LIME STABILISATION OF ROAD SUBGRADES BENEFITS AND RECEPTIVE SOIL TYPES

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SUMMARY

Soil stabilisation is not new in New Zealand having been practised some thirty years or more. Lime stabilisation, however, is only now being considered as a primary option in the process of road construction.

Lime reacts with clay to varying degrees depending on the mineral composition of the clay. Plastic soils whether they are fine grained clay or gravel-clay in nature are responsive to lime, whereas organic soils and soils with a low Plasticity Index (P.I.) are generally not.

The advantages of lime treatment is that it leads to a reduction in the construction time and cost if carried out correctly. It thus makes it imperative to recognise when it is a viable option. Simple tests can identify lime responsive soils, but further laboratory tests are required to enable a cost efficient result to be achieved.

INTRODUCTION

Lime stabilisation is a technique being utilised on more and more occasions as an alternative to conventional pavement construction. The New Zealand Institute of Highway Technology have described it as "a means of permanently consolidating subgrade soils and basecourse materials by substantially increasing their strength and bearing capacity whilst, at the same time decreasing their sensitivity to the ingress of water and volume change during wet/dry cycles". Today it involves spreading burnt lime over the surface, slaking it, hoeing the resultant material into the underlying surface, compacting this mixture and then trimming it to the desired shape.

With advances in equipment in carrying out these processes and the increasing cost of metal of the required quality, it is of no surprise that lime stabilisation in some instances is the most efficient option.

Consequently it is imperative to understand what type of soils are responsive to lime. However, before we are able to achieve this we must familiarise ourselves with the chemical reactions resulting from such interactions.

GENERAL LIME REACTION

The addition of burnt lime and water to clay soils results in two main chemical reactions:

CaO (Burnt Lime)	+	H_2O (Water)	=	$Ca(OH)_2$ (Calcium Hydroxide)	+	Energy (Heat)		(1)
$Ca(OH)_2$ (Calcium Hydroxide)	+	H_2O (Water)	=	Ca^{2+} (Metal Ions)	+	H^+ (Hydrogen ions)	+ 3OH (Hydroxide Strong Base)	(2)

Calcium hydroxide forms through the reaction with calcium oxide with water (1). The hydroxide is a strong base and dissolves in water to liberate metal, hydrogen and hydroxide ions (2).

The first main reaction is a base ionic exchange which occurs with the clay particles. The clay minerals react with ionised water molecules and bond into permanent ionic configurations. The fine plastic clay particles collect together in a mass of coarse friable particles and the ionic exchange is completed, taking only minutes if the proportion of reagents are correct and mixed thoroughly.

The second reaction is a slow chemical response in which lime reacts with silica and alumina minerals in the original clay to form calcium silicates and alluminates. This is the hardening action and is the result of the formation of these very hard dense minerals which have great stability. This process continues for a year or more if sufficient moisture is available to drive the reaction.

SUITABILITY OF SOIL TYPE

The prime consideration as to whether a soil type will respond to lime treatment is thus the content of clay minerals contained within.

Cohesive soils react both physically and chemically with lime to achieve an improved pavement material. The exceptions are the organic soils that contain 20% or more of organic material and some volcanic based soils. Soils with a low P.I. and non plastic soils can have the lime silica reaction induced through the addition of a secondary additive (i.e. fly ash).

Granular soils with a P.I. greater than 10 have been known to react with lime, but cement stabilisation is a more efficient alternative for these types of soils.

ON SITE ASSESSMENT

Lime reactive soils can be assessed within the field, however, this only comes through experience and gives only a qualitative account of the soils nature. Laboratory tests are required to enable us to achieve the optimum application of lime for the desired result.

Field testing is by no means definite, with many Engineers utilising their own techniques.

However, the general "Palm Squeeze Test" is used on most occasions to determine the plastic nature of the soil and thus it's ability to react with lime.

The New Zealand Institute of Highway Technology have suggested a technique requiring only plastic bags and a small amount of slaked lime to determine the potential reactivity of a soil sample.

The test involves mixing two samples with water and kneading them until they become plastic in nature and are thoroughly mixed. Both samples are then placed in plastic bags. One sample has 10% by volume of slaked lime added and this combination is then mixed by kneading the outside of the sealed plastic bag. The other bag is sealed and used as the control. After two days of storage both samples are removed from the plastic bags and placed in two litre packs of water to determine the degree of disintegration after 24 to 36 hours of submersion.

If the lime stabilised sample shows no significant disintegration compared to the control then the soil warrants further laboratory testing.

CONCLUSION

Lime stabilisation has significant advantages over conventional pavement construction. These include;

1. It's ability to increase the workability of the subgrade.

2. It's ability to reduce the compactive effort required by reducing the moisture within the soil.

3. It's ability to reduce the shrinkage swell characteristic of clay soils.

4. The increase in unconfined compression strength of the subgrade that can be obtained.

5. The formation of a working platform resistant to water.

6. The reduction in depths of high quality metal required in pavement construction.

7. The reduction in time and cost indicative of all of the above.

Lime reacts with clay minerals, plastic clay soils with P.I. greater than 10 tend to be the most responsive to the lime stabilisation process.

Simple field test can determine whether a soil is receptive to lime; laboratory tests however are required to identify an efficient application rate.

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