PROCEDURES

Mixing & Pumping Cementitious Grouts

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INTRODUCTION

We at Bluey Technologies have produced this document as a reference guide to help our customers through the process of mixing and pumping cementitious grouts. We do not intend to cover every single aspect of the mixing and pumping process, but aim instead to answer many frequently asked questions about it. If this does not answer one of your questions, or if you encounter a complex situation, we encourage you to contact one of our qualified engineers.

It is important to consider numerous factors both before and during the mixing and pumping process. This document details the most important ones.

THE GROUTING MATERIAL

Bluey Technologies provides grouts for various purposes. Our cementitious grouts cover the requirements for floor self-levelling, rapid strength gain, reinforcing strata, general void filling, and grouting in underwater conditions. Each grout has different characteristics and therefore influences the mixing and pumping process in different ways. You can find the characteristics of each cementitious grout on the technical data sheet (TDS) that accompanies the product. Before you start mixing it is important to understand the grout's characteristics fully in order to plan and implement the most efficient mixing and pumping process. Ignoring this point may lead to an unsuccessful process and cost you time and money.

SELECTING THE RIGHT CEMENTITIOUS GROUT FOR THE JOB

All the cementitious grout products in the Bluey Technologies BluCem range have been produced for specific purposes. They contain multiple additives to provide their unique characteristics. They are all one-component powders that require only the addition of water to produce a pumpable product. The following descriptions of the products in our BluCem range clarify their differences.

BluCem High Builds (HB) have high strength and durability. BluCem High Strength (HS) produces grouts that are sometimes required for structural integrity and for structures subject to high loads. HS grouts have been designed to return structures to their original strength or to increase their strength. BluCem Underwater (UW) are special grouts designed to react with water to allow grouting in underwater conditions. BluCem Fast Setting (HE) have fast setting times to allow structures to return to service quickly.

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POINTS TO CONSIDER BEFORE MIXING THE GROUT

In order for you to pump grout effectively it must be a homogeneous solution with flowable characteristics. The mixing process is the key to generating the correct viscosity and smoothness for this. The TDS that comes with each grout product that Bluey Technologies supplies contains specific information about mix ratios, yields, set time, and compressive strength. Please note that these figures may alter in different or unique situations or environments. We therefore suggest that you consider the following factors when specifying the mixing and pumping process.

STANDARD OF MIX WATER

You should use potable water in the mixing process to enable correct hydration to occur. You should make every effort to avoid using surface water or water containing a high percentage of dissolved mineral content, as this could affect the grouting material's performance.

MIX WATER TEMPERATURE

The mix water's temperature should be kept as low as possible to prevent the grout from hydrating too rapidly. The warmer the mix water, the more rapid the rate of hydration and the higher the pumping pressure at any pumping rate.

POWDER AND ATMOSPHERIC TEMPERATURE

As with the water temperature, the higher the air temperature the more quickly the grout hydrates and sets. We at Bluey Technologies specify specific mixing times and set times at an ambient temperature of 20°C. We advise you that these times do vary with temperature fluctuations, and you need to make adjustments to compensate for this. Exposing the hose to the sun on a hot day accelerates the product's set time. In some cases it may be worth cooling the material, the mix water, or even the hose itself during the process and pre-planning the storage of all materials to keep the temperature as low as possible.

MIXING FRICTION'S IMPACT ON TEMPERATURE

High-shear mixing can add 1 to 2°C per minute of mixing. In order to minimise this effect, you need to add all ingredients to the mixer as quickly as possible and minimise prolonged batch-mixing procedures.

YIELD

There is no point in mixing more product than you can pump before the product sets. Some Bluey Technologies products' TDSs contain information on pump life that you should take into consideration before mixing them. Pump life is related to changes in the characteristics of the grouting material during the process. Its viscosity increases as it starts to cure, causing the pressure required for pumping to increase. This increased pressure reduces the application's efficiency and increases the risk of the pump blocking or exceeding the maximum pressure it has been designed to handle. We at Bluey Technologies recommend that you calculate to determine the correct volume of grout required before you start mixing.

CURING TIME

The grout-curing process goes through a series of phases. These are (a) increasing viscosity, (b) the gel phase, (c) initial set, (d) final set, (e) and cure. Keeping the grout moving in the mixer delays the onset of the gel phase and ultimately prolongs the length of curing time. This is an important point when you require a short curing time.

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WATER VOLUME

The ratio of water to solids within the grout solution is a key determinant of the final grout's durability, viscosity, stability, cohesion, and strength. High volumes of water produce weaker and less viscous grouts and can cause segregation between its different components during pumping, a process known as press filtration. Press filtration occurs when the grout is unstable. The water in the solution separates from the aggregate during pumping due to the pressure the solution receives, resulting in the water being pumped out and the aggregate being left behind. This (a) increases the chance of the pipe or mixer becoming blocked, (b) covers the substrate with water that may extend the application time in situations requiring a dry substrate, and (c) may force you to repeat the application.

One way in which Bluey Technologies has adapted its grout products to minimise the required water volume is by adding superplasticisers to the formula. Superplasticisers allow the product to maintain strength and cohesiveness whilst maintaining the ability to flow. Once again, we stress that you should add only potable water to our grout products during the mixing process.

One way to control the water volume is to use such accurate water-measuring devices as a resettable water meter that you can preset to shut off when the desired amount of potable water has been added to the mixture. Both careful planning and pre-testing may also be required to achieve the correct ratio before the main application run.

ADDITIVES

Bluey Technologies adds certain additives to specific grouts to increase or decrease their setting time or to control bleeding. This is particularly true of repair mortars and other spray-applied materials that need to gain strength fairly rapidly. It is extremely important to understand the effects that such additives have on the grout mixture when you select a mixing and pumping process. If the grout has a rapid set time you need to pre-plan to ensure enough time to mix it in a batch mixer before it sets. If you fail to do so the grout may start to set in the mixer and block the pumping lines, wasting product and time, and ultimately increasing the operation's cost. Therefore, be sure to check the grout's pump life before mixing and pumping.

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SELECTING THE CORRECT EQUIPMENT FOR MIXING AND PUMPING

It is extremely important that the equipment you use to mix, store and pump the grout is compatible with both that grout's specific characteristics and the project's requirements. In projects that involve mixing large volumes of grout it is important that the storage equipment is sufficiently large to hold the volume and to maintain the correct consistency of the grout. The grout's quality depends significantly on the quality of the mixing process.

PADDLE MIXERS: MIXING BY AGITATION

The grout-mixing process with paddle-mixing machines involves a stirring action that generates minor shearing forces to blend the mix components together continually. They then gravity-feed the resulting product into a holding tank or agitator. They can closely monitor the water-cement ratio. They are batch mixers, which means the operator adds the water and cement before starting the mixing.

Their principal limitation is that it is possible that unmixed cementitious lumps may be within the mix. This is a sign of an unstable product, and can cause such problems as blocked pumping equipment or a grout with the wrong characteristics.

You should use this mixing method with grouts that have a high proportion of solids and therefore require mixing under low shearing forces.

Paddle mixers are available with different styles of blades. Those with pitched blades are ideal for providing radial and axial flow, which are the two components that generate good mixing. Those with curved blades are ideal for starting up in a tank of settled solids.

They do generate a circular motion during this process, and you need to minimise this to ensure a good blend of the substances. We at Bluey Technologies suggest offsetting the axis of rotation to minimise circular motion, but this is limited to lower-energy applications to prevent the load from stressing the agitator arm. Another solution is to add baffles to the tank, as shown in Figure 1.

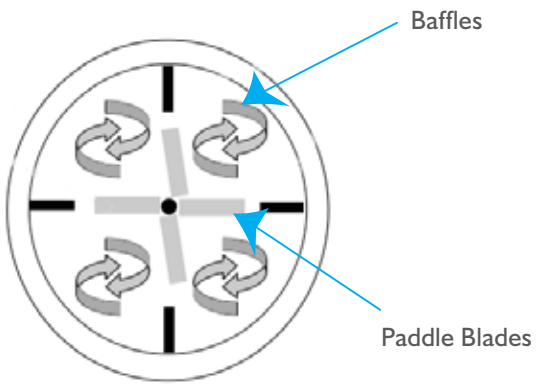

Figure 1 - Flow in a paddle mixer with the introduction of baffles to reduce circular flow

COLLOIDAL-MECHANICAL MIXING: CREATING HIGHER SHEAR

The basic process of high-shear mixing involves the introduction of one liquid, solid, or gas ingredient into a main continuous liquid with the aim of producing a homogenous solution. When mixing grouts this process usually mixes powder, water, and additives, depending on the grout's type and function. It is important to mix the ingredients for a sufficient amount of time to ensure that a homogenous solution forms. The process relies on the mixer creating high shear forces to ensure that the different ingredients move at different speeds, allowing the continuous movement of one into the other. Two types of high-shear mixers are batch and continuous.

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BATCH HIGH-SHEAR MIXERS

Batch mixing requires the completion of a full mixing cycle before the mixer can pump the mixture out. Once a batch mixer has produced a batch it is common practice to transfer the load into an agitator that holds and slowly maintains the grout's homogenous state. This frees the batch mixer to process another batch. This is a useful process when you require continuous pumping, as it provides a continuous supply of grout. Large applications may require the setting up of multiple mixers and agitators to serve the job's requirements.

The batch-mixer process involves feeding the components to be mixed into the mixing tank from the top. The mixing tank contains the mixer on a rotating shaft at the tank's bottom. When the mixing blades rotate they produce high shear forces that naturally create a speed differential between the inside and outside of the mixture. These mixers pump water from the mixture continuously from the bottom of the mixture and feed it back into the top of the mix tank to ensure continuous mixing.

Their benefits include (a) the faster mixing of a given volume of material at the same power rating than continuous inline rotor-stator mixers and (b) the ability to mix large volumes of grout in one process.

Their principal limitation is that the accumulated impact of higher mixing volumes than continuous inline rotor-stator mixers could be the difference between a profitable and unprofitable process, as they may produce waste products due to their insufficient pumping rates.

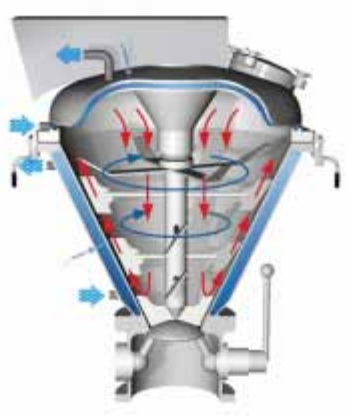

Figure 2 - Schematic diagram of a high-shear batch mixer (Source: 'Get your slurry in a hurry with high-shear mixer' in www.engineerlive.com)

CONTINUOUS MIXERS

Continuous mixers use a constant feed of product through a pipe whilst adding water automatically to the mix at a set ratio. The system consists of a pipe containing a series of inline short elements. The pipe is open at both ends and the system pumps the grout components through it, the elements continuously splitting and turning the fluid through 90°. The constant twisting of the fluid throughout the length of the mixer generates shearing forces that change the fluid's speed from one section to the next. The differences in velocity between the fluid sections ensures that the system mixes all the components into a homogenous grout (Figure 3).

You can repeat this process if necessary to ensure that the grout mix has the correct consistency. You can also use this method as a supplement to batch mixing, drawing the mixture from the batch mixer through the inline high-shear mixer and then back into the batch mixer.

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Continuous mixers' benefits include their mixing process being more closely controlled than in batch configurations due to the mixer being positioned in a flowing stream. This means that the operator can monitor the number of passes made through the high-shear zone and can add additional components to the mixture with a good knowledge of the outcome. The inline mixer also does not need to be removed from the mix tank for regular maintenance.

Their principal limitation is that you need a substantially larger inline unit to duplicate the processing capacity of a batch mixer.

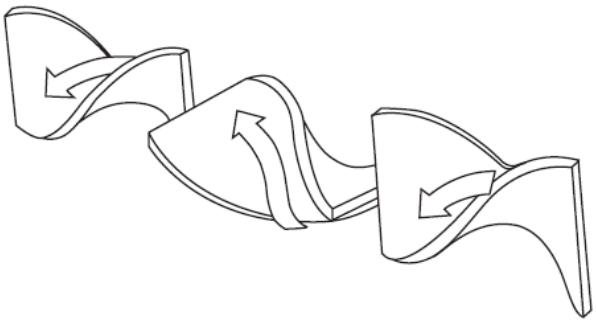

Figure 3: Inline static mixer elements create shear forces that allow continuous mixing of the grout components.

GROUT MIXER SPECIFICS

Various models of batch mixers and continuous mixers are available on the market, all with varying specifications. It is particularly important to match your application's specifics with the capabilities of the mixer and pump. We at Bluey Technologies recommend that you research the various mixers available thoroughly to ensure having the correct one for the job. Some key aspects to consider include their dimensions, power source, weight, speed, capacity, and hose type.

First note the space available on-site for the machine. As mixers are available in different sizes, it is important that you select a machine with the correct dimensions for the job. Both electrically and petrol-driven machines are available. The mixer's weight determines whether you need specialist lifting machinery at the job site to unload and load it into place safely. Mixers have different speeds that determine their mixing capabilities. We advise you to identify the product-specific mixing speed before selecting a mixer in order to ensure having one with the correct settings for the job. It is also important to select a mixer with the right capacity to ensure an efficient mixing and pumping process. Most mixers come with a discharge hose. It is important to get the right length and diameter hose for the application to ensure an efficient application. If the hose supplied is not specific to the job you will need to find an appropriate one. The next section will address this in more depth.

We at Bluey Technologies recommend that our clients contact Kennard Concrete Care, or visit their website at www.concretecare.com.au to obtain mixer-specific technical details.

THE PUMPING PROCEDURE

Once the grout has been mixed you need an effective pumping method to deliver it to the area of application. You can connect the pump either directly to the batch mixer or to the agitator. It is important to get the correct pumping equipment for the proposed application.

The correct type of grout pump varies with the conditions of the grouting application. In underground grouting applications it is more common to use a piston pump, whereas surface-based grouting tends to use mono pumps. It is important to select a pump that allows the operator to adjust the pressure and control the flow rate

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throughout the process to ensure that the system maintains the correct rates for the specific grouting application.

It is particularly important to try to keep pumping distances to a minimum and hoses running as straight as possible, as the introduction of bends increases the risk of blockage, and the longer the pumping distance is the greater the chance of losing pressure during the grouting procedure. Some grouts simply cannot be pumped for long distances due to their characteristics. We advise all operators to understand the characteristics of the specific grout, including its maximum pumping distance, before attempting the main application. In some cases it is advisable to carry out a test run.

The pumping hose, or grout line, must have a pressure rating that exceeds that of the maximum anticipated grout pressure. It is also important that the diameter and length of the hose be specific to the application's requirements. All hose connectors should also have a pressure rating greater than the anticipated grouting pressure.

In some situations the grouting application may require the use of an injection packer. Operators use these to seal boreholes in order to allow the grout to flow through and build up pressure within them. Once the pressure has built up the grout flows into the cracks and seals the substrate.

BASIC MIXING AND PUMPING PROCEDURE

SITE SETUP

Pre-plan the work area for the procedure. It is important that the operators have ease of access to a water supply and, if required, a power supply. You also need to consider the disposal of waste materials and wash-out residue.

In some situations you need to ensure access for lifting and loading machinery. Plan the machinery setup, as operators need easy access to all parts of the equipment in case a blockage occurs. Furthermore, long pipes may present a trip hazard. Such solid materials as cement, fly ash, and sand should be readily accessible to ensure an efficient mix process.

Jobs with high production rates require multiple mixers and agitators, so ensure that you have enough space to accommodate these and to set them up in a formation that allows efficient switching between systems.

EQUIPMENT PREPARATION

Visually inspect the pump and mixer or mixers for foreign objects. Remove any if necessary and then connect all the equipment, ensuring that all operating valves are placed in the "NEUTRAL" or "OFF" position and that the power source is set at "OFF." Then turn on the power source and check each mixer for functionality by running the mixer through its various settings.

Rinse the mixer or mixers and charge the pump hopper with sufficient water to flush the pump and all grout lines thoroughly. Check to ensure that all lines and hoses are clear and unobstructed.

Test the pumps discharge pressure to ensure that it can achieve the correct rating. When the operator is satisfied that the mixer and pump are ready for the procedure, you can shut the pump off and drain the water.

Depending upon the specific grout you are pumping it may be necessary to lubricate the system with cement or water slurry before adding the production material, as some pre-blended materials and some on-site mixes of sand and cement both tend to separate and clog the hoses upon contact with residual water. You need to pre-plan this to make the operators aware of it.

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GROUT APPLICATION

Ensure that everyone on-site wears the correct personal protection during the mixing and pumping procedure.

Mix the desired volume of grout following the product guidelines and any pre-planned requirements, including pump life and water-to-solids ratios.

Load approximately 80% of the water anticipated for the batch size to be mixed. Then, with the mixer running, add the required amount of powder.

Continuously monitor both the pumps and the mixers or mixers' performance, being alert to any changes in conditions.

Keep the mixer or mixers free of material build-up, keep the outside of the machine clean, and ensure the correct pressure ratings are maintained throughout the procedure.

Do not let the pump run when it contains no product, as doing so causes severe damage.

THE CLEAN-UP PROCESS

Dispose of excess production material in the correct manner. Carefully wash out mixer tanks and agitators into the pump hopper and pump the resulting washout material through the grout hoses to a suitable disposal site. Continue this operation until the hoses discharge only clear water. Drain any water out of the lines and hoses. Clean down the machinery and surrounding areas.

IMPORTANT NOTES

Please note that this document has been specifically written for use with cementitious grout products from the Bluey Technologies range. You can find additional documentation for resin- and epoxy-based grouts on our website.

Bluey Technologies offers this application document as a standard guide for the mixing and pumping of our cementitious grout products. It remains the responsibility of the engineer or client to determine the correct method for any given application.

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