WAKA KOTAHI NZ TRANSPORT AGENCY

PILOT NOTES TO SPECIFICATION FOR IN-SITU SUBGRADE STABILISATION

(These notes are for guidance of the supervising officers and consultants commissioned to draft tender documents and must not be included in contract documents)

1. SCOPE

The purpose of this Specification is to have a framework to ensure best practices when specifying stabilisation activities on the state highway network.

The other in-situ stabilisation specifications are:

- Stabilisation of modified pavement layers (TNZ B/5: 2008)
- Stabilisation of strongly bound pavement layers (NZTA B/6: 2010)

Before using the in-situ stabilisation specifications, the user needs to be aware of the aim of the stabilisation activity to understand what the stabilisation activity is intended to achieve. This specification covers subgrade stabilisation, aiming at reducing moisture content, reducing water susceptibility; provide a homogeneous substrate for overlying pavement layers and to increase the shear strength of the material being treated.

Because of the nature of the various binders that are described, this Specification tends towards a method-type specification as opposed to being performance based. This Specification is suitable for the stabilisation of subgrade layers, both in new construction and in maintenance work of a substantial size, such as area-wide pavement treatments (AWPT). It is therefore not generally suitable for application in maintenance patch-type operations.

2. DEFINITIONS

Subgrade Soil

Any material that can be characterised by particle grain size as clay, silt, sand or gravel, or a combination of any or all of these components

Stabilisation

Any chemical or physical treatment of a subgrade material that enhances the engineering properties and thus the ability to carry out its function. Stabilisation is used to increase the shear strength, reduce moisture susceptibility, provide a uniform substrate and/or dry the subgrade soils by the reactions of cementation and/or modification.

Cementation

When water is added to cement, fine molecular strings “grow” from each particle of cement, which joining together around the aggregate, and thus bind the entire matrix together. This is also known as a hydraulic reaction.

Modification

Modified stabilised materials are those to which quantities of binders are added to improve the performance attributes of the material. This stabilisation type is adopted when it is desired to increase bearing capacity, increase stiffness and/or decrease moisture susceptibility and possibly reduce moisture content while at the same time maintaining flexible subgrade characteristics.

Cement

Cement is a mixture of mainly Portland cement clinker (65 to 100%) and other additives, such as slag, pozzolan, volatile ashes, fired slate or limestone. Portland cement clinker is a substance consisting of at least two-thirds calcium silicates, the remainder being aluminium-oxide, iron oxide and other elements.

The main task of cement is to bind the mineral mixes, thereby increasing their stability. Cement also contains a certain percentage of calcium oxide, which modifies the clay molecules of plastic materials. The percentage of calcium oxide in cement is much lower than that of lime. Therefore, generally, cement-only treatment should be used with subgrades which have a plasticity index (PI) of less than 15.

Lime

Several terms are used to describe different forms of lime used in stabilisation. It is important to understand the meanings of these terms from the outset so that no mistake is made interchanging one form of lime for another. The two most common forms of lime available are:

- **Burnt Lime (Calcium Oxide)** – produced by burning high quality limestone at elevated temperatures. The resulting product is then crushed and screened to specific sizes as required. The resulting product is stable but will react violently with water releasing considerable heat and steam. The fine burnt lime is very suitable and effective in drying and conditioning soils in bulk earthwork operations. This product must be kept dry until used.

- **Hydrated Lime (Calcium Hydroxide)** – produced by the reaction of burnt lime with enough water to form a white powder. The product is then separated into different particle sizes through air separators in order to meet the manufacturer’s specifications. The resulting product is stable and should be kept dry until use.

Slaking of Burnt Lime

After spreading, and prior to hoeing, sufficient water shall be applied to completely slake the burnt lime. Application of water shall be via pressurised spray equipment that is capable of applying a coarse spray evenly over the spread lime without displacing it. Depending on the size of the burnt lime multiple passes shall be undertaken, and overwatering shall be avoided. The water shall ideally be applied by means of a side mounted swing bar (or similar) where it is not necessary to traffic the area being slaked. Hoeing shall not commence until the lime oxide has been fully slaked.

Chemical Stabilising agent blends

Different blends of lime and cement for various applications are available on the market. Those with higher lime content are mainly used for stabilisation of fine grained ‘clayey’ soils, while those with higher cement content are mainly used for the stabilisation of coarser grained silt and/or sandy soils.

Other Agents

The Engineer may approve other forms of stabilizer agents. Factors that the Engineer will consider include adequate documentation to support consistency of agent performance, stabilisation test results and environmental impact.

Hoeing

Hoeing is another term for stabilising, and is the physical in situ operation of mixing the subgrade soils with the stabilising agent(s) and, in most cases, water by means of a mechanical Stabiliser or Hoe. This is equipped with a horizontally spinning stabilising drum that has many paddles or point attack tools attached to it.

Pre-Hoeing

Pre-Hoeing is the physical on-site operation of loosening or “particle sizing” the existing subgrade with a hoe without the addition of stabilising agents. There are several reasons why pre-hoeing is done. Some reasons being where it is suspected that the moisture content will vary substantially within a treatment area (or is required to be corrected prior to treatment) or where the hoe does not (or is not expected to) granulate the existing materials in a satisfactory manner over a single pass.

Pre-Treatment

Pre-Hoeing is the physical on-site operation of improving the moisture condition and/or strength of the existing subgrade with a hoe prior to the stabilising operation with the addition of stabilising agents. Generally pre-treatment is done for moisture correction and/or strength gain where conventional stabilisation equipment can traverse the subgrade or greater confidence can be gained in achieving in design parameters.

3. MATERIALS

As defined above, in-situ stabilisation is used to improve the physical properties, primarily shear strength and/or moisture condition, of the soils found within the subgrade materials. The treated subgrade will comprise either insitu and/or imported materials, and will exhibit the characteristics of a subgrade / subgrade improvement layer.

In-situ materials

To ensure that adequate information is available to design the pavement and to draft a tender document, a preliminary investigation of the existing road or network must be carried out. The investigation is outside the scope of this Specification. However, as a minimum requirement for stabilisation purposes, the following pavement investigations (test pit) and laboratory tests for each section should include;

- Detailed description of the subgrade parameters
- Scala penetrometer test to a minimum depth of 1 m from the top of the subgrade
- Moisture content(s) of each layer at the time of investigation
- Optimum moisture content of each material type
- Reactivity testing to ascertain design properties are achieved for the proposed treatment

Imported natural materials

Natural material (soils, gravels etc) may be required to mix with the existing subgrade soils for the purpose of:

- Level correction – particularly cut to fill or import to fill
- Altering the properties of the material to be stabilised

These imported materials should comply with the requirements of TNZ F/1.

4. STABILISING AGENTS

The type of stabilising agent or combination of stabilising agents that are to be employed shall be detailed in the Project Specifications. The choice of stabilising agent or combination of stabilising agents is outside the scope of this Specification. However, it is assumed that reactivity trials will have been undertaken on representative subgrade materials to ensure that design requirements are achieved.

4.1.2 Cement

Cement that is suspected of not being stored in a way that protected it from deterioration shall be retested in accordance with NZS 3122.

Before considering the use of cement (or Portland cement-lime combinations) for sulphate-bearing aggregates, i.e. those with Total Potential Sulphate (TPS) content greater than or equal to 0.25% SO_4, refer to the Britpave Technical Guideline *Stabilisation of sulphate bearing soils*.

5. WATER

The Specification sets out the procedure for modifying the physical properties such as plasticity, moisture content and moisture susceptibility of the treated material, to achieve a subgrade that achieves improved performance and durability characteristics.

Caution and common sense need to be exercised when sourcing water other than for public supply. The main components in water that could affect the setting time, strength and durability are salts, sugars and suspended matter such as oil, clay, silt, leaves and vegetable debris. Sugars are rarely found in waterways, and salts could be found in waterways that are close to oceans and are under tidal influence. If water is sourced from such waterways and/or potential contamination is suspected, then the water shall be tested by the reactivity strength test. The results of these reactivity strength tests shall be greater than 90% of the results from the reactivity test carried out with the same material using water from the public water supply.

In addition, sound practices, such as avoiding silty areas and drawing from the bottom of the source, should be applied while drawing water from water sources other than public supply.

6. PLANT AND EQUIPMENT

6.3 Plant for applying water to the subgrade

The plant for applying water shall have switch-on and cut-off control within the cab so that the operator can ensure no over-application.

7. CONSTRUCTION

7.1 Limitations

7.1.1 Weather Limitations

Temperature

If work is undertaken below the temperatures given in Table 1 of the Specification, the risk is that the treated materials may not develop their full mix-designed physical properties, thus potentially causing early pavement failure.

Dryness, wind

These weather conditions will cause excessive dust, a situation which has to be controlled.

The main reasons for preventing excessive dust are:

- Safety – excess cement or lime dust can cause a safety hazard in the construction site
- Health – excessive cement or lime dust can cause a health risk to the workers and general public
- Environment – agricultural and environmental harm

Therefore consideration should be given to the following conditions:

- Seasonal and regional wind direction, speeds, etc.
- Agriculturally sensitive areas
- Urban environments with high pedestrian use nearby

In these cases careful planning and methodology must be utilised that mitigates these conditions or plant that has dustless capability (i.e. does not create dust) should be specified.

7.1.2 Time Limitations

The time limitations for different stabilising agents are specified in this Specification to ensure that the mix-designed physical properties are achieved and maintained in the field. Where these limits are exceeded the Engineer shall review the density achieved at that time and approve the kind of remedial action to be undertaken.

7.2 Before Stabilisation Commences

7.2.1 Surface Preparation

Where test pit results show that the in-situ moisture content of the material to be stabilised is in excess of the moisture limitations described in clause 7.4 of the Specification, pre-treatment before stabilising will be necessary. The Project Specification will describe the requirements of such pre-treatment if such preparations are anticipated.

It is imperative that the shape is corrected before the actual stabilisation takes place, as any change in shape after hoeing will change the final stabilised layer thickness and thus influence the pavement's long term performance.

7.3 Spreading of lime and/or cement

Where a blended product is spread and slaked, it is not intended that larger size burnt lime (Calcium Oxide) chip is used. Where burnt lime with particle size greater than 3 mm is used with cement, to avoid slaking / overwatering problems it should be slaked and hoed separately, and prior to, the cement component

7.3.1 Slaking of burnt lime

An offset bar allows the water tanker to ravel on firm ground, and thereby avoid the slaked lime which can get very slippery during the slaking operation. Multiple passes of the water tanker are often required to ensure that adequate slaking has taken place. The slaking process is complete when all the lime is broken down to a fine powder. It is however advisable to add additional water by an extra pass, to prevent dust during the mixing phase.

7.6 Compaction

The compaction requirements generally follow those of the other NZTA stabilisation specifications however it must be noted that placing laboratory based compaction targets on subgrades requiring stabilisation is very difficult and in extreme cases may not even be appropriate.

It is recognised that insitu materials and moisture condition can change quickly in some instances, and in these circumstances it can be difficult to maintain control of optimum moisture content and to do it in a timely manner. In these situations the moisture condition should be monitored. An experienced operator can obtain a good indication via the use of "squeeze tests" where the treated material can be compressed in the hand to evaluate proximity to optimum moisture. If the material is too dry it will crumble, too wet and it will extrude between fingers and excess moisture may be apparent. If the moisture content is at or close to optimum the 'squeezed' soil sample should maintain cohesion without demonstrating excess moisture. This evaluation can be used to supplement and not replace regular quality assurance testing as called for in NZTA F/1 or the contract documents.

10 BASIS OF PAYMENT

10.4 Extra over or under Clause 10.3 for the supply and spreading of stabilising agents (tonnes)

At times mix designs have not been carried out at the time of tendering. In these situations the consultants will typically specify an assumed depth and content for the materials expected to be used for stabilisation.

The actual binder contents and/or depth may however change from the assumed amount. In these cases it is practical to have the extra or lesser amount of actual binder priced. The quantity shall be calculated by the difference between the assumed theoretical total amount of binder as scheduled in clause 10.3, and the theoretical amount calculated with the new binder content as follows:

$$Q_{EO\ or\ EU} = \frac{(A_{Sched} \times B_{Sched}) - (A_{Design} \times B_{Design})}{1000}$$

Where:

Q_{EO} or Q_{EU}	-	Extra or lesser binder quantity	[tonne]
A_{Sched}	-	Scheduled area at tender	[m2]
A_{Design}	-	Design Actual area stabilised	[m2]
B_{Sched}	-	Scheduled application rate	[kg/m2]
B_{Design}	-	Design application rate	[kg/m2]

And

$B_{Sched} = t_{Ass} \times C_{Ass} \times D_{Ass}$

And

$B_{Design} = t_{Act} \times C_{Act} \times D_{Act}$

t_{Ass}	-	Scheduled Hoe depth	[m]
t_{Act}	-	Design hoe depth	[m]
C_{Ass}	-	Scheduled binder content	[%]
C_{Act}	-	Design binder content	[%]
D_{Ass}	-	Scheduled density	[kg/m3]
D_{Act}	-	Design density	[kg/m3]

REFERENCES

[1] Britpave, the British In-situ Concrete Paving Association. 2005. Technical Guidelines: Stabilisation of sulphate-bearing soils. *Technical data sheet BP/16.* Britpave, Camberley, Surrey.