ENW Celsius Substation Cable Trench Thermal Backfill Trials Installation Guide

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March 2018

Bentonite/ Silica Sand Mix Introduction

- The objective of the substation trials is to compare the performance of previously thermally monitored LV circuits with that when they are evenly surrounded by a thermally enhanced backfill mix.

Bentonite

- Has often used to increase the thermal conductivity of cables in ducts as it is much better than the still air in ducts.
- But has a lower thermal conductivity than some clays and silted gravels so it is unlikely to improve the ratings of cables that are directly buried in those types of soils.
- However, when mixed 10/90 with Silica Sand, the mix has a much higher thermal conductivity under both wet and dry conditions and should increase the effective surface area of the cable to the general backfill and thus increasing the cable ratings.

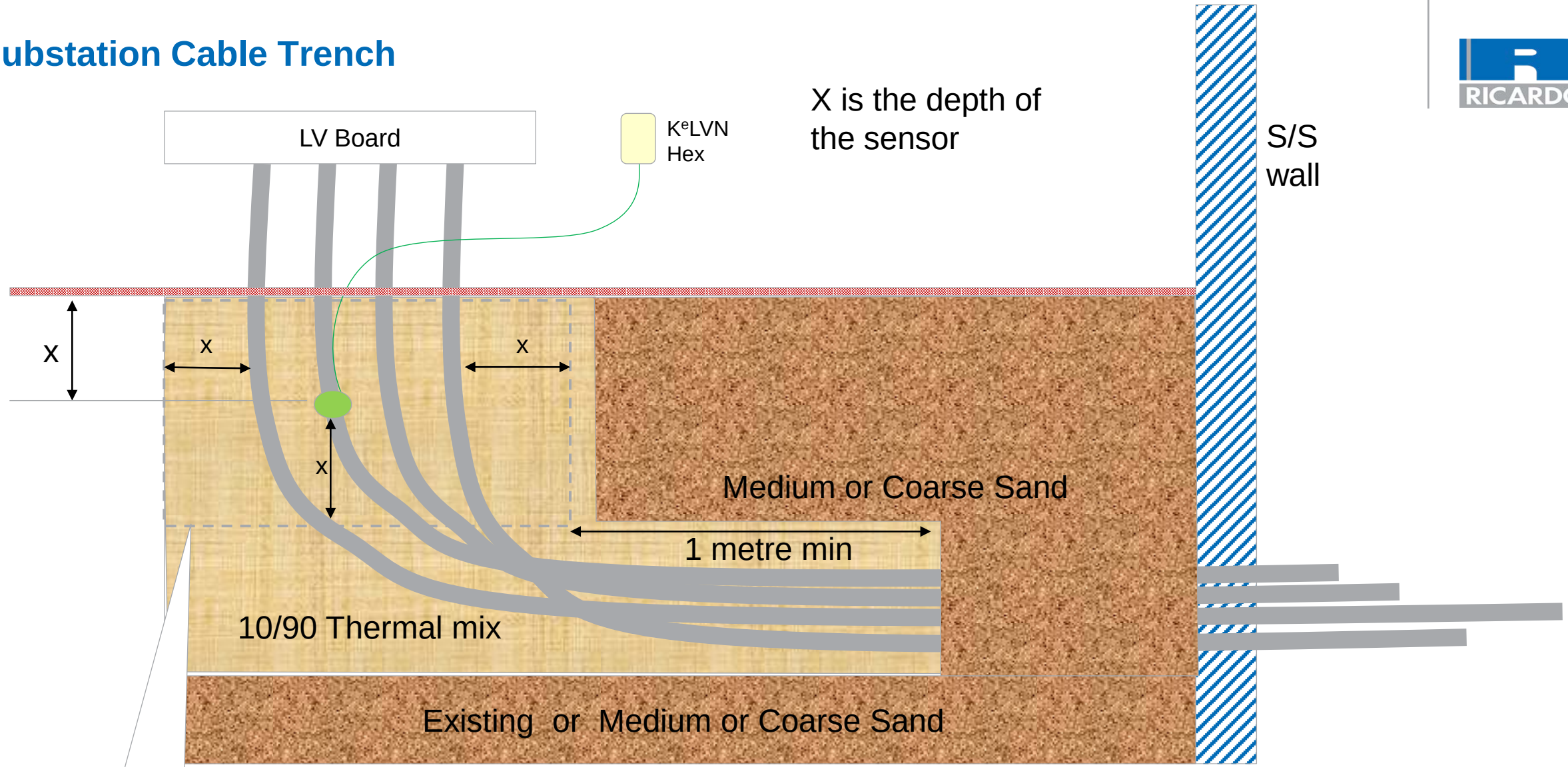
- **Buried PILSTA cables in previously sandy soils are likely to benefit more from this than are Waveform cables in the same conditions, since the external PVC sheath forms a significant barrier to thermal transfer.**

Installation Guide for Trenches Inside Substations
Introduction

- Some selected sites may have trenches filled with sand or soil backfill whilst others at present may be unfilled.
- All trial trenches will be backfilled but there are some installation differences for each of the above types that are noted
- One more LV cables will have a temperature sensor fitted to them, with a connecting cable to a K^{e}VLN Hex
- Care must be taken not to damage the sensor, cable or Hex.
- T**he position of the sensor must not be moved or rotated**
- The LV board should be screened an all ENW prescribed safety measures including the equipment to be used and the PPE to be used must be followed.

- The dimensions of the trench and the depth and position of the sensor(s) shall be recorded
- The date and time of starting practical works on site and completing the backfill shall be recorded
- Photos should be taken at each stage of the works
- Seek guidance if unsure

Substation Cable Trench



Read diagram in conjunction with the installation procedure

Installation Guide for Trenches Inside Substations

- Excavate trench (as necessary and practical) as per diagram
- Fill empty trenches to within 100mm of the underside of LV cables using **Medium of Coarse Dry sand** in 100mm layers, compacting each layer before adding the next
- Thoroughly Dry Mix 10 parts of **Bentonite SB** and 90 parts **Silica Sand** in a trough or cement mixer
- Add water and mix again until the consistency and workability is similar to that required for fresh concrete

  See ***just right*** https://www.youtube.com/watch?v=T8gKvi9XXN0
- Fill the relevant sections of the trench as per the diagram with the prepared **thermal mix** and other sections using **Medium or Coarse Dry sand**. And both in 100mm layers at a time
- Division between sections can be maintained with hessian sacking of other permeable divisions
- Compacting each 100mm layer before adding the next. Paying particular attention to ensuring the **thermal mix** is in full contact with the cable sheaths.
- Leave completed fill uncapped for a period of 3-4 weeks for settlement and water evaporation before filling as required and making good and completing the surface to match existing.
- At all stage leaving the site clean, tidy and safe for routine network operations

Procurement - Materials

RS Minerals Ltd

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Bentonite

Civil engineering and geotechnical applications
Sealing of ponds and lakes, effluent treatment
Production of drilling muds and seed coatings
Special Effects

Types of Bentonite

Several different types of bentonite are stocked and all can be supplied in 25Kg sacks; most are also available in 1 tonne IBCs. Bentonite powders can also be supplied in bulk (tanker deliveries):

Bentonex CB (calcium bentonite powder, also known as Fullers Earth) is used in pelletising applications, fertilisers, seed coatings and effluent treatment.

Bentonex SB (sodium bentonite powder) is ideal for the production of slurries and grouts for civil engineering and geotechnical applications. It is popular for the lining of lakes and ponds and is also used in effluent treatment.

Bentonex SB Granular (sodium bentonite granules) offers slow hydration, allowing use in deep water applications. It is ideal for a range of civil engineering and geotechnical applications such as filling cable trenches and the plugging of boreholes and landfill gas wells. This product is also used to improve electrical conduction around earthing rods.

Bentonite SB Granular
This is only an example supplier
Ricardo used this supplier for the Ridge trials – on time an as described

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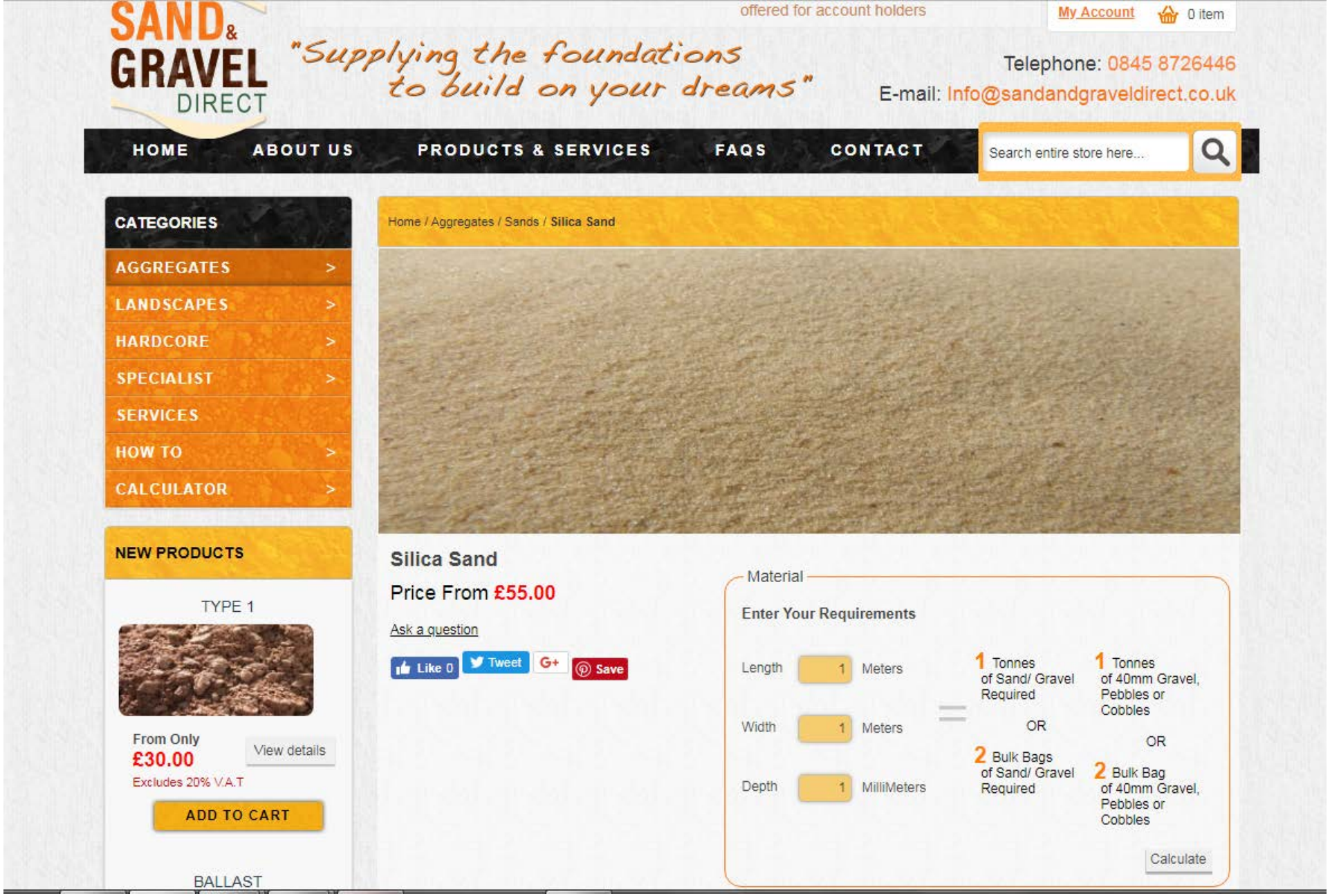

Silica Sand

Many suppliers
This is only an example

No experience of recommendation of this or any other supplier in the ENW area

https://www.sandandgraveldirect.co.uk/aggregates/sands/silica-sand.html

Mixing & Pumping

Tip-Up Concrete Mixers

LOW TRADE PRICE

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Concrete Mixer Tip-Up Electric - 110...

PRODUCT CODE: **42141**

The rotating, tilting stand of this mixer allows you to mix up to 85 litres of concrete or mortar and tip it straight into a barrow.

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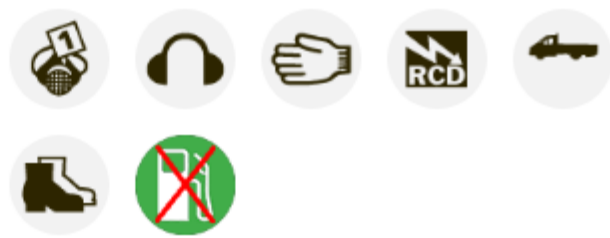
VIEW FULL DETAILS

Safety information & instructions

647 Safety Guide.pdf PDF



Dry and wet mixing probably best done with a mixer and insulated barrow?

Bentonite Pumps

The Sykes Bentonite Pump range has been specifically designed to pump heavy slurries and is available for hire from Sykes Pumps depots nationwide. Available in both diesel engine and electrically driven versions, these units have been developed for the continuous pumping of bentonite and heavy slurries. This range of specialist units are suitable for arduous applications, utilising tried and tested components selected to ensure maximum reliability and cost effective servicing.

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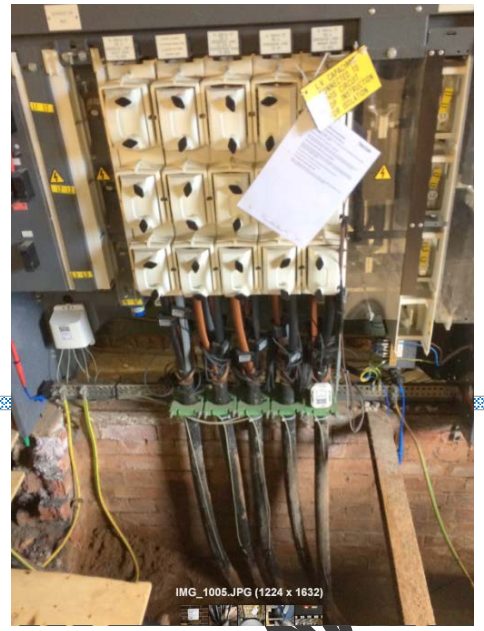
Probably isn't necessary for the scale of the work
- But pumps are possible for awkward locations

- Suitable for a wide range of Bentonite applications
- Hard wearing components for trouble free pumping
- Designed to pump sludge and slurry

These pumps are easy to maintain and have been designed to meet the challenging conditions of Bentonite applications. Through the use of tried and tested components, coupled with the unique Sykes expertise and on-site service, we are able to ensure maximum reliability.

Technical Information

Thermal cable constraints in and in the vicinity of Substations



S/S floor level

Ground level

Plan View

Section

The buried cable sections in close proximity to each other inside and immediately outside the s/s are those likely to be the most thermally constrained

Sand-Bentonite Mixes

- Test results showed that the thermal conductivity of sand–bentonite mixtures first increased with increasing percentage of bentonite by dry mass, then reached **a peak at the range from 10% to 12%,** beyond which the thermal conductivity decreased quickly.
- With an optimal sand–bentonite backfill material, the heat injection and heat extraction rate were enhanced on average by 31.1% and 22.2%, respectively, compared with the case with a common sand–clay material

Effects of Sand–Bentonite Backfill Materials on the Thermal Performance of Borehole Heat Exchangers

Huajun Wang , Yahui Cui & Chengying Qi School of Energy

Bentonex SB Granular

On it own the thermal conductivity of Bentonite is better that sand and worse than clay but when mixed 10/90 with silica sand is much better than any of them

- **Bentonex SB Granular** (sodium bentonite granules) offers slow hydration, allowing use in deep water applications. It is ideal for a range of civil engineering and geotechnical applications such as filling cable trenches and the plugging of boreholes and landfill gas wells. This product is also used to improve electrical conduction around earthing rods.

- When bentonite is mixed with water, the water molecules will enter between the clay plates, forcing them apart. While the plates are dispersed, the bentonite slurry becomes quite fluid. However, on standing the particles become oriented with the negative surfaces of the plates being attracted to the positive edges. Viscosity increases and a gel is formed – a reversible effect known as thixotropy.

- The thermal value is approx. 0.89 W/mK.

- http://www.rsminerals.co.uk/bentonite

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Thermal Conductivity of Soil Types

Table 1: Summary of values of thermal conductivity and specific heat capacity of variou

Soil Type	Water Content (%)	Bulk Density (Mg/m^3)	Dry Density (Mg/m^3)	Thermal Conductivity (W/m K)
BH C13 88	21.3	1920	1583	2.89
China CLAY (D)(sat.)	46.2	1730	1183	1.52
China CLAY (D)(dry)	0	1390	1390	0.25
Sandy CLAY	26.5	1890	1494	1.61
Sandy CLAY	19.5	2100	1757	2.45
Soft dark grey sandy gravely CLAY	28.5	1912	1488	3.57
Soft grey fine sandy CLAY	54.6	1650	1067	4.20
Soft grey fine sandy CLAY	41.4	1741	1231	3.03
Stiff dark grey sandy gravely CLAY	10.1	2299	2088	3.69
Stiff dark grey sandy gravelly CLAY	9.6	2369	2161	3.28
Stiff grey brown sandy gravelly CLAY	9	2352	2158	3.20
Very soft grey fine sandy CLAY	46.2	1711	1170	3.51
Grey slightly silty sandy GRAVEL	11.1	1983	1785	4.44
Grout	166	1250	470	0.64
Grey limestone (very hard)	0.1	2690	2687	2.54
Course SAND (dry)	0	1800	1800	0.25
Course SAND (sat.)	20.2	2080	1730	3.72
Dark grey clayey fine sand/silt	28	1848	1444	4.26
Fine SAND (dry)	0	1600	1600	0.15
Fine SAND (sat.)	24.6	2010	1613	2.75
Made ground (Silty gravely sand)	13.9	2182	1916	5.03
Medium SAND (dry)	0	1700	1700	0.27
Medium SAND (sat.)	20.2	2080	1730	3.34

Medium or Coase Dry sand is to be preferred for the general backfilling of open trenches in substations

Determination of Thermal Conductivity of Coarse and Fine Sand Soils
Proceedings World Geothermal Congress 2010 Bali, Indonesia, 25-29 April 2010

Bentonite and Sand Mixes

Table B.3 Thermal Conductivity Data for Various BHE Grouting Materials

Material	Thermal Conductivity (k) $W \cdot m^{-1} \cdot K^{-1}$
Bentonite (20–30% solids)	0.73–0.75
20% Bentonite/80% silica sand	1.47–1.64
15% Bentonite/85% silica sand	1.00–1.10
10% Bentonite/90% silica sand	2.08–2.42
30% Concrete/70% silica sand	2.08–2.42
Graphite–Bentonite mixture	2.10–2.77

This concurs with the recommended 10-12% Mix

http://onlinelibrary.wiley.com/doi/10.1002/9781118961957.app2/pdf

Geothermal Heat Pump and Heat Engine Systems: Theory and Practice

Cable sheath thermal conductivity

The external sheath of Waveformal cable is PVC

http://uk.prysmiangroup.com/en/business_markets/markets/pd/downloads/datasheets/Waveform.pdf

The thermal conductivity of PVC is poor in relation to other cable sheath materials and to most soils

Plastic	Thermal Conductivity *(W/(m K))* *(Btu/(ft h F))*
Acrylic	0.20
Epoxy	0.17
Epoxy glass fibre	0.23
Nylon 6	0.25
Polyethylene, low density (PEL)	0.33
Polyethylene, high density (PEH)	0.50
PTFE	0.25
PVC	0.19

PVC is poor

http://www.engineeringtoolbox.com/thermal-conductivity-plastics-d_1786.html