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Comparison of RoadCem Soil Concrete Technology with traditional cement and lime stabilisation

The use of Lime and Cement for soil stabilisation has been generally accepted for construction purposes in the UK since the early eighties.

This has never been the case though for the stabilisation of organic top soils in fact the majority of building regulations and Tender specifications still call for a complete strip of all top soils before construction commences.

If you have a look at our website: www.soilconcrete.co.uk you should at least consider the more sustainable soil stabilisation option of RoadCem soil concrete. Currently the only available method that will allow you to use all your existing site soils and not replacing them. Reducing trucking to and from site, saving resources, time and money. Plus keeping your site neighbours happy and healthy., With reductions in Human Toxicity levels of up to 300% compared to trucking in stone.

In the UK we are blessed or may be cursed with deep top soils and generally a lot of fine grained soils. Clay soils when there is no organic material present can react well to treatment with Lime, quickly becoming drier and more friable. This industry acceptance of the treatment of clay soils with Lime is actually better considered as a soil **modification** rather than a **stabilisation.**

Modification can generally be described as an improvement of either the moisture content and/or the workability of the material. It works in two ways, firstly, by adding quick lime (CaO) to a material it has a drying effect created due to the exothermic reaction generated as the lime hydrates with the free water available in or around the host material, therefore driving off a certain amount of water.

Care does need though to be taken to ensure that the Lime is fully hydrated (this is surprisingly difficult to achieve) and that the material is at the correct moisture content for compaction (normally determined by lab tests to assess the dry density/moisture content relationship of the soil).

This modification process is generally only used with a minimum amount of binder necessary, making a material which was deemed to be unsuitable (e.g. too wet), into a material which can be deemed suitable (i.e. now within its moisture range).

Lime stabilisation is normally used where there is no requirement for a permanent increase in the strength over and above that of the natural material in the modification process, even though some stabilisation/strengthening takes place in the short term and long term as a result of this modification treatment.

Lime stabilisation cannot be used without a protective wearing course and is not really suitable for temporary works, that will require short term reinstatement. As the active curing period can continue for many months.

Stabilisation only occurs when enough Lime is added to raise the pH significantly, typically to 12 and over, so that an environment is created which promotes the dissolution of silica and alumina from the clay particles which react in turn with the calcium ions from the Lime to form calcium silicate hydrates (CSH) and calcium aluminate hydrates (CAH).

These hydrates eventually crystallise into calcium silicate/aluminate hydrate which is similar to what happens with cement stabilisation. Though this reaction is relatively slow and inconvenient from a construction perspective.

Where the soil is silt rather than clay, granular, sandy or organic, stabilisation generally cannot be conducted with Lime. Silts require the further addition of a more pozzolanic material such as cement, PFA, or ground granulated blast furnace slag (GGBS) to create the cementing effect. Other than certain fine grained clays no other soils benefit from treatment with Lime, so testing is always important to prove it will be effective.

There can however be also be a downside to the modification or stabilisation of fine grained (clay) soils with Lime. It has been estimated that in Britain in the 10-year period between 1995-2005 swelling and shrinkage in Sulphate bearing clay subgrade soils had caused over 3 billion pounds' worth of damage to our roads.

Generally, the swelling behaviour of a coarse grained soil depends on its particle size distribution, whereas the swelling behaviour of a fine grained soil can depend much more on its geological history and structure, rather than its particle size distribution. In less dense soils expansion initially takes place three dimensionally into the zones of looser soil (i.e. voids) before volumetric expansion takes place. However, in densely packed fine grain soil with low void space the soil mass has to swell more or less immediately to accommodate the volume change, and if confined will often swell in a one dimensional manner, i.e. upward, potentially causing serious damage to roads and structures.

Sulphates are a common problem especially in central and south western areas of the UK. When these mix with alumina's (a primary constituent of clay), calcium (from lime or cement) and water, they can create a highly expansive crystalline formation called ettringite (calcium-aluminate-sulphate-hydrate mineral).

Sherwood (1993) explains the importance in understanding the factors which are likely to affect stabilised soil.
"The reaction between sulphates and the hydrated silicates and aluminates lead to products that occupy a greater volume Than the combined volume of the reacting constituents".
It is mentioned that with all forms of sulphate attack, water is an essential part of the reaction.
Generally, there will be insufficient water at the time of mixing to dissolve very much sulphate, so that unless extra water is able to enter the material, no appreciable attack will occur, even if high concentrations of sulphate are present."

With Cement stabilisation the hydration results in gel forming around cement particles and growing into a gluing matrix which coats the soil particles. The effect of the use of cement in soil stabilization may be to lower the plasticity of the material and make it more moisture insensitive or to create an agglomerated structure of calcium silicate hydrates and calcium hydroxide which bind surrounding particles. The later can result in increased tensile strength which can be susceptible to cracking if overstrong as well as shrinkage cracking as the cement hydrates.

If there is significant percentage of particles smaller than 425 microns within the material being stabilized, application of cement in soil stabilization is not an optimal solution, as these fine particles hinder the cementitious process.

Although considered as proven solution cement in soil stabilization has some drawbacks. It is not effective in all soil types, and if dosage rates are high the failure mechanism can be brittle in nature, it can also be susceptible to unsightly shrinkage cracking which allows the entry of moisture.

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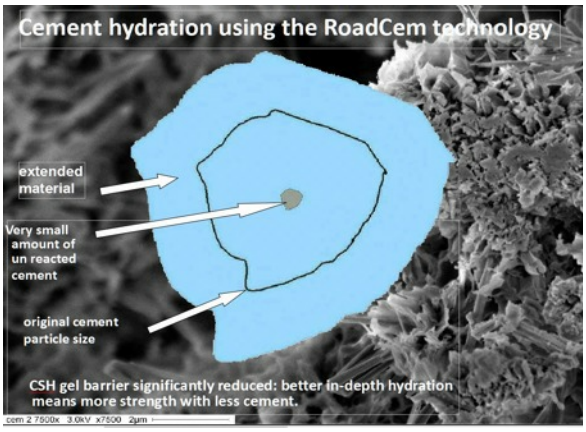
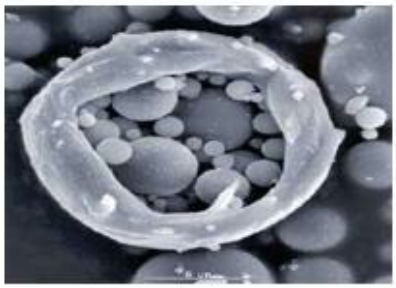
There is one factor that is common to the majority of traditional Lime and Cement soil stabilisation applications especially where fined grained or organic materials are present and that is water. It is the presence of available water that is the primary cause of potential swelling in clay, acidic attack and failure.
For long term durability the control of water both in and out and also trapped/retained in the stabilised material is critical. This aspect is the real advantage of using RoadCem technology.



The active components of RoadCem, break the surface bonds of the water to form a highly-reactive delivery system diffusing between the soil particles.

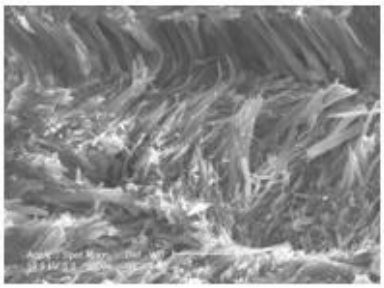
These capillary forces ultimately transport the cementitious solution through the whole matrix, ensuring that the entire cement content is reactive, creating bonding forces between the soil particles and ensuring that any trapped water is forced out of the stabilisation and kept out indefinitely.

Traditional Stabilisation:



Cement glues the particles together
Gluing is "Brittle"!

With RoadCem Additive:



Formation of long strings, interlocking the particles
Wrapping is "Flexible"!

Traditional Cement stabilisation can be effective with most sub soils, providing no peat or organic material is present including all but the most plastic of soils. But because cement is a gluing technology there needs to be enough angular material present for strong compressive strengths to be achieved.

Material and soils bound together with cement are brittle with reduced bending/recovery capability.

If the construction application requires high point loading or long term durability, such as heavy haul roads, the high cement content mix needed to achieve this strength can lead to increased risk of cracking in the stabilisation with just cement alone.

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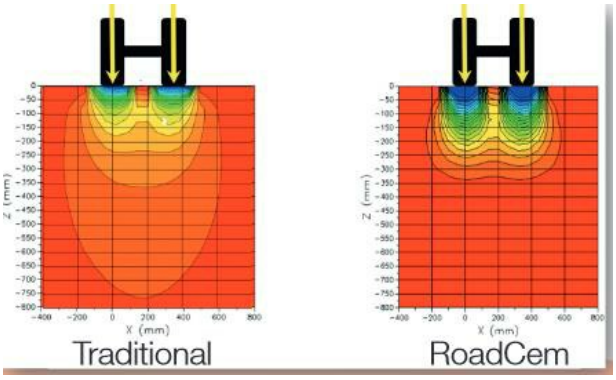
RoadCem allows the use of high cement values of 10% or more that are needed to cope with high loading requirements, without any cement induced cracking taking place.

Importantly this high compressive strength is aligned with better tensile strength and high modulus of elasticity, creating greater stiffness to enable the spanning of weaker sub grades and reduced loading to the sub soils as shown below.



RoadCem technology is proven to improve the capabilities of cement when used for stabilising soils, reducing cracking even when high strengths are required and is well established as a cost effective technology for the stabilisation of organic soils and marginal materials.

There is every reason to extend its use in the UK as a replacement technology for traditional Lime and/or Cement stabilisation for the treatment of all soils including Sulphate bearing clay soils, particularly where water and or swelling/heave are identified as a potential problem. Or for all soils where greater load bearing capacity or longevity are a requirement.

In summary:

- Enables the stabilisation of organic soil.
- Reduces swell/heave when sulphates are present.
- Eliminates voids, forcing problematic water from the stabilisation.
- No available water means no frost damage and also protection from extreme heat.
- Greater modulus of elasticity, meaning increased stiffness and reduced loading to sub-grades.
- RoadCem soil stabilisation's are 100% recyclable.
- Unlike Lime stabilisation RoadCem allows all year round working

Shell Canada specify that RoadCem is used for their ground works in sensitive environmentally protected areas not just for strength gains but more importantly for the permanent molecular level encapsulation of all toxic elements.

As all their works are subjected to independent environmental testing for the Canadian Government to prove that RoadCem stabilised soils do not leach nor exhibit any deleterious effects.

Traditional soil stabilisation with Cement, Lime or Flyash in any combination without RoadCem added will have the potential to contaminate groundwater through leaching and migration of the toxic elements.

If construction industry wants to keep using Cement, Lime and Flyash for soil stabilisation we all will need to be proactive about eliminating all hazards.