TNZ B/5 NOTES: 2008

NOTES TO SPECIFICATION
FOR IN-SITU STABILISATION OF MODIFIED PAVEMENT LAYERS

(*These notes are for the guidance of the supervising officers and consultants commissioned to draft tender documentation 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 two in-situ stabilisation specifications are:

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

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 modified layers, aiming at reducing the risk of water susceptibility of the aggregate, and to increase the shear strength of the pavement layers being treated.

Using modified materials prevents the risk of excessive shrinkage cracks and/or fatigue-induced cracking, both of which are associated with strongly bound pavement layers. Because strongly bound pavement layers require special design considerations such as crack mitigation layers, and extra operational considerations such as additional curing before trafficking, these considerations are covered by the Specification for strongly bound pavement layers.

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 a sub-base and/or a basecourse layers, both in new construction and in maintenance work of a substantial size, such as area-wide pavement treatments (AWPT). It is therefore not suitable for application in maintenance patch-type operations and rut-fill contracts.

2. DEFINITIONS

Some typical stabilisation terms that are used throughout the Specification and Notes are defined here.

Stabilisation

Any chemical or physical treatment of a road pavement material that enhances the engineering properties of the pavement, and thus the ability to carry out its function. Within the upper layers of a pavement, stabilisation is used to increase the shear strength of the aggregate 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 join 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 small quantities of binders are added to improve the performance attributes of the material while still maintaining the properties of an unbound granular material.

This stabilisation type is adopted when it is desirable to increase bearing capacity, stiffness and/or decrease moisture susceptibility, and at the same time maintain flexible pavement characteristics.

The two distress mechanisms of modified stabilised pavement materials are vertical deformation and shear. The materials should not exhibit the excessive shrinkage cracks and/or fatigue-induced cracking which are associated with strongly bound pavement layers.

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 should only be used with aggregates which have a plasticity index (PI) of less than 10.

Lime

Several terms are used to describe the different forms of lime used in stabilisation. The meanings of these terms need to be understood 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. This 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, and modifying marginal aggregates. 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.

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 modification, while those with higher cement content are mainly used for cementation.

Bitumen emulsion

There are two different types of bitumen emulsion: cationic and anionic. When the emulsion makes contact with the aggregate, it will "break" at different rates according to its composition. The break is defined as the point in time when the bitumen separates from the water. This transition can be described visually when the brown emulsion turns dark brown and cheesy, and then viscous black when only bitumen remains and most of the water has been expelled from the aggregate.

For stabilisation, cationic bitumen emulsions are used more often. While anionic emulsions (with negatively charged bitumen particles) offer a watery intermediate layer when sprayed, cationic emulsions will, depending on the emulsifier type, chemically release the bitumen. These cationic emulsions (with positively charged particles) react particularly well with acid-based mineral aggregates such as granite and quartzite, and can be formulated to break at different times after mixing with mineral aggregate and cement (if cement is included). Both types of emulsion enable mixing to be carried out with damp mineral aggregates.

Foamed bitumen

Foamed bitumen is manufactured when small amounts of water are added to hot penetration-grade bitumen (above 170°C). The surface area expands and the viscosity of the bitumen is lowered significantly. In this condition, the bitumen is ideally suited for mixing with cold and damp aggregates. Foamed bitumen can be used as a stabilising agent for a wide range of aggregates, from high quality crushed stone to marginal aggregate usually up to a PI of 10. In addition, a wide range of material qualities can be produced with foamed bitumen depending on their bitumen and cement content. These materials can, depending on the formulation of the foamed bitumen and cement, be flexible, or granular-type, or very stiff.

Hoeing

Hoeing is another term for stabilising, and is the physical in-situ operation of mixing the aggregate 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 in-situ operation of loosening the existing road with a hoe without the addition of stabilising agents. Pre-hoeing is carried out for many reasons. For example, where the profile (cross- and long-sections) of the road changes significantly, or where the moisture content is suspected to change substantially within a particular area-wide pavement treatment (AWPT), or where the hoe does not granulate the existing road in a satisfactory manner.

3. MATERIALS

As defined above, in-situ stabilisation is used to increase the physical properties, primarily shear strength, of the aggregate found within the existing pavement. Therefore, it would not make sense and would not be possible to specify the material that is found in-situ. One can, and should, however make sure that the treated material, which is a mixture of imported material together with the existing pavement material, will exhibit the characteristics of a sub-base or basecourse, depending on where it is being used.

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. This 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 each layer within the existing pavement structure up to and including the subgrade;
- Scala penetrometer test to a minimum depth of 1 m from the top of the subgrade;
- Grading and plasticity of the material from the upper pavement layer(s) that will be hoed by stabilising operations; and
- Moisture content(s) of each layer at the time of the investigation.

Imported natural materials

Natural material (sand, gravel, etc.) and/or crushed stone products may be required to mix with the existing road pavement materials for the purpose of:

- Altering the grading of the post-stabilised material;
- Achieving mechanical modification; and/or
- Supplementing the stabilised material for shape correction.

These imported materials should comply with the requirements of TNZ M/4: *Specification for basecourse aggregates*. However, as a minimum, materials must meet the requirements of Appendix 1 of this Specification where the Engineer provides suitable grading.

4. STABILISING AGENTS

Stabilising agents may include either one or both chemical and bituminous types. 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.

4.1.2 Cement

Cement that is suspected of not being stored in a way that protected it from deterioration shall be tested for loss of ignition in accordance with AS 2350.2 or Appendix B of NZS 3122.

Type GP cement with loss of ignition test result greater than 3.0% shall not be used.

Types GB and LH cement with loss of ignition test result greater than determined by the cement manufacturer shall not be used.

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.*[1]

4.2.1 Foamed bitumen

Due to the range of temperatures experienced in New Zealand, the 80/100 penetration-grade bitumen is well suited to provide sufficient stability in both the high and low temperature zones. However, in alpine conditions where the pavement is exposed to numerous frost/thaw cycles, the 180/200 penetration-grade bitumen should be specified. The expansion of the bitumen is more critical than the half-life and thus a minimum of 10 times expansion of the original binder volume is specified. Larger expansion results in thinner bitumen film, which results in smaller bitumen particles when the "bubble" breaks, which in turn causes more efficient mixing. Refer to Roading New Zealand Technical Note 001 *Foamed bitumen treated materials*[2] for more detailed information.

4.2.2 Bitumen emulsion

It is critical for the mixing process, the compaction and the finishing of the layer, that the bitumen emulsion breaks during compaction of the stabilised material. As a guide, medium to slow setting emulsions usually meet these criteria.

5. WATER

This Specification sets out the procedure for modifying the physical properties such as plasticity and moisture susceptibility of the aggregate, to achieve an aggregate that usually is modified or slightly bound.

Caution and common sense need to be exercised when sourcing water other than from 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 that 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 a 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.

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 – excessive cement dust can cause a safety hazard in the construction site
- Health – excessive cement 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 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 taken.

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 7.5 of the Specification, pre-treatment before stabilising will be necessary. The Project Specifications will describe the requirements of such pre-treatment if such preparations are anticipated.

Where surface defects are to be corrected and/or modifications made to the grade line of the pavement surface, the Project Specifications should detail the new surface level requirements. These may be achieved before stabilising by either pre-milling to remove in-situ material, or by importing material and spreading it accurately on the existing road surface. 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 pavement layer thickness and thus influence the pavement's long-term performance.

In cases where the geometry of the road is critical to the safety of the user, referencing the required horizontal alignment should be specified and controlled. For example to prevent flattening or steepening of cambers in high-speed cambered corners.

7.2.3 Supply of aggregate to site

Should the thickness of imported material exceed the intended stabilising depth, then the seal of the existing pavement shall be scarified to ensure adequate drainage. In addition, scarification shall be considered in the case of bound layers, where the potential of excessive moisture being trapped above the bound layer could adversely affect the performance of the pavement. To provide continuity and consistency of the materials, the scarified material should be granulated by a rotary spinning drum, such as those found on a milling machine or hoe. If a grader is used, then care should be taken to remove all particles larger then the nominal size allowed for that particular layer.

Occasionally material for shape correction and material modification will be required, in which case both shape-correction and material-modification operations will be required.

7.3 Spreading of lime and/or cement

7.3.1 Slaking of burnt lime

An offset spray bar allows the water tanker to travel 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.

7.5 Addition of water

When stabilising using bitumen emulsion, the amount of water added needs to take into account that the bitumen emulsion is a fluid during the mixing to some of the compaction phase. Therefore, the water added is estimated as follows:

$$W_{add} = OWC - W_{Agg} - W_{Emu} - 0.5 \times B_{Emu}$$

W_{Add} - Water that is added during hoeing

OWC - Optimum water content determined by NZS 4402, test 4.1.3, *NZ Vibrating hammer compaction*

W_{Agg} - Water in the aggregate before treatment

W_{Emu} - Water in the emulsion

B_{Emu} - Bitumen content in the emulsion

* Typically bitumen emulsion consists of 40% water and 60% bitumen (ignoring the small amounts of emulsifiers and other chemicals). In addition, typical bitumen emulsion contents are 3% to 5% by mass of the aggregate. Therefore, with a 40/60 bitumen emulsion and a bitumen emulsion content of 4%, WEmu and BEmu are 0.4 x 3% = 1.2% and 0.6 x 3% = 1.8% respectively.

7.7 Compaction

The compaction requirements generally follow those given in TNZ B/2.

7.12 Presealing requirements

After primary compaction has been achieved and within 4 hours of adding any cementitious binders, running course conforming to TNZ B/2 clause 10 should be applied to the finished surface as an armouring protection layer, and to assist in developing a tightly consolidated surface. The Contractor can decide however whether or not to use a running course, as this is material- and traffic-dependent and therefore not always necessary.

Until the section of pavement is sealed, construction work should include:

- Channelling the traffic, by the use of cones and flagmen, so that wheel loads are applied across the whole cross-section of road, and to avoid creating wheel paths by vehicles tracking over the same line.
- Providing non-vibratory, secondary rolling (e.g. PTRs).
- Providing additional running course if deemed necessary (use clause 10 of TNZ B/2 as a guide).
- Keeping surface damp but not wet to prevent dry out and unravelling.
- Drag-brooming the whole surface to keep a balanced distribution of running course.

This work should continue for a minimum period of 24 hours working time before sealing.

The Contractor should have prepared the surface for sealing in accordance with clause 7.10 of this Specification and of clause 7 of TNZ P/3, and have dried it back to a moisture content consistent so that it conforms with clause 7.12. Generally with materials requiring hydration this requirement is easily met, providing construction water is tightly controlled using machine injection techniques.

Foamed bitumen is similar, being constructed at dry of optimum water. A well-constructed formation that is weathertight requires careful surface management only in times of inclement weather.

Under no circumstance should thin lenses of material be added if the surface is not acceptable. If more material is required, the area under consideration shall be re-hoed and finished.

As a general guide a conventional seal design should be undertaken. For foamed bitumen or bitumen emulsion stabilisation, the residual bitumen of the first coat seal should be reduced by 10%–20%, while for cement or lime stabilisation it should be reduced by 5%–10%.

9. BASIS OF PAYMENT

9.5 Extra over or under Clause 9.4 for the supply and spreading of cementitious stabilising agents (tonnes)

9.6 Extra over or under Clause 9.4 for the supply and injection of bituminous stabilising agents (tonnes)

At times mix designs or pavement 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 9.4, and the theoretical amount calculated with the new binder content as follows:

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

where:

$Q_{EO\ or\ EU}$	-	Extra or lesser binder quantity	[tonnes]
A_{Ass}	-	Assumed area at tender	[m^2]
A_{Act}	-	Actual area stabilised	[m^2]
B_{Ass}	-	Assumed application rate	[kg/m^2]
B_{Act}	-	Actual application rate	[kg/m^2]

and

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

and

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

t_{Ass}	-	Assumed hoe depth	[m]
t_{Act}	-	Actual hoe depth	[m]
C_{Ass}	-	Assumed binder content	[%]
C_{Act}	-	Actual binder content	[%]
D_{Ass}	-	Assumed density	[kg/m^3]
D_{Act}	-	Actual density	[kg/m^3]

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.

[2] Roading New Zealand. 2007. Foamed bitumen treated materials. *RNZ Technical Note 001.* Roading New Zealand Inc., Wellington. http://www.roadingnz.org.nz/pubs.html

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APPENDIX 1

IMPORTED AGGREGATE PROJECT SPECIFICATION

Scope
This Appendix sets out requirements for the aggregate intended for use as one or more of the following (Informative, tick whichever is applicable, can be more than one):

Purpose	Tick
Correction in the longitudinal profile of the existing road	
Correction in the transverse profile of the existing road	
Correction in the particle size distribution	

Compatibility
The contractor shall ensure that the material supplied is compatible with the intended treatment.

Proportion of broken rock
In each of the aggregate fractions between the 63.0 mm and 4.75 mm sieves, not less than 50% by weight shall have two or more broken faces. It shall be free of organic matter.

Crushing resistance
The crushing resistance shall not be less than 110 kN when the aggregate is tested according to NZS 4407:1991 Test 3.10 *The Crushing Resistance Test*.

Weathering resistance
The aggregate shall have a quality index of AA, AB, AC, BA or CA when tested according to NZS 4407:1991 Test 3.11 *Weathering Quality Index Test*.

Sand equivalent
The sand equivalent shall not be less than 25 when the aggregate is tested according to NZS 4407:1991 Test 3.6 *Sand Equivalent Test*. The sand equivalent test may be neglected if the grading test shows less than 4% passing the 75 micron sieve.

Plasticity
The sand and/or filler (aggregates less than 2 mm), when added for the purpose of altering the particle size distribution, shall be non-plastic.

Particle size distribution
When tested according to NZS 4402:1986 Test 3.8.1 *Standard Method by Wet Sieving*, the grading of the aggregate, before hoeing, shall fall within their respective envelopes defined below:

Sieve size (mm)	**% of Weight passing (%)**		
	Section 1 envelope	**Section 2 envelope**	**Section 3 envelope**
63			
37.5			
19			
9.5			
4.75			
1.18			
0.075			