

## **Engineered low strength grouts for use in construction projects.**

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### **Low-strength grouts making a difference.**

Engineers routinely specify high strength, high density grouts for various and wide ranging applications on different projects. Whilst high strength materials are necessary for these high performance applications often the grouting/void filling solution calls for a different, lower density material. These lower density grouts do however come with a trade off on strength i.e. lower strengths in line with the lower density exhibited by these products.

Consultants, Contractors, and Engineers are sometimes unaware of other products in the marketplace offering lower strengths which are better suited for the projects in hand and that provide better overall solutions than more traditional grouts.

Foam concrete with densities as low as 400 kg/m<sup>3</sup>, lightweight aggregate and bentonite/cement mixes have all been successfully used in many grouting applications where their low density and concomitant low strength, coupled with other unique features and benefits, have contributed to meeting

the grouting requirements on site. A key feature of these materials is that they are typically more cost effective than conventional materials. This is as a result of the overall 'powder' content of these low density mixes which are typically around 20% of normal grout mixtures. Like all mixes however a decrease in powder content does reduce strength.

One material that stands out, performance wise in the category of low density/low strength grouts is bentonite or, more specifically, bentonite/cement and bentonite/cementitious grouts.

Bentonite is the commercial name of a whole range of natural clays with a high water absorption capacity causing it to expand and swell. Bentonite predominantly consists of montmorillonite. It can absorb up to 10 times its own weight in water and can swell to 18 times its dry volume.

The use of bentonite is not new, however with the introduction of innovative grout mix designs and improvements in process, equipment and placement techniques has resulted in a rise in use of bentonite containing grouts providing unique and lasting solutions to often complex problems experienced on site.

Bentonite grouts exhibit a density typically in the range of 1000-1350 kg/m<sup>3</sup> with a cementitious powder content of 100-450 kgs/m<sup>3</sup>. Whilst the bentonite grout will exhibit low strength it will provide less shrinkage, less bleed and less thermal build-up of heat when compared to a grout with up

to 1200 kg/m<sup>3</sup> of cementitious powder in the mix. This thermal build-up can be a particular cause for concern as the higher the cementitious powder content then the possibility of thermal cracking increases.

When water is added to cement an exothermic reaction (hydration) occurs that produces heat. The rate of heat generation is higher in the initial stages of setting and reduces gradually over time. In mass concrete structures, a significant temperature gradient is generated between the core and the surface.

This build-up of heat can cause thermal cracking and in extreme cases can cause rupturing of the placed material.

Mineral additives can be added to compensate and mitigate against this heat of hydration. Examples of these additives include ground granulated blast furnace slag (ggbfs), pulverised fuel ash (pfa/fly ash), bentonite, and limestone powder. In large structural concrete pours (dam walls as an example) ice is often used in cooling the concrete mix prior to placing.

Over the last few years, our company, Bentonite Manufacturing & Supply Ltd (BMSL) has been successfully using a range of special pre-blended bentonite mixtures in conjunction with cement, silica sand, limestone dust, pfa and ggbfs. The individual constituents and proportions are dependent on the required properties of the grout and project requirements.

Our mixes can be engineered and designed to obtain 28-day strengths ranging from 3-5000 kPa (0.003-5

N/mm<sup>2</sup>) with densities in the order of 1000-1350 kgs/m<sup>3</sup>. Due to the unique properties of bentonite, these mixes exhibit little or no bleed water once placed.

Low powder contents and low strengths ensure that there is minimal heat build-up which, as previously mentioned, could cause thermal cracking or worse, rupturing. The placed low density grout also has the added benefit of being easily removed at a later date if required.

Bentonite Manufacturing and Supply Limited (BMSL) is a family-owned run business and was formed in 2014. Prior to the formation of BMSL, the owners acquired over 40 years' experience in the supply of light weight concrete (Foam Concrete Limited) and specially designed grouts.

The Company has invested in bespoke high and low volume output equipment which can manufacture any volume from 2 m<sup>3</sup> to 300+ m<sup>3</sup> /day and with the ability to pump bentonite slurries up to 2000+ linear metres.



**Site set up of 16m<sup>3</sup> batching mixing unit producing up to 300+m<sup>3</sup> /day**

BMSL has in place key raw material supply agreements with leading, quality assured material blending companies. These companies source the specific materials we require for different projects. Once sourced, the powders are blended to the prescribed mix design for a given project which can then be supplied either in dry bulk cement tankers or in 1-ton bulk/jumbo bags to site. Packaging and delivery options depend on which type of machine is required and the scope of project.

### **Typical Applications using Bentonite Grout**

- Void filling – to prevent water ingress or gas build up.
- Gas main ducting i.e. to control heat build-up and prevent migration of gas.
- Cut-off walls in order to prevent migration of contaminants in soil.
- Dam walls: as alternative or supplement to clay fill or to repair leaks.
- Canal/river bank stabilisation.
- Bund walls to protect the environment around sensitive installations
- Injection into leaking tunnel surrounds to prevent water ingress.
- As the grout can be pumped long distances i.e. up to 2000+ linear metres it is ideal for use in locations with poor access.

- Infilling of cable ducts (around electric cables) to dissipate the heat from the cable.
- Infilling of abandoned underground pipelines.
- Drilling bentonite is used as a mud constituent for oil and water well drilling.
- Secant pile walls (soft piles) typically specified as 0.7-1.0 MPa after 28 days.
- Geothermal piles
- Supporting piles to prevent collapse prior to infilling with concrete.
- Sealing a leaking lake or pond.
- Used for earthing mats from static discharge in electrical storm.

### **Benefits of Bentonite Cement Slurries.**

- Light-weight so low material cost. The typical SG of the final set grout is 1000 - 1350 kgs/m.
- Fast and ease of installation- can be mixed and placed on a continuous basis.
- Depth of pour presents no placing problems as no breakdown of material occurs in deep excavations.

- Excellent Sealing Properties – permeability values as low as  $1 \times 10^{-11} \text{m/s}$ .
- Lower solids content (low cost) as little as 100kg of solids /m<sup>3</sup> of slurry so cheaper than cement only grouts which are typically 1800kg/m<sup>3</sup> (cement 1200 kg plus water of 600 litres = 1800 kg/m<sup>3</sup>)
- Wide strength ranges of 30-5000 kPa (.003-5N/mm<sup>2</sup>) - can act purely as void filler or can match the strength of the surrounding ground.
- Flexible mix design formulation where the set time can be easily accelerated or retarded, and when mixed with geothermal sands, will produce high thermal conductivity grouts ranging from 0.7-2.0 W/mk.

### **The Role of Bentonite in Grout**

The fact is that at >0.6 W/C ratio, a grout needs some sort of suspending agent to prevent the cement settling, or alternatively, the use of bentonite at 2-10% by weight.

Pulverised fuel ash and ggbfs are effectively cheaper supplementary cementing materials. So the overall solids content is still very high at circa 700-1200kg/m<sup>3</sup> which, in turn, means grout density is high as is strength and material cost.

Bentonite on the other hand is a reactive solid, with much better suspension characteristics than either pulverised fuel ash or ggbfs so it makes

higher w/s (water/solids) grouts possible. These higher w/s ratios produce weaker grouts but they have the benefit of needing less material e.g. 400-500kg/m<sup>3</sup> for a 4-5 N/mm<sup>2</sup> grout down to 100kg/m<sup>3</sup> for a 3-4 kPa void filling grout compared to the 1200kg/m<sup>3</sup> of a cement only grout. The use of bentonite is therefore very cost effective with the added feature of being very flexible in terms of formulation and placement.

### **The Unique Characteristic of Bentonite Grouts**

Bentonite/cement grout has a significant and unique advantage over any other form of grout and that is its low permeability i.e. it is really excellent for sealing and protecting sensitive zones or containing hazardous zones that could contaminate the wider environment.



***Infilling cut off wall sealing contaminated land.***

Bentonite/cement grout can be formulated to provide extremely low permeability down to around  $1 \times 10^{-11}$  m/s. There is no other material which can provide such low permeability as clay, which is why clays and their metamorphosed derivative, shale, are the cap rocks that contain many oil and gas reservoirs and can even shield nuclear radiation.

### **How to choose the right grout for the purpose?**

The key questions to ask are:-

1. What Strength is required at 28-91 days?
2. Are you looking for a Sealing grout?
3. What permeability is required?
4. What depth of void is to be filled and how far must it be pumped?
5. What is the daily volume requirement?
6. Is a level of quantifiable consistency important?
7. Is thermal conductivity important?

### **Strength**

#### **Bentonite/Cement grout can be formulated in the range:-**

100-150kPa – Very weak soil, firm to touch but exudes between fingers when squeezed like putty.

600-700 kPa - Hard soil difficult to indent with thumbnail.

1000-1500 kPa – Very hard soil to weak rock that will crumble when hit with a hammer.

3000-5000 kPa – Weak Rock

Bentonite contents of these mixes can vary from 6% up to 80% of the total cement solids with dose rates in the range of 100-500 kg/m<sup>3</sup>.

### **Bentonite/Cement/GGBS**

B(MS)L have developed unique blends of material. These blends of special formulated grout (SFG) are all pre-blended products that combine relatively high strength i.e. in the range 500-1500 kPa, with a very low binder content in the order of 200-300kg/m<sup>3</sup>. Coupled to this is the exceptionally low permeability property in the range of circa  $1 \times 10^{-10}$  or  $1 \times 10^{-11}$

### **Sealing**

As previously mentioned, all bentonite based grouts provide very low levels of permeability

It can be noted that Pulverised fuel ash (Pfa) and ground granulated blast furnace slag (ggbfs) containing grouts do exhibit marginally better permeability than Portland cement only grout.

### **Placement**

Bentonite/cement grout can be pumped long distances provided the pumps and pipes are sized correctly. There is effectively no limit to the depth or quantity of bentonite grout that can be placed at any one time. Low strength bentonite/cement grouts set more slowly and so provide a much longer placement time.

## Consistency and Accuracy

Our Special Formulated Grouts (SFG) are delivered pre-blended whereby a computer controlled mixing system (that accurately measures the powder and the water additions) mixes the grout in purpose-built high efficiency mixers. The mixing system then provides a print-out of the quantity of material used. This added assurance of on-site testing and sampling guarantees that the material placed does in fact meet the design specification.



***Computerised control panel in the 16 m<sup>3</sup> mixing plant***

## Thermal Conductivity

For certain applications, like geothermal loop installation or electrical cable installation, it is desirable to match the grout conductivity to that of the surrounding ground.



## ***Infilling of electrical cable ducts***

Ground conductivity can vary significantly depending on its density, moisture content, and degree of compaction. Values can range from 0.6 to 1.5 W/mK

The conductivity of most cement or bentonite grout is 0.6-0.7 watts/m/oc .

However bentonite grouts can support large quantities of geothermal sand to produce grouts up to 2.0 W/mK but in practice a grout with a conductivity of 0.9- 1.5 W/mK works well for most applications.

The higher the density due to the sand content the more critical is the formulation and mixing, plus it becomes increasingly difficult to pump this material over long distances.

## **The Total Solution for Low Density/Low Strength Grouting**

Bentonite (Manufacture and Supply) Ltd, work with Clients/Contractors to recommend the grouts that best suit their needs on each project.

B(M&S)L offer a full package supplying the Special Formulated Grouts (SFG) mixing and placement to the Contractor.

This is achieved by accurate mixing and placement of the chosen grout using state of the art mixers and control systems that can produce/place up to 30 m<sup>3</sup> of bentonite grouts per hour.

**For further information please contact**

### **Bentonite (Manufacturing & Supply) Limited**

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