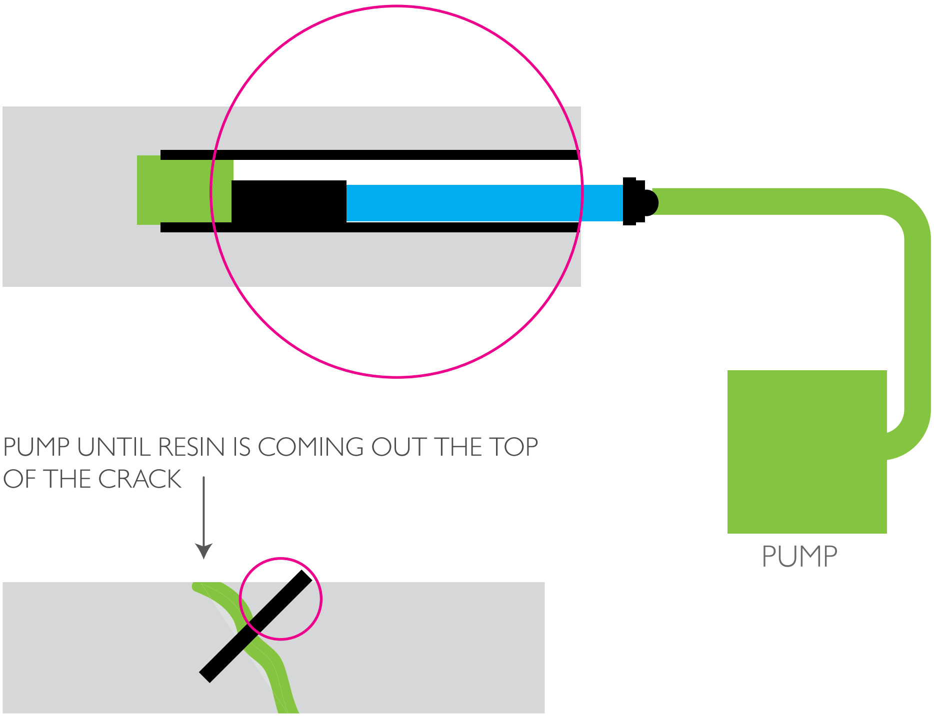
You need to monitor the success of any injection repair system. We recommend ultrasonic testing or drilling concrete cores as acceptable methods for evaluating the state of the repair.

IMPORTANT NOTE

Bluey Technologies offers this application document as a standard guide for the application of our crack-injection products. It remains the responsibility of the engineer or client to determine the correct method for any given application.

Bluey Technologies accepts no liability, either directly or indirectly, for any losses suffered in connection with the use or application of our products, whether in accordance with any advice, specification, recommendation, or information it has provided or otherwise.

Figure 4: Schematic representation of the pumping process. This should be repeated for each injection packer along the crack.



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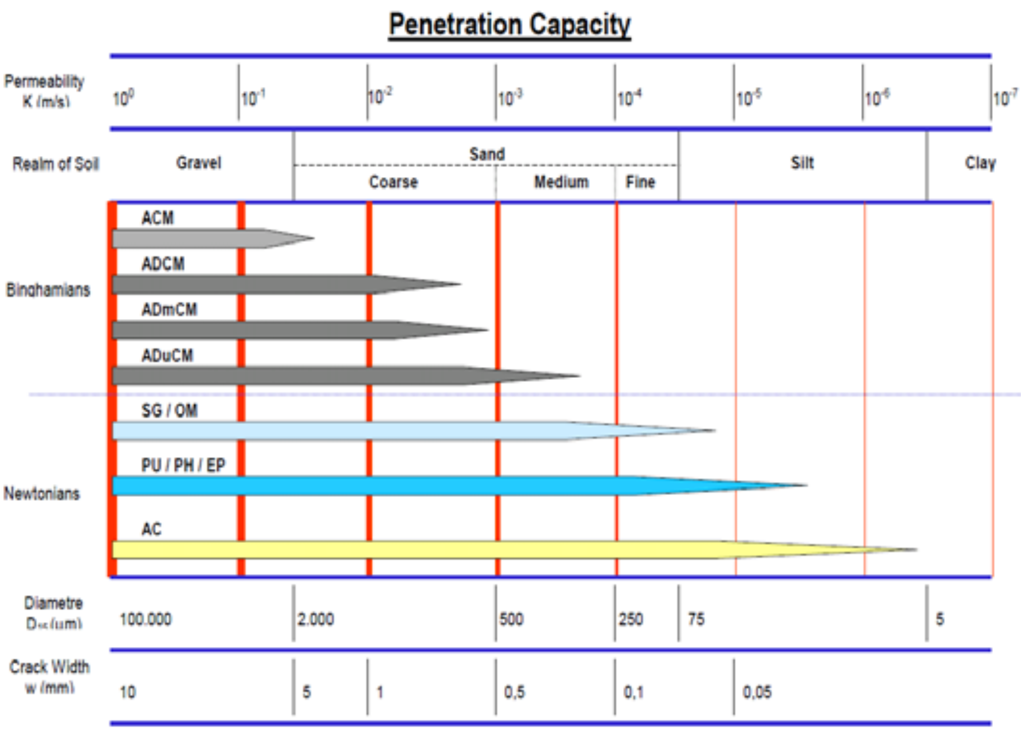
REFERENCE

Machon, R. J., Consulting Ingenieur Services GmbH, 1999, Injektionen – Wiederherstellung von Tunnels, 1st. International Congress for Grouting Technique in Mining and Civil Engineering

APPENDIX A



STATEMENT OF RESPONSIBILITY

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