Model Specification for insitu stabilisation of subgrades and pavement materials using lime for Local Government Roads

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Australian Stabilisation Industry Association LIMITED

AustStab

Preface

Insitu stabilisation is a proven technique for both new construction and rehabilitation of existing roads and improving subgrades. Performance studies of existing roads in excess of 20 years have shown that Councils achieve excellent value-for-money results from this pavement technique.

A lack of design details, poor specification clauses, and poor construction practices by contractors with little knowledge of the process, quality control and materials may cause early distress of roads. Also, one of the problems faced by contractors during tendering is the variation of specifications. For example, in insitu stabilisation specifications are likely to change from one region to another region or State. It is frustrating to find that one council would specify binder content by volume and another by weight. This all leads to confusion and may lead to insufficient binder content in the pavement material.

In an attempt to minimise problems with road stabilisation AustStab has sought to produce a model specification for use by Councils and Shires. A working group in AustStab was formed to prepare this model specification aimed at specifying insitu stabilisation of local roads for both urban and rural areas. It also gave consideration to practices adopted in all regions of Australia, such that specifiers would not require tedious amendments.

In the specification there are options to include and delete paragraphs and clauses based on the contractual requirements and practices by Councils and Shires in Australia. At the end of the specification is a schedule of rates that is required to be completed by the contractor in their submission to the tender documents.

The specification and commentary contained in this document is available on disk and on the AustStab Internet web site at **www.auststab.com.au** The disk copy has various word processing formats and it is recommended that the readme.txt file is printed to ensure that the best file is opened for your computer setup. Amendments to the specification will be on the AustStab web site or you may telephone AustStab. It is hoped that the model specification and commentary will be widely used and the Association looks forward to your feedback, such that further amendments will reflect best practice.

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AustStab Model Specification for insitu stabilisation of subgrades and pavement materials using lime for local government roads

1 General

The purpose of this specification is for the construction of new or existing subgrades or pavement materials for lightly-trafficked roads by insitu stabilisation with quicklime or hydrated lime. Incorporation of the binder shall be accomplished using a purpose built spreader and stabilising mixer with mixing box referred to as a "stabiliser".

This specification shall be used with a schedule of rates and may be used for one or a series of projects for a contract.

The Council shall carry out detailed inspection of the site for services and asphalt patching greater than 75 mm in thickness. Council shall be responsible for all service alterations that are necessary before stabilisation commences

If cement is used after the addition to lime, the Contractor shall use AustStab Model Specification for insitu stabilisation of Local Government roads using cementitious binders including lime.

2 Description

The stabilised pavement shall be composed of a combination of soil and binder uniformly mixed, moistened and compacted in accordance with this Specification and shaped to conform to the lines, grades, thicknesses and typical cross-sections shown on the plans, or as directed by the Engineer.

3 Materials

3.1 Binder

The binder that shall be used is lime supplied to Australian Standards AS 1672.

The lime supplier should provide a minimum available lime guarantee and this guaranteed minimum should be used when determining the lime application rate.

When required by the Engineer, the Contractor shall furnish documentary or other acceptable evidence of the quality of the binder, and any binder that is not satisfactory shall be rejected**.**

3.2 Water

[*Delete paragraph that is not applicable*]

The water used for the work shall be supplied by the Contractor and shall be potable. Where the water is drawn from natural sources, an efficient filter is to be provided on the suction pipe to ensure freedom from weeds, roots, etc., which could cause blockage of jets in the stabiliser.

[*OR*]
The Council shall supply the water used for the work.

4 Lowering of Services

Council will located all services and lower services and utilities as necessary.

5 Initial Shaping

[*Delete if not applicable*]

The surface shall then be trimmed to the required alignment, levels and cross-sections necessary to produce the required final compacted thickness of stabilised material.

6 Spreading of Binder

The lime shall be uniformly spread at a controlled mass by area rate (kg/m^2) across the pavement. The rate of spreading shall be such as to provide the specified binder content in the compacted material. The spreader shall be equipped with gates to allow variable widths of binders to be deposited onto the pavement surface.

The contractor shall record the area of spread, tonnage of binder used per run, and mat or tray results at regular [at least daily] intervals, and keep these records as recommended in the Quality Manual. The construction tolerance for the spread rate is ±10% of the specified value.

Once the binder has been spread, the only traffic that may travel over the area to be stabilised, shall be construction plant employed for the stabilisation work.

If the lime used is quicklime slaking shall be carried out before mixing.

7 Slaking of quicklime

If quicklime is used the material shall be slaked using water meeting the requirements of Clause 3.2. The addition of water shall be sufficient to fully slake the lime.

8 Mixing

The total specified quantity of lime required for the full depth of the treatment shall be uniformly spread over the surface to be treated prior to the mixing process, or incorporated in the pavement by an approved controlled mechanical feed in one operation in a manner satisfactory to the Engineer. No equipment except that used in spreading and mixing will be allowed to pass over the freshly spread binder until mixing operations are complete.

Water, where practical, shall be added during the mixing process by means of a controlled pressure feed distributor located inside the mixing chamber or behind a water truck. The moisture content shall be uniformly distributed through the pavement material.

The mixing equipment shall be so constructed and operated that the compacted depth of stabilised pavement shall be to the full-specified depth. Mixing using graders, profilers, rotary hoes and other agricultural type implements will not be approved for stabilisation work. After pulverisation and mixing, all stabilised material shall be capable of passing a 47.5 mm sieve.

9 Compaction

Compaction of the material shall commence in the same day as mixing.

The compaction achieved, as determined by tests of the insitu material, shall not be less than 95% (Standard) of the maximum dry density.

10 Finishing

The finished surfaces shall be true to line and level, with correct crossfall, and free from loose pockets, holes, bumps and flakes of material.

[*Delete next paragraph if not applicable*]

The finished surface shall be 25 mm (+10mm or - 5mm tolerance) below the adjacent lip of the gutter and/or the edge of the sealed pavement to allow for a 25 mm thick layer of asphalt.

[*OR*]

Where a bitumen seal is to be used as the wearing course the pavement surface is to be finished to a straight uniform profile from the crown of the pavement to the lip of the gutter (+10mm or - 5mm tolerance) in the case of full width stabilisation.

The finished stabilised pavement shall not vary by more than 10 mm in any direction when tested with a 3 m straight edge.

Where shoulders only are to be stabilised, the finished profile shall comprise a straight uniform crossfall from the edge of the existing pavement to the outer edge of the construction.

All final trimming shall be cut to waste or reused in other applications as directed by the engineer.

11 Curing

[*Delete this section if not applicable*]

The stabilised pavement shall be protected from moisture loss for a period of 4 days or until a wearing surface or further pavement layer is applied; whichever the earliest.

This curing may be attained by:

- keeping the pavement damp by means of water spray
- applying an overlying layer that may be part of the overall pavement design
- applying a sprayed bituminous curing membrane consisting of either a rapid-setting bitumen emulsion or a cutback bitumen within 24 hours of the finishing operations.

[*Delete correct situation*] The Council/Contractor shall carry out the necessary curing works.

12 Provision for Traffic

The contractor shall be permitted to carry out a full road closure during the work.

The work shall be executed so that each section is completed to the full width at the end of the days works.

The provision of flagmen and temporary warning signs shall be the responsibility of the [*Delete correct situation*] Council/Contractor.

13 Sampling and Testing

13.1 General

The Contractor shall make available equipment and a Soils Technician to carry out moisture, compaction control or other specified tests as required by the Engineer. The contractor shall submit with the tender unit prices for this service and those noted below.

13.2 Spread rate

The spread rate shall be verified as per AustStab National Guideline *Verification of binder spread rate* once in every lot or as directed by the engineer.

13.3 Depth

The depth of stabilisation shall be verified by measuring the depth of "cutting" adjacent to an existing pavement material in at least two locations within the lot and measured to the nearest 5 mm. The construction tolerance for the stabilised and compacted depth is ±20 mm.

13.4 Density

The density of stabilisation shall be verified by testing in at least two locations within the street in accordance with AS1289 Method 5.4.1 and Method 5.3.1 or by Nuclear Density Gauge in direct transmission mode to AS1289.5.8.1.

13.5 Other Tests

Other tests, such as UCS and moisture content, to be carried out as directed by the Engineer at the Councils expense.

14 Acceptance/Rejection Criteria

Where the compaction standard, shape or stabilised depth does not meet the specified tolerances, the principal and contractor will resolve the disposition satisfactorily.

Schedule of Rates

<u>The following rates are exclusive of GST.</u>

Description	**Unit**	**Rate ($)**
Operations:		
Supply at x kg/m^2, spread, mix and compact	m^2	
Spread, mix and supply water cart(s)	m^2	
Testing:		
Density test	No.	
Compaction Testing	No.	
Variation of Rates:		
Additional quicklime at ***kg/m^2	kg/m^2	
Dispose of surplus material	tonne	
Number of mixing passes for lime stabilisation	1 or 2	

Project Cost ______________________
(from sum of rates and quantities)
GST (10%) ______________________
Total Cost ______________________

Commentary to AustStab's Model Specification for insitu stabilisation of subgrades and pavement materials using lime for Local Government Roads

The purpose of this commentary is to provide a background to the clauses in the model specification to assist the specifier in completing the document ready for tendering. The model specification was prepared by the members of AustStab and provides best practice. This commentary makes reference to various AustStab National Guidelines and Technical Notes, and these are available from members or the AustStab Web site at **www.auststab.com.au**

The possible applications of lime stabilisation are to:

- increase subgrade stiffness,
- reduce PI of insitu pavement material,
- enhance volumetric stability for the top layer of select material,
- subbase layers to improve stiffness of the pavement, and
- temporary construction platforms for civil works,

Lime stabilised materials may either be modified or bound, and the choice is a function of the application as shown in the above list.

The specification allows for part or full-service contracts. A full service contract is defined where the contractor will supply all materials and equipment, compact, trim and cure.

The aim of this specification is for Council to specify the same construction principles around Australia and the specification may be used for new or existing lightly-trafficked roads. Binders that are suitable with this specification are hydrated lime and quicklime. The appropriate lime content should be derived from a laboratory test program and further information may be found in references 1 to 3.

The council or shires representative for the work is described as the council engineer in this document. Other terms used in this document are defined in the AustStab National Guidelines [Ref.4] and *Lime Practice Notes* [Ref.5].

The format for this commentary follows the same number and title sequence as the specification.

Amendments to the specification will be available through AustStab members, listed in *AustStab News* and the AustStab web site.

1 General

Road stabilisation involves the use of specialised equipment that uniformly mixes the lime and subgrade material to the specified depth plus construction tolerances. The powerful equipment used during stabilisation may damage services and therefore, the council engineer should identify if any services that have to be lowered before work commences. The un-expected service that is higher than estimated in the initial inspection should be immediately repaired to not cause significant delay in the mixing or compaction of the stabilised pavement.

Reclaimers and stabilisers are manufactured with the mixing box located centrally or at the rear. These purpose built machines incorporate special rotors aimed at mixing the material within the mixing hood. The use of agricultural equipment, profilers, rotary hoes and graders are not substitutes for insitu stabilising as they tend to have very poor mixing properties that result in inadequate performance.

2 Description

The general construction process is

(a) Where the existing road requires the subbase and/or base pavement material to be removed a profiler is commonly used to wind row the material into the adjacent lane. After lime stabilisation of the subgrade the pavement material can be returned to the top of the subgrade by grader.

(b) Binder shall be spread upon the prepared pavement
(i) where a conventional stabiliser is used for the mixing, the pavement may need to be pretyned to the depth of stabilising prior to spreading the binder. This tyning should not exceed the depth of the stabilising.
(ii) where a reclaimer/stabiliser is used for the mixing there is no need for pre-tyning prior to spreading the binder. The binder is spread directly on the pavement as long as the levels are correct.

(c) The binder and soil is then mixed to achieve the compacted depth and degree of pulverisation specified. This stage allows for the binder to mix with the soil in the mixing chamber with the materials relatively dry.

(d) A second pass is then carried out with the required quantity of water. This stage then enhances the mixed material and water to provide optimum uniformity of mixing of the materials. In some cases the stabilised material may need to be cured for a period ranging from about 24 to 72 hours. In addition, where the lime application rates are in excess of 4% sometimes half the lime is applied in the first pass with the remaining mixed in the second pass.

(e) As soon as material is sufficiently compacted, grading must commence and be carried out in conjunction with compaction until a smoothly graded finish is obtained.

(f) The stabilised pavement should undergo a curing process.

(g) The initial pavement layer is constructed, and this may consist of a granular or stabilised base material.

3 Materials

3.1 Binder

Lime used for road stabilisation should comply with an Australian Standard as noted in the specification. However, the content of the lime should be proven in laboratory trials.

A three-month limit is introduced in this clause as experience has shown that lime loses its capability to react with the clay when aged over three months in a laboratory storage environment.

The Available Lime Index (%) is the portion of the lime that is chemically active in modification and stabilisation reactions and more details can be found in Section 6 of this commentary. It is noted that the Available Lime Index can vary dramatically depending on source of supply.

3.2 Water

The water used for stabilisation should be potable. The characteristics of the water that is sought are that it is soft, reasonably clean, and free from oil, acid, alkali, organic or other impurities. Seawater has been used for insitu stabilisation on several occasions around Australia and found to provide satisfactory performance.

4 Lowering of Services

AustStab member experience with many projects has indicated that Council staff are in a better position to organise and/or to carry out the work to lower all services and utilities as necessary.

5 Initial Shaping

Experience has shown that level improvements to the top of the subgrade before stabilisation can only assist with low surface roughness (ie for ride quality) being achieved during the construction of the subbase and base layers.

6 Spreading of Lime

In the laboratory hydrated lime is used and the $Ca(OH)_2$ component determines its reaction with pavement materials. In the field quicklime is used extensively and slaked on site to form hydrated lime. As the available CaO in quicklime and accordingly $Ca(OH)_2$ when slaked, varies with source and manufacturer, a conversion factor to determine the field spread rate for quicklime is necessary. In summary, hydrated lime used in the laboratory is not pure and quicklime used in the field varies significantly in the Available Lime Index[1] among sources.

The Available Lime Index can be expressed as either “available CaO” or “available $Ca(OH)_2$”. These terms are directly related by a conversion factor for a specific sample of hydrated lime. The atomic mass of CaO is 56 and $Ca(OH)_2$ is 74 and the ratio (56/74 = 0.76) of atomic masses is used to determine the conversion factor from hydrated lime to quicklime. To clarify this further, pure 100% $Ca(OH)_2$ (hydrated lime) has an Available Lime Index of 100% of $Ca(OH)_2$.

The designer can determine the percentage of quicklime at 100% CaO based on the % calcium hydroxide in the hydrated lime used for testing as follows:

$$Rate_{FQ} = 0.0076\,(Rate_{LH} + Rate_{TOL})\ AL_x$$

Where:

$Rate_{FQ}$ = Field application rate of quicklime (%)

$Rate_{LH}$ = Hydrated lime rate percentage determined in the laboratory test program using hydrated lime from supplier X (%)

$Rate_{TOL}$ = Allowance for construction tolerance (%)

AL_x = Available Lime Index for $Ca(OH)_2$ using hydrated lime in the laboratory test program from supplier X determined from AS4489.6.1 (%)

The contractor will determine the quicklime spread rate in kg/m^2 ($Rate_{SPREAD}$) according to the Available Lime Index of the quicklime (CaO) to be supplied, dry density of the pavement material and depth of stabilisation.

This is done using the following equation:

[1] Available Lime as determined from AS 4489.6.1

$Rate_{SPREAD} = Rate_{FQ}\ \gamma\ T / AL_y$

Where:
$Rate_{SPREAD}$ = Field spread rate of quicklime (kg/m^2)
$Rate_{FQ}$ = Field application rate of quicklime (%)
AL_y = Available Lime Index of quicklime
. expressed as available CaO from supplier
. Y determined from AS4489.6.1 (%)
γ = Dry density of the pavement material (kg/m^3)
T = Thickness of stabilised layer (m)

An example of how this may be applied in practice is shown below.

A laboratory test program using hydrated lime from supplier X established that the minimum amount of this hydrated lime required to meet the subgrade CBR improvement was 3%. The hydrated lime used in the laboratory program had an Available Lime Index of 90% (i.e. $Ca(OH)_2$ content) and the contractor proposes to use quicklime from a supplier where the Available Lime Index is 85% (ie CaO). The road authority uses 0.5% for construction tolerance, and the pavement stabilisation depth is 200 mm and the dry density of the material is 1900 kg/m^3. The designer would specify the following application rate of quicklime:

$$Rate_{FQ} = 0.0076\ (Rate_{LH} + Rate_{TOL})\ AL_x$$
$$= 0.0076\ (3 + 0.5) \times 90$$
$$= 2.4\%$$

The spread rate of quicklime from supplier Y would be:

$$Rate_{SPREAD} = Rate_{FQ}\ \gamma\ T / AL_y$$
$$= 2.4 \times 1900 \times 0.2 / 85$$
$$= 10.73\ kg/m^2$$

Using AS 2706 for rounding numbers the spread rate of quicklime for this project would be 11 kg/m^2.

The practice in NSW and Queensland is that specifications call for the supply of hydrated lime to have a minimum content of Ca $(OH)_2$ of 85%. Laboratory testing is carried out using approved hydrated lime and the field requirement is specified directly as a percentage of an approved lime. In these cases the laboratory determined available lime is not used as described above. In this instance, if quicklime is used in the field then the application rate should be 0.76 of the specified hydrated lime application rate.

Spread rates in the field can be verified by examining the load cell readings from calibrated spreaders or the use of trays or mats [Ref.6].

The maximum amount of hydrated lime that may be spread is 20 kg/m^2 to ensure uniform mixing of the lime and subgrade material. Where the specified spread rate exceeds 20 kg/m^2, the contractor shall spread and mix the binder in at least two passes. For quicklime the maximum spread rate is 12 to 15 kg/m2 to ensure that all the quicklime is slaked.

7 Slaking of quicklime

The completion of the slaking quicklime may be determined in the field using one of the following simple approaches:

- Using a glove the quicklime has been slaked when the lime becomes a fine powder.
- No steam occurs after the quicklime is sprayed with water.
- There is no further temperate rise (use a surface thermometer).

In some fine-grained clay soils the OMC is 30 to 40%. If this material is over wet due to exposure to wet weather it may be impractical or unnecessary to slake the quicklime as sufficient moisture may be present in the host material to react and therefore slake the quicklime. In this instance an experienced contractor may forgo or only partially slake the quicklime as the moist soil will contain sufficient water to react with the quicklime to form the Ca ions need for stabilisation.

8 Mixing

Uniform mixing of the binder and water is paramount to the success of the stabilised pavement, and therefore, it has been previously noted that specialised machines should only be used in this process.

For the mixing process to be effective water is added through the mixing chamber or behind a water truck with spray bars under a controlled pressure feed distributor.

The moisture content of the material immediately after mixing is set at a range of 80% to 110% of the moisture content specified by the Engineer, and less than the optimum moisture content. A contractor has to monitor the moisture content during mixing and this is carried out by feeling the soil in the palm of the hand. Experienced staff follow the stabiliser and bring problems to the operators attention.

For local government roads with stabilised layers up to 300 mm the mixing and compaction process is carried out in one layer, that is full depth. The construction of multiple layers is uneconomical.

The number of passes for lime stabilisation to obtain adequate mixing is based on the type of soil and experience by the contractor, and therefore, the number of passes needs to be noted in the schedule of rates.

All AustStab contractors work to a well planned and proven procedure based on their quality manual. Unfortunately, wet weather conditions, plant breakdown or other causes may prevent the lime from being uniformly incorporated into the pavement in accordance with the above procedure. If this occurs a GP cement binder may be used to provide additional stiffness to the material to continue with the lime stabilisation process.

Mixing generally proceeds in lanes working from one side of the pavement to the other, without intervening lanes of unmixed material. Typically the overlap is 100 to 200 mm and additional lime should not overlap beyond this region.

Joints are formed by cutting back into the previously stabilised and compacted work. The material disturbed during cutting back is re-mixed to full depth and incorporated into the new work. The minimum distances of cutback into previously stabilised material is typically:

(a) longitudinal joints - 75 mm
(b) transverse joints - 2 metres.

The contractor sets a layout of all joints based on the following requirements:

(a) Minimise the number of joints to be formed.
(b) Transverse joints are formed at right angles to the road centreline.
(c) Longitudinal joints are formed on the separation lines of the travel lanes and a minimum of 300 mm outside the edge lines in the shoulder area.
(d) Internal longitudinal joints are formed such that each is at a constant offset to the road centreline.

In some regions of Australia cement may be mixed after lime stabilisation and it is recommended that the engineer uses AustStab Model Specification for insitu stabilisation of Local Government roads using cementitious binders including lime.

9 Compaction

Compaction of the material in the pavement is best carried out immediately so that final trimming can be achieved. The use of lime allows more flexibility with compaction times. In colder climates, a “cool” soil may slow the setting of the lime and this should be taken into consideration in the design stage.

Selecting the right compaction equipment is typically carried out by the stabilisation contractor.

Traffic may be allowed onto the subgrade surface provided that strict speed controls are posted and there is no likelihood of rain.

10 Finishing

Two options are provided in this section of the specification, namely to trim to a specified level below the existing kerb and gutter profiles or to a specified crown with cross fall, such as in a rural area.

All final trimming should not be incorporated into the surface and recompacted as studies have shown that the trimmed material becomes an unbonded layer and it is likely to strip under traffic loading. To prevent false pavement layers all trimming of base material should not be incorporated into the surface.

11 Curing

When lime stabilisation is used for base course materials, curing is important to ensure that the surface does not crack and granular material is formed. Poor curing or lack of curing can create a “granular” type surface that may rut under loading. Curing may be attained by:

- keeping the pavement damp by means of water spray
- applying a sprayed bituminous curing membrane consisting of either a rapid-setting bitumen emulsion or a cutback bitumen within 24 hours of the finishing operations.
- Applying an overlying layer that may be part of the overall pavement design.

12 Provision for Traffic

The provision of traffic signs and flagman during construction should be established by the council engineer so that signs and procedures do not hinder the safety of construction crew and the road users [Ref. 6]. In some instances the road may require full-closure to expedite the work.

Typically the work is executed so that each section of roadway is completed to the full width at the end of the days works.

13 Sampling and Testing

13.1 General

Ongoing road stabilisation in a council area or shire by the specified procedure provides a low-cost road construction solution. Testing is sometimes considered necessary in new areas of the council or shire. However, testing is an additional cost to the project and therefore, selecting the type and frequency of tests should be carried out with experience.

13.2 Spread rate

AustStab has prepared a test procedure to verify spread rate and refer to reference 4 for more detail.

13.3 Depth

The depth of stabilisation is normally established by comparing the depth of the insitu material with the depth of cut made by the stabiliser.

13.4 Density

Density of the stabilisation material is very important to its performance. The attainment of good density is dependent on the use of suitable rollers and good compaction practices [Ref.5].

The sand replacement or Nuclear Density Gauge (in direct transmission mode) methods may be used for density measurement testing. If there is a requirement for density testing the responsibility for the testing should be clearly stated.

13.5 Other Tests

Other tests, such as UCS and moisture content, may be carried as directed by the engineer and are used to establish “soft” spots in the pavement or unexplained failure in the pavement after curing.

14 Acceptance/Rejection Criteria

Where the compaction standard or stabilised depth falls well short of that required it is common for the Council engineer and the Contractor to negotiate payment. Typically this is done at a unit rate of area stabilised.

References

1. Austroads *Guide to Stabilisation in Roadworks* Sydney, 1998.
2. Austroads AP-TP10 *Mix Design for Stabilised Pavement Materials* Sydney, June 2002.
3. AustStab Technical Note 1 *Lime stabilisation practice* Australian Stabilisation Industry Association, Chatswood, May 2002.
4. AustStab National Guidelines *Terms* Australian Stabilisation Industry Association, Chatswood, 1998.
5. AustStab Technical Note *Lime Practice Notes* Australian Stabilisation Industry Association, Chatswood, April 2005.
6. AustStab National Guidelines *Australian Binders used for the Stabilisation and Road Recycling Industry* Australian Stabilisation Industry Association
7. AustStab National Guidelines *Verification of Binder Spread Rate* Australian Stabilisation Industry Association.
8. Mayfield, M, Symons, MG and Collins, JR *Guide to the Selection of Vibratory Rollers for Road Construction* Structural Materials and Assemblies Group, University of South Australia, March, 1994.
9. Australian Standards HB8 *Handbooks for Traffic Control Devices on Roads* (six volumes)

NOTES: