

Filling the Void

Engineered low strength grouts for use in construction projects

“Engineers routinely specify high strength, high density grouts for various and wide-ranging applications on different projects,” explains Lynton Cox – Director with Gravesend-based specialist, Bentonite Manufacturing & Supply (BMSL).

“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/m³, 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, and with the introduction of innovative grout mix designs and improvements in process,



Photograph Above. Bentonite can be used on secant pile walls (soft piles) typically specified as 0.7-1.0 MPa after 28 days and geothermal piles

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/m³ with a cementitious powder content of 100-450 kgs/m³. 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/m³ of cementitious powder in the mix. This thermal build-up can be a particular cause for concern

■ Winvic Construction (tel. 01604 678960) recently awarded two retaining wall contracts at its ICON site in Manchester to Aarsleff Ground Engineering (tel. 01636 611140 att: Ashley Carter).

The Newark-based specialist’s remit involves the installation of 170m of sheet piling, with a retained height of 2.5m and 81m of King Post Wall with a retained height of 4.25m.

■ Environment Agency (tel. 0370 850 6506) are at the project appraisal stage on its £74,000 (eur. 84,000) valued Bessy Brook Improvement Scheme .

The flood prone watercourse starts at High Rid reservoir and meanders through Lostock, near Bolton and through a number of residential areas before joining Middle Brook near Lostock Railway Station.

The scheme, which is due to commence in 2022, is intended to better protect 101 properties from flooding.

The Agency (tel. 0370 850 6506) are also currently at the project appraisal stage on its £759,000 (eur. 858,000) valued Calstock Flood Defence Improvement Scheme.

Work on the scheme, which is intended to protect 11 properties from tidal flooding, is expected to commence in 2021.

■ CleanEarth (tel. 0800 975 5635) are nearing the completion of the foundations for its 4MW wind turbine at Rush Wall Lane, Redwick.

The project, which is on the Gwent Levels near Newport, comprised the installation of 57 Nr. CFA piles which have been driven within a sheet-piled coffer-dam and through the peat and clay and into the bedrock.

■ Roscommon County Council (tel. +353 90 662 7004 att: David Meade) appear to be moving forward on its £106.1M (eur. 120M) valued N5 Ballaghaderreen to Scramoge Road Development with the main construction documents being finalised.

The 72-month scheme partly involves piling to facilitate the construction of three road under bridges, an overbridge and four river bridges; approximately 290m of retaining walls at three locations; and 14 Nr. culverts.

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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, we have 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.”

These mixes can be engineered and designed to obtain 28-day strengths ranging from 3-5000 kPa (0.003-5 N/mm²) with densities in the order of 1000-1350 kgs/m³. 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.

“The company was formed in 2014, but prior to its formation, the owners acquired over 40 years’ experience in the supply of light weight concrete (Foam Concrete Limited) and specially designed grouts and have invested in bespoke high and low volume output equipment which can manufacture any volume from 2 m³ to 300+ m³ /day and with the ability to pump bentonite slurries up to 2km in length.

“We have 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, these 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.



Photograph Above. Bentonite being applied

- Dam walls: as alternative or supplement to clay fill or to repair leaks.
- Canal/riverbank 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

■ Dublin-based National Treasury Management Agency (tel. +353 1 238 4000 att: Anthony Higgins) recently had tenders returned for appraisal on its Project Nore - Site Investigation Works.

■ Environment Agency (tel. 0370 850 6506) are currently at the project appraisal stage on its £1.05M (eur. 1.18M) valued Whimble Flood Defence Scheme.

Work on the scheme, of which the plans will be going out to Devon County Council (tel. 0845 155 1015) for approval,, is expected to commence in 2022.

On completion of the scheme, 53 properties will be better protected from flooding.

The Agency are also at the project appraisal stage on its £225,000 (eur. 255,000) valued Castleford Flood Alleviation Scheme - Replacement.

This scheme, which is also due to commence in 2022, is intended to protect 325 properties from flooding.

■ Tipperary County Council (tel. +353 761 065000 att: Peter Fee) are currently out to tender on its N65 Carrigahorig to Balleiragh - Geotechnical Investigation scheme.

■ North Killinghome-based Cube3 Construction (tel. 01469 541737) recently awarded a foundations contract at the Arbor Forest Products site in New Holland to Aarsleff Ground Engineering (tel. 01636 611140 att: Chris Glenn)

The Newark-based specialist’s remit involves the installation of 102 Nr. 200mm² by 15m-long driven precast concrete piles.

■ Dublin-based Housing Agency (tel. +353 1 656 4100 att: Fiona Fleming) have had tenders returned for appraisal on a scheme titled - Knocknaheany Avenue and Killala Gardens - CNWQR Phase 4A - Site Investigations Works.

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

- 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 extremely high at circa 700-1200kg/m³ which, in turn, means grout density is high as is



Photograph Above. Infilling of electrical cable ducts

problems as no breakdown of material occurs in deep excavations.

- Excellent Sealing Properties – permeability values as low as 1 x 10⁻¹¹m/s.
- Lower solids content (low cost) as little as 100kg of solids /m³ of slurry so cheaper than cement only grouts which are typically 1800kg/m³ (cement 1200 kg plus water of 600 litres = 1800 kg/m³)
- Wide strength ranges of 30-5000 kPa (.003-5N/mm²) - can act purely as void filler or can match the strength of the surrounding ground.

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 i.e. 400-500kg/m³ for a 4-5 N/mm² grout down to 100kg/m³ for a 3-4 kPa void filling grout compared to the 1200kg/m³ of a cement only grout. The use of bentonite is therefore very cost effective with the added feature of being

■ Developer Rural Renaissance (JS Crawford) (tel. 01896 822030) recently got the heads-up from Scottish Borders Council (tel. 01835 824000) for the construction of its proposed West Grove retirement development off Waverley Road in Melrose.

The scheme will involve piling to facilitate the construction of the Camerons Strachan Yuill Architects (tel. 01896 753077)-designed four-storey structure and 40-space car park.

■ Bord Na Móna Powergen (tel. +353 45 439000 att: Mary Brophy) have had tenders returned for appraisal on its Derryadd Windfarm - Site Investigation scheme.

The scheme will facilitate the construction of a wind farm consisting of 24 wind turbines and associated infrastructure on a 1.9ha site spanning the Derryadd, Derryaroge and Lough Bannow bogs which are located approximately 9km south west of Longford Town.

■ Hellens Group (tel. 0191 418 0020 att: Gavin Cordwell-Smith) recently awarded a retaining wall contract at Loadman Street, Newcastle-upon-Tyne to Aarsleff Ground Engineering (tel. 01636 611140 att: Nathan Follows).

The Newark-based specialist's remit involves the installation of 97m of King Post Wall, with a retained height of up to 1.8m.

Work is due to commence on site in October 2020.

Homes England, the government's housing agency, together with Hellens Group, recently entered into a Collaboration Agreement to progress the development of the 700-unit Burtree Garden Village residential-led mixed-use development, which is located at Faverdale on the western edge of Darlington.

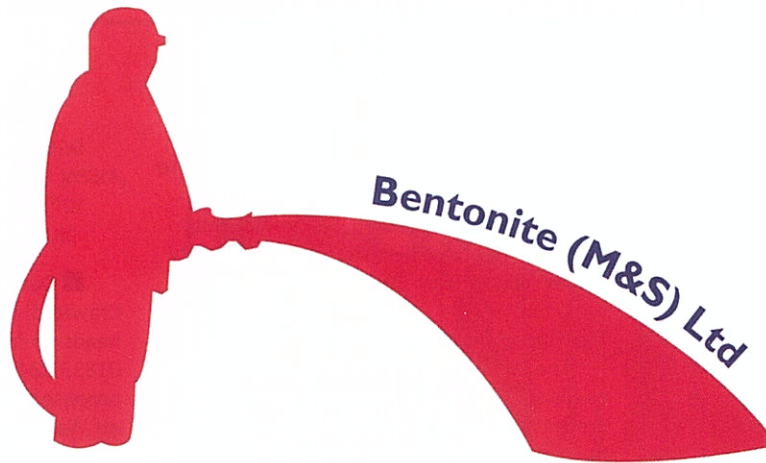
Piling and foundations on the scheme could start on site before the end of 2020.

■ Environment Agency (tel. 0370 850 6506) are in the early stages of assessment on a planned £9.54M (eur. 10.67M) scheme aptly titled the River Dearne Washlands Optimisation Study.

The capital project is intended to protect 190 properties from fluvial flooding.

The Agency (tel. 0370 850 6506) are also at the project appraisal stage on its £460,000 (eur. 520,000) valued Leigh Expansion and Hildenborough Embankments Scheme.

Work on this scheme is expected to commence in 2022.



Bentonite (Manufacturing & Supply) Limited is a Family owned company supplying special grouts and foam concrete to the construction industry. With bespoke equipment that can supply up to 300 m³ /day of bentonite blended materials and 400+m³/day of light weight foam concrete. We can offer special bentonite mixes for secant piles with strengths of 0.7-1.0 MPa @ 28 days. We can also supply light weight foam concrete to densities of 400 kgs/m³ with strength of 0.5 MPa. We have special materials for Cable ducting and also for Geothermal Loop Piling giving Thermal Resistivity of 1.2 -2.0 W/Mk and Thermal Conductivity of 0.795-0.499 MKw. Slurry walls we have special pre mixed material that can give a minimum permeability of 1 x10⁻⁹ m/s.



16 m³ batching plant and silo.



Slurry wall infill



Infilling underground electric cable ducts



Supplying secant piling rigs with a special pre-blended Material giving strength from 0.7-1.00 Mpa @ 28 days



Foam Concrete batching plant with silo fully computerized densities from 400-1500 kgs strength 0.5-10 MPa @ 28 days.

BENTONITE (MANUFACTURING & SUPPLY) LIMITED.
East Court Yard, Lower Higham Road, Chalk, Gravesend, Kent, DA12 2NZ.
Suppliers of Bentonite Grouts and Light Weight Foam Concrete.

Tel No;- 01474 825045
 e-mail;- sales@bentonititems.co.uk
www.bentonititems.co.uk

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

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:

3-5 kPa – Very weak soil, firm to touch but exudes between fingers when squeezed like putty.



Photograph Above. Infilling of cut off wall sealing contaminated land

around 1 x 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?

30-70 kPa – Soft plastic clay that can be deformed easily by thumb pressure

100-150kPa - Stiff soil, can be indented by thumb but which will support a person's weight.

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/m³.

■ Limerick City and County Council (tel. +353 61 556000 att: *Mairead Corrigan*) recently had tenders returned on an integrated engineering and environmental consultancy for the Limerick City & Environs Flood Relief Scheme.

Part of the project will involve the delivery of a geotechnical assessment of the existing embankments within the scheme area.

■ The Environment Agency (tel. 03708 506 506 att: *Vanessa Collins / Leila Huntington*) recently kicked off work on the £2.7M (eur. 3.05M) valued Ponteland Flood Alleviation Scheme in Northumberland.

The scheme, which is being undertaken by BAM Nuttall (tel. 0191 273 7000), will involve the online replacement of existing flood defences on the south bank of the River Pont, between the Memorial Hall footbridge and Callerton Burn Pumping Station, with one continuous sheet piled flood wall.

Work on the scheme is expected to be completed by spring 2021.

The Agency are also looking to move forward on the £4.1M (eur. 4.63M) valued Hexham Industrial Estate Flood Alleviation Scheme.

■ Kildare County Council (tel. +353 45 980 200 att: *Veronica Cooke*) recently issued a Request for Tender for the provision of consultancy services to carry out a Flood Risk Assessment of the next cycle of land use plans including up to 12 Local Area Plans.

■ Graham Construction (tel. 0161 877 5533 att: *Alastair Lewis*) are currently well into their work on the £90M valued Congleton Link Road on behalf of Cheshire East Council (tel. 0300 123 55 00) - a 5.5km-long road that connects the A534 Sandbach Road (to the west of Congleton) with the A536 Macclesfield Road (to the north of the town)

W&B Civil Engineering (tel. 01524 770433 / 07530 804426) have been utilised as a subcontractor and have undertaken the construction of a 40m x 22m by 8m deep storm relief tank including storm pumping station and incoming and outgoing pipework within a sheet piled cofferdam.

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Bentonite/Cement/GGBS

"We 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/m³. Coupled to this is the exceptionally low permeability property in the range of circa 1 x 10⁻¹⁰ or 1 x 10⁻¹¹."

Sealing

"As previously mentioned, all bentonite-based grouts provide exceptionally 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."

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.

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

■ IM Properties (tel. 0121 730 8050 att: Jason Jasper) recently awarded Northampton-based Winvic Construction (tel. 01604 678960 att: Rob Cook) a £21M (eur. 23.2M) valued contract for the construction of an employment park adjacent to junction 11 of the M42 in north west Leicestershire.

The scheme comprises an extensive earthworks programme, where over 1,000,000m³ of material will be excavated and remodelled to accommodate a development plateau along with 7.5km of underground drainage, together with major driven piling works and the construction of three areas of highway improvements.

The civils and infrastructure works are due to be completed in December 2021.

■ Environment Agency (tel. 0370 850 6506) are at project appraisal stage on its £1.5M (eur. 1.69M) valued Boston Tidal Defences Scheme (upstream of barrier).

Construction is due to start on the project in 2021.

■ Volker Ground Engineering (tel. 01772 708620) recently completed the installation of a 51.8m-long steel sheet piled retaining wall on the A27 Polegate bypass, east of Lewes, using a TM22 leader rig.

The Preston-based specialist pre-augered the ground, which consisted of stiff clays, before installing the Z piles and will complete further works to install two further walls at the Polegate Junction and Salt Barn in January 2021.

■ Department of Agriculture, Food and the Marine (tel. +353 1 607 2000 att: Gearoid O'Shea) recently had tenders returned for appraisal on its An Daingean FHC Small Craft Harbour - Ground Investigation contract.

■ NMCN (tel. 01623 515008) recently awarded a foundations contract at Cockfosters WTW, Barnet to Aarsleff Ground Engineering (tel. 01636 611140 att: Ashley Carter / Gemma Tatler).

The Newark-based specialist's remit involves the installation of 116 Nr. 450mm dia. contiguous piles for a temporary wall using a Soilmec SF-50 rig.

Piling is due to commence on site by early November 2020.



Photograph Above. Site set up of a 16m³ bentonite batching mixing unit producing up to 300+m³ /day

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

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."