SUITABLE SOLUTIONS

DESIGN OF LIME STABILISED SUBGRADES USING CBR OR UCS

In the design and/or construction of pavements the designer may consider stabilisation of the subgrade or prepared formation to take advantage of:

- A stronger subgrade stiffness being achieved with lime and cementitious binders.
- A stable subgrade resisting shrink/swell characteristics in expansive clays being achieved with lime binders.

Subgrade stabilisation may be chosen to enhance construction processes by:

- Use of lime in drying out wet material for trafficability and compactibility.
- Use of lime or cementitious binders to produce a construction platform facilitating construction in all weather conditions.
- Producing sound platform against which satisfactory compaction of overlying layers can be achieved.

Financially, the cost of stabilisation is often offset by:

- A stronger subgrade requiring a thinner overlying pavement.
- A stronger subgrade enabling specified compaction levels of overlying pavement layers to be achieved.
- A stable subgrade enhancing pavement rideability and reduced maintenance.
- A more trafficable subgrade expediting the construction progress.
- A more impervious subgrade increasing the life of the pavement.

Lime stabilisation, as a road solution to poor quality subgrades, has grown in popularity over the past few years in Australia. However, with any new practice, competing methodologies on how it is used emerge.

There are two different soil-testing methods that are used within these practices – California Bearing Ratio (CBR) and Unconfined Compressive Strength (UCS). CBR is a penetration test to evaluate the mechanical strength of road subgrades and basecourses, while UCS is testing the strength of the soil when it is crushed uniaxially without lateral restraint.

In Australia, three design procedures for lime-stabilised subgrades are currently being used. These are an Austroads method using CBR with imperial design charts, CBR using CIRCLY – pavement design software – and another process implemented by Queensland Transport and Main Roads (QTMR) using UCS.

All three methods acknowledge that suitable soil lime stabilisation results in reduced soil plasticity, dries the soil due to chemical reaction, yields improved compactability, strength and stability, and reduces shrinkage and swelling. However, the question remains – in which situation should CBR or UCS be used?

Greg White, Executive Officer at AustStab, talks to *Roads & Civil Works Magazine* about the two testing methods and how they correlate with the three design procedures currently employed in Australia.

Mr. White explains that it is first important to understand the number of effects lime has on soils. "Lime requires the soil to have a sufficient clay content to react with the lime," he says. "The majority of clays contain natural pozzolans that react with the lime to form a cementitious compound." He adds that this cementation can be affected by lack of pozzolans, excessive organic carbon, soluble sulphates and high ferric oxide levels.

"For this reason it is imperative that laboratory testing be carried out to assess the suitability of lime stabilisation of each soil considered," he says. In these tests, the differing amounts of lime are added to a soil to determine minimum lime required for a permanent reaction and the subsequent CBR or UCS results.

Mr. White says that some road authorities would prefer to use mechanistic design methods, normally using the CIRCLY software – one of the three aforementioned methodologies, to design pavements with stabilised subgrades. This is commonly done using the CBRs found in laboratory testing. However, organisations such as QTMR have implemented their own respective design procedures.

QTMR employs a UCS design procedure, which is described in the Technical Note TN74 "Structural Design Procedure of Pavements on Lime Stabilised Subgrades".

In this method, QTMR targets a UCS of 1.5 megapascals. With this relatively high strength, the layer can be utilised to reduce the total pavement thickness. Mr. White says that QTMR feel very confident that if 1.5 megapascals is achieved then the treated subgrade will be a permanent structural layer with low permeability. "Indeed research by QTMR has shown that UCS strengths continue to grow strongly after 28 days with cores taken from jobs over 12 months later giving very high strengths with four to five megapascals more common and often much higher," he says. "It is also noted, due to presumably slow strength gain, there is negligible cracking observed in long-term pavements."

Mr. White says that AustStab has one concern with the use of the QTMR methods. "If a large amount of lime is required to achieve the 1.5 megapascal target, sometimes as high as nine per cent or more, this can make the use of lime stabilisation uneconomical," he says. "AustStab sees that if large amounts of lime are required chasing a UCS result then it is usually far more economical to use a CBR method."

Austroads has published its design methodology in the document entitled "Proposed Procedures for the Design of Pavements on Select Subgrades or Lime Stabilised Subgrade Material".

In 2013 Austroads clarified this design methodology on the procedure of designing granular pavements on stabilised subgrades. Mr. White says the method is quick and simple, but is not applicable to alternate pavement configurations that incorporate bound layers or thick asphalt layers where mechanistic design methods are required.

The design CBR of a subgrade has considerable influence on the required pavement thickness. This is because of the need of the pavement to "protect" the subgrade from deformation under traffic loading, so the weaker the subgrade the thicker the pavement required.

If the designer wishes to take advantage of a thinner pavement through stabilisation of the subgrade, the depth of stabilisation required needs to be determined.

Austroads proposes a three-step process using its design methodology, which is only for granular pavements with spray seal or asphalt less than 40 millimetres thick.

The first step is to calculate the required pavement thickness above the in-situ subgrade, the second is to determine the cover to the subgrade, which must always be maintained. The third step is to calculate the cover required on the improved CBR stabilised layer. Mr. White explains that this method uses the stabilised layer as a subbase, making up part of the required pavement thickness.

He says there are a few requirements in using this method.

A formal mix design to determinate the type of binder and amount required needs to be undertaken in accordance with the procedure detailed by Austroads.

If lime is the only binder to be used, a lime demand test should be carried out to derive the minimum lime content of the stabilised layer.

The allowable maximum design CBR must also be checked with state road agencies.

Finally, the stabilised layer should not use a design CBR greater than the original CBR multiplied by two, raised to power of layer thickness and divided by 150. "As an example, if the original CBR was four per cent and the stabilised layer 300 millimetres, then the maximum allowed design CBR is 16 per cent," explains Mr. White.

He says that subgrades can be stabilised using various binders the most common being lime, slag and lime or lime and cement. "The choice of binder depends on the characteristics of the in-situ material with clays usually more suited to lime and sandier materials requiring a cement or slag," he says. "Local geotechnical consultants or contractors can normally advise on the most suitable binder."

Each of these methodologies and testing procedures has its own characteristics and techniques that may have different applications in various situations. Mr. White asserts that the stabilisation of the pavement subgrade in general, using these methods, offers a number of advantages, each with its own unique benefits.

Contact AustStab for more information about lime stabilised subgrades and its design using CBR or UCS.