PILOT SPECIFICATION FOR IN-SITU SUBGRADE STABILISATION

1. SCOPE

This specification shall apply to the in-situ stabilisation of subgrade layers comprising either natural in situ soils, imported fill materials or a combination of both using cement, lime or a combination of these.

The subgrade layer(s) shall be constructed in accordance with the levels, grades and cross-sections shown in the drawings of the Project Specifications.

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.

2. DEFINITIONS

Definitions of terms that are used in these specifications are described in the Notes to these Specifications.

3. MATERIALS

Imported subgrade fill materials, if any, shall comply with TNZ F/1 "Specification for Earthworks Construction" and/or shall comply with the Project Specifications.

4. STABILISING AGENTS

4.1 Chemical Stabilising Agents

Chemical stabilising agents shall be either one, or a combination, of the following:

4.1.1 Lime

Lime shall comply with NZTA M/15.

4.1.2 Cement

Cement shall comply with NZS 3122 Specification for Portland and blended cements (General and special purpose) for:

- General purpose Portland cement – Type GP;
- General purpose blended cement – Type GB; or
- Special purpose low heat cement – Type LH

General purpose Portland cement, type GP, shall be used unless otherwise specified in the Contract Documents.

Cement shall be stored and handled to provide protection against deterioration or contamination. If the cement is stored by the contractor for more than 3 months and is over 6 months from its manufacturing sampling date, or is suspected of not being stored in a way that protects it from deterioration, the cement shall be re- tested in accordance with NZS 3122.

5. WATER

The Contractor shall be responsible for ensuring that the water for stabilisation, construction and curing of stabilised layers is free from impurities that may deleteriously affect the setting, hardening or strength of the stabilised material.

Water from sources other than public supply may have its suitability established to the satisfaction of the Engineer by repeating the final laboratory-based mix design tests with the water considered for use. The results of these mix design tests shall be greater than 90% of the final results from the mix design. In addition, work shall be stopped if any discolouration or residue is observed when adding or sprinkling water into or onto the material.

6. PLANT AND EQUIPMENT

All plant shall be supplied and operated so that it will uniformly spread, or add the stabilising agent and thoroughly mix it to the specified depth with the in-situ material.

Stabilising and spreading plant shall be purpose-built by a manufacturer having a demonstrable track record and manufacturing history for the particular type of equipment used. Plant and equipment not meeting this requirement shall not be allowed on site.

6.1 Plant for supply of stabilising agents

Stabilising agents shall, for areas greater than 500 m^2, be delivered to the site in bulk tankers or trucks unless otherwise approved by the Engineer. Each bulk tanker shall be issued a *Certificate of Loading* that contains the following information and shall be part of the project quality plan:

- Tanker's identification details including certification number;
- Product identification;
- Name of the supplier;
- Batch number and date of manufacture (if possible);
- Date, time and place of loading;
- Comments on the state of the tanker at the time of loading in terms of cleanliness, details of the previous load carried and whether any residual product from the previous load remains;
- Details of any chemical or other substance added to the product before, during or after the loading procedure, if any, and
- Net weight of product before and after discharge into the mechanical spreaders.

6.2 Plant for spreading chemical stabilising agents

Transfer of all stabilising agents into the purpose-built spreading equipment shall be undertaken in such a manner to ensure that no contamination of the environment occurs. Where pressurised lime or cement powder is transferred release filters shall be utilised to contain dust.

The spreading equipment shall be capable of varying the spread width to cater for different application widths. Where the chemical stabilising agent is applied directly to the surface of the subgrade prior to stabilising, the spreader unit shall be a purpose-built calibrated belt or pneumatic rotor spreader incorporating adjustable spreader curtains.

6.3 Plant for applying water to the subgrade

The addition of water may be required for slaking of burnt oxide. Where water is applied for slaking of burnt oxide it shall be undertaken prior to hoeing and shall be carried out with a pressurised side bar with sufficient nozzles to ensure an even distribution in both transverse and longitudinal directions that does not require trafficking of the spread lime once slaking has commenced. Capability to vary application width shall be a requirement to avoid overwatering of overlaps/ tapers. The application rate will be restricted to avoid ponding or lateral movement and where necessary multiple passes shall be carried out prior to hoeing.

Water for moisture correction (i.e. compaction water) shall be added via direct injection into the hoe mixing drum by a pressurised bar with sufficient outlet nozzles to allow uniform delivery of water across the entire how width. The direct injection water delivery shall be of sufficient pressure and flow capacity to accommodate the forward ground speed otherwise the speed of the hoe will need to be reduced. The direct injection water delivery system shall also be capable of varying width to restrict water application to the required portion of hoe width, to avoid overwatering of previously treated subgrade. The water flow through the bar shall be controllable from the cab by the operator. Water application rate shall be monitored via a flow meter and regular checks shall be made of optimum application via “squeeze tests”.

6.4 Plant for stabilisation (mixing process)

Mixing using graders, profilers, or asphalt milling machines and agricultural type implements, shall not be permitted.

As a minimum, the stabilising machine shall have the following features:

- A capacity that has adequate rating for maintaining a constant rotor and forward speed, in addition to a capability for stabilising to the specified depth.
- A stabilising drum that rotates upwards into the direction of advance, located between the axles, which shall achieve at least 2.0 m of cut width in a single pass and shall have a level control system that maintains a depth of stabilising within a tolerance of +0 mm and -30 mm of the required depth during continuous operation.
- Where the hoeing depth exceeds 200 mm, the mixing chamber shall have an effective volume that can increase in relation to the depth of the cut, in order to accommodate additional material generated by increasing the depth of cut. This is achieved by the stabilising mixing drum being independent of the mixing chamber housing.
- An adjustable exit gate to ensure that the mixed material exits from the mixing chamber in a manner that prevents particle segregation.

Where the stabilisation plant is capable of hoeing the subgrade material with water (if required) and chemical stabilising agents in one (or more) operation, the mixing equipment shall include the following features:

- A controlled pumping and metering system to regulate the application of water and/or fluid stabilising agent(s) in relation to travel speed and mass of material being stabilised. The pumping systems shall be calibrated to deliver within a tolerance of ± 5 % by volume,
- A system of nozzles that promotes a uniform application of water and/or fluid stabilising agent(s) across the full width of treatment. The application systems shall be capable of adjustments for varying widths of treatments;

7. CONSTRUCTION

7.1 Limitations

7.1.1 Weather Limitations

Temperature

Work shall not be started if the temperature is below the temperature of the component set out in Table 1:

Table 1: Minimum working temperature of stabilising agents.

Stabilising Process	Component to measure	Min. Temp (°C)
Cement	Ambient air temperature	5 °C
Lime	Ambient air temperature	10 °C
Cement / Lime	Ambient air temperature	10 °C

If, during construction the governing component's temperature drops below the limits set in Table 1 above, then no further work, other than compaction and finishing, shall be permitted.

Dryness, wind

Spreading of powdered chemical stabilising agents on the surface ahead of the recycling machine shall not continue when the chemical stabilising agent becomes a dust problem or when the wind speed exceeds 25 km/hr, except if the mixing and spreading is carried out in one unit that effectively contains the chemical stabilising agent

Rain

No spreading of binding agents shall commence if it is raining. If rain is likely to start before the binding agent(s) can be mixed into the subgrade, then spreading of the binding agent(s) shall not take place.

7.1.2 Time Limitations

The maximum time period, from mixing of the materials to primary compaction of the stabilised subgrade, shall be determined by the type of stabilising agent(s) used, as follows:

Cement: two (2) hours;
Lime: four (4) hours;
Cement / Lime: two (2) hours;

Where two or more stabilising agents are used, the time limitation shall be the shorter of the individual agents. Where the time limit is exceeded, details of the remedial actions taken by the Contractor shall be submitted to the Engineer for approval. Where other stabilising agents are used the maximum time period to completion of primary compaction shall be demonstrably proven prior to acceptance for use, and subsequently adhered to at all times.

Where drying is the purpose for stabilising and strength gain is not required from chemical bonds a relaxation of time limitations may be adopted at the discretion of the Engineer.

7.1.3 Design Strength

It is assumed that sufficient testing has been undertaken to confirm that the permanent strength and durability of the stabilised material will achieve (or better) the required design parameters. Of particular importance is to determine the range of water content within which the subgrade soil(s) can be

stabilised with the selected stabilising agent dosage to achieve the required design strength / durability properties.

7.2 Before Stabilisation Commences

7.2.1 Surface Preparation

Before any work commences, the surface of the area to be stabilised shall be prepared by:

- Cleaning all vegetation, detritus and other foreign matter;
- Removing any standing water;
- Installing lift pegs if required by the Project Specification.

The area to be stabilised shall conform to the subgrade shape, compaction and tolerances according to TNZ F/1 or as specified in the project specifications before spreading commences. The stabilising process and materials shall not be used to make good deficiencies in shape or thickness; this shall be achieved prior to commencing stabilising operations.

7.2.2 Production Plan

The contractor's quality plan shall contain a description in the agreed works programme how the stabilisation process is to fit into the overall project, ensuring that the plant and materials required for effective stabilisation are available when needed, and that preparation of and post stabilisation curing and management of the stabilised subgrade is completed in accordance with this Specification.

During the stabilisation works, and prior to start of work every day, the contractor shall prepare a production plan detailing their proposals for the forthcoming day's work. This plan shall indicate:

- A sketch showing the overall layout of the length and width of subgrade intended for stabilising during the day, broken into number of parallel cuts required to achieve the stated width, and the overlap dimensions at each joint between cuts;
- The amount and type of stabilising agent, or agents, to be applied to each cut;
- The depth of each cut;
- The sequence and length of each cut to be stabilised before starting on the adjacent or following cut;
- An estimate of the time required for spreading the binder(s), Slaking (where required), mixing and compacting each cut. The sketch shall also show the time when the completion of each cut is expected;
- The location where samples were taken for determining in situ moisture contents, and the results of the tests;
- Proposed water addition for each cut, and the location at which any change is to be made within that sequence;
- Proposed quality control testing programme;
- The number of passes to achieve sufficient mixing of the binder;
- Locations of existing services and mitigation/contingency plan to avoid conflict with the stabilising operation;
- Other information as requested by the Engineer;

The contractor's site representative shall keep the daily production plan on site at all times. The plan for the following day shall be amended as required in response to feedback from the current days work.

7.3 Spreading of lime and/or cement

The stabilising agent shall be uniformly spread at the specified application rate across the pavement with an approved mechanical spreader to the tolerances set out in Table 2:

Table 2: Tolerance for Lime and/or Cement

Test	Frequency	Tolerance
Mat test: (1 m^2 canvas)	Nominally every 400 m^2	Within ± 0.5 kg/m^2 of the specified rate
Average usage test: Compare tonnes used (from delivery docket) with measured area	Upon emptying the spreader and bulk tanker	Within ± 5 % of the specified rate

The type of binder(s) and application rate(s) shall be specified in the Project Specifications.

Where more than one product is to be used the spreading methodology shall be undertaken so as to ensure that no loss of efficacy results. Where lime and cement are to be spread and hoed separately, the lime component shall be spread and hoed first. Where the products are spread together and hoed simultaneously the quantity of water required for slaking shall not compromise the efficacy of the cement component. Where blended lime and cement are used the maximum burnt oxide chip size shall be 3 mm.

The Contractor shall record and keep records of the tonnage of lime and/or cement used per area, including the Mat results.

During the operation utmost care shall be exercised to ensure that all runoff is contained within the road "footprint" or in a designated attenuation area with appropriate controls. In the event of any binding agents entering any waterways the Engineer, and the environmental authority for the region shall be notified immediately.

No traffic, including non-essential construction plant, shall be permitted to move over the stabilised subgrade surface until mixing, primary compaction and shaping has been completed in accordance with this and the project specification. Following this period, control of traffic is still required until curing and overlying aggregate or alternative cover is placed to ensure that the stabilised layer is not reshaped or overstressed.

7.3.1 Slaking of burnt lime

Slaking of burnt lime shall be carried out using a purpose built, offset and pressurised spray bar on a water tanker to ensure thorough water penetration into the burnt lime. Slaking shall continue until no further reaction with additional water is visible and the slaked lime is completely converted to powdered form. Over-watering shall be avoided. Precautionary measures shall be taken to ensure that the public will not be exposed to unslaked lime blown by the wind or at any time during the slaking operation.

7.4 Addition of Water

Sufficient water shall be added during the stabilising process to bring the material to the required compaction moisture content (slightly dry of OWC). Particular care shall be taken to prevent any portion of the work from excessive wetting.

The optimum water content (OWC) of the stabilised materials shall be determined by NZS 4402, test 4.1.1, *New Zealand Standard Compaction Test*.

Water shall only be applied, where necessary to bring the subgrade soils to optimum moisture content, while mixing. As a guide the water content of the stabilised subgrade materials should be at optimum moisture content, but no more than +2% of optimum moisture content.

The addition of stabilising agents, such as Calcium Oxide Fines, may be undertaken as part of a pre-treatment process to dry a wet subgrade or bring the subgrade materials to optimum (or an improved) moisture content.

7.5 In situ mixing

The stabilising equipment shall be carried out by a machine specifically designed for this purpose and set up and operated to ensure that the following key requirements are met:

7.5.1 Control of Cut depth

The project specification shall specify the thickness of the stabilised layer required. The actual depth of the cut shall be physically measured at both ends of the stabilising drum at least once every 200 m along the cut length. Maximum variation from the specified depth of cut is +0 and -30 mm from the compacted depth nominated in the specification.

7.5.2 Overlap on Longitudinal Joints

To ensure complete stabilisation across the full width of the subgrade, longitudinal joints between successive cuts shall overlap by a minimum of 100 mm or half the layer thickness, whichever is the greater. Where soft soils or uneven surface limit accuracy the overlap shall be increased to ensure the nominal overlap is achieved.

Unless stated to the contrary in the Project Specifications, longitudinal joints shall be planned to coincide with each and every change in cross-fall across the road width, regardless of the implications of overlap width. Water and stabilising agent(s) shall only be applied to the overlap during the last cut to the overlap.

The overlap width shall be marked out before starting each new cut sequence and any adjustments made to ensure that the amount of water and stabilising agent(s) is (are) reduced proportionately by the width of the overlap.

7.5.3 Continuity of Stabilised Layer

The exact location of the end of the cut shall be carefully marked. This mark shall coincide with the position of the centre of the mixing drum at the point at which the supply of stabilising agent ceased. To ensure longitudinal continuity of the stabilised layer, the next successive cut shall be started at least 1 m behind this mark.

The stabilised area shall be squared off at the end of the day's production, and the location shall be recorded on the production plan for that day.

7.5.4 Particle size distribution of the stabilised subgrade

The forward speed of the stabilising machine, rate of rotation of the stabilising drum and the positioning of the gradation control beam shall be adjusted to ensure that the in situ material is broken down to an acceptable particle size

distribution as specified in the Contract documents, and thoroughly mixed with the stabilising agent(s).

To ensure that design requirements are met the freshly hoed material shall be assessed within the first 20m run of each section, and then in an ongoing frequency as required based on variability of in situ materials. The freshly hoed subgrade particle size distribution shall be assessed for uniformity. Where the subgrade particle size is considered too coarse and stabilising speed and/or drum configuration cannot be adjusted to achieve a satisfactory particle size distribution further passes shall be undertaken until the specified particle size is achieved. Where further passes are required they shall be undertaken immediately. The maximum particle size should be as small as possible to ensure optimum mixing of stabilising agent(s) and water, however as a general rule the maximum particle size desired for a heavy clay is 19 mm with no particles retained on a 26.5 mm test sieve.

7.5.5 Mixed material testing

During construction, when agreed with the Engineer, the Contractor shall take representative samples of the mixed and stabilised materials from behind the hoe (just before starting compaction) and shall have these samples prepared into compaction moulds (preferably on site to avoid changes in moisture content). The compacted samples shall then be returned to the laboratory for controlled curing. Cured samples should then be tested for CBR. Note that compaction, curing and soaking are to be the same as used in the design. The collection of these ongoing test results should enable both the Contractor and Engineer's Supervisor to refine their understanding of the desirable OWC and MDD targets for a range of stabilised material mixes, thus improving the ongoing decision process required under clause 8 of this Specification.

7.6 Compaction

Compaction shall be achieved by the minimum necessary number of passes of compaction plant, not by traffic. Details of plant shall be given in the Quality Plan.

The Contractor shall be responsible for carrying out laboratory tests according to NZS 4402:1986, Test 4.1.1 to determine the maximum dry density (MDD) at the OWC of the stabilised material. The tests shall be undertaken on the stabilised material that is representative of that used in construction and a grading for the material tested shall be supplied with the results.

At the outset of compaction the contractor shall undertake plateau density tests for the purpose of determining the practicality of both the OWC and the MDD targets, the minimum, and possibly the maximum, number and type of roller passes required to achieve the MDD for the proposed compaction plant and stiffness of lower pavement 'anvil' beneath the layer to be compacted. The plateau tests shall be undertaken with compaction plant that is to be used for construction – which shall be appropriate for the depth and type of materials to be compacted. The plateau tests shall be undertaken to confirm the optimum pattern of static and vibratory passes for the unique site settings and shall be undertaken in an area where lower pavement stiffness is representative. Repeated plateau density tests shall be undertaken when the material to be compacted or lower pavement parameters change visibly.

Compaction plant shall include type (i) for primary compaction, and type (ii) for the final consolidation of the top portion of the layer, as defined below:

Type (i) Padfoot vibratory rollers with single vibrating drum

Type (ii) Smooth double drum roller

Type (ii) rollers may be replaced with a combination roller, which has one smooth drum at the one axle and rubber-tyred pneumatic wheels across the full width at the second axle of the roller.

The rolling operation shall not extend beyond the width of the stabilised cut unless the adjacent stabilised material is within the time limitations of clause 7.1.2. Rolling beyond the stabilised cut onto longitudinal adjacent cuts that have already partly cured may fracture especially where there is a change of cross fall such as along the crown of the road.

The contractor shall measure immediately after primary compaction and provide the results of the water content and achieved density to the engineer. Frequency of testing and lot sizes shall be as defined in clause 8.1.

7.7 Curing, Protection and Maintenance

The Contractor shall protect and maintain the completed stabilised layer until the next subgrade layer is applied. In addition to the curing of the stabilised layer by frequent light watering as required, maintenance shall include the immediate repair of any damage to or defects in the layer and shall be repeated as often as necessary.

During the curing period the surface of the stabilised subgrade shall be kept in sufficiently moist condition to maintain the average moisture content at close to optimum and alleviate dust until the subgrade is covered within the subgrade layer(s). Water shall be applied uniformly as required. The curing period and any trafficking restrictions during the curing period and through overlying layer placement shall be as per the contract documents and shall be managed to avoid any damage to the subgrade layer and surface finish.

Overwatering leading to any instability of the subgrade surface, slurrying or leaching of the stabilising agent should not occur. In the event that it does, the contractor will need to implement suitable remedial works, to the Engineer's satisfaction, prior to moving to the next stage of construction.

Where aggregate is used to protect the subgrade surface as a running course, or as a means to protect the surface moisture content the maximum particle size and grading of the covering layer shall be designed by the contractor to suit the stabilised subgrade soils and environmental conditions encountered

8 ACCEPTANCE CRITERIA OF THE CONSTRUCTED LAYER

8.1 Compaction

The stabilised pavement layer shall be compacted to a uniform, dense, stable condition.

Compaction testing of the stabilised pavement layers shall be carried out in lots. A lot is defined as a section where the pavement layer appears homogeneous and evenly compacted. The area of a lot shall not exceed 1000 m2.

The degree of compaction for each lot shall be determined by testing at least five randomly selected areas. The compaction requirements shall be met if the mean and minimum compaction values of the tests taken comply with the values in Table 2. In preference to random selection the Engineer may carry out any testing for uniformity to determine the location of density tests.

The Maximum Dry Density of the stabilised material shall be determined for each layer at a minimum frequency of one Maximum Dry Density per 5,000m2 of material laid. If the aggregate source, processing method, or stabilised materials are expected to change then a new OWC and target MDD shall be determined.

Table 2: Mean and minimum degree of compaction for pavement layers

Degree of Compaction	Treated Subgrade
Mean	≥ 98 %
Minimum	≥ 95 %

Where the Acceptance Criteria are based on laboratory results and cannot be met, the Engineer shall nominate an independent laboratory to repeat the laboratory tests and supervise a repeat of the Plateau Density test. Should the Criteria still appear unachievable the Engineer may accept the Plateau Density tests as the Maximum Dry Density. This process may be repeated for each MDD determined at the Engineer's discretion. Should all of the additional testing find the same as the Contractors testing, the testing shall be at the Principal's cost.

8.2 Surface Shape

Trimming and Rolling

The entire surface of the subgrade shall be made firm, uniform, and smooth by blading, grading and rolling. Rolling associated with the surface finishing shall be the same as that which would produce the compaction specified for the particular material in Clause 8.1.

The use of construction traffic on the finished subgrade shall be controlled so as not to damage the completed work.

Surface Finishing Tolerances

The surface of the subgrade shall be finished so that all points are within 30 mm from a 3 m straight edge laid parallel to the centreline of the road and from a cross-section camber board placed at right angles to the centreline. The subgrade surface shall not pond water, where the design slope of the subgrade is 2% or steeper.

The reduced level of any point shall be within the limits of zero above to 30 mm below the designed or nominated level.

Subgrade Uniformity Testing

Benkelman beam or other subgrade testing shall be carried out as described in Contract documents.

9 QUALITY PLAN

Compliance with the requirements of clauses listed in Table 3 shall be checked by the contractor, included in the project's Quality Plan, and records made available for inspection by the Engineer.

Table 3: Summary of stabilisation tolerances

Construction / Stabilisation activity	Clause reference
Addition of Chemical stabilising agents	7.3 - Table 2
Stabilisation depth	7.5.1
Strength testing (ITS)	7.5.5
Compaction	7.6 & 8
Surface shape	8.2

Measurements of crossfall should not be necessary unless there are indications that the requirements of this specification have not been met. If the surface subsequently deteriorates such that finished surface levels may be affected then the contractor shall carry out further measurement of the construction dimensions to confirm compliance.

10 Basis of Payment

If not included in the contract documents, the basis of payment shall be as follows.

All miscellaneous items, lodgings, supervision, setting out, contingencies, conveyance of plant, and other incidental work, general overhead administration and maintenance shall be incorporated in the unit rates listed in the schedule.

10.1 Preparation of surface

If any special treatment is required to the existing subgrade other than those described in this specification, it shall be specified in the Project Specifications.

Payment will be made on the solid volume measured in cubic meters of inferior pavement removed and/or the area measured in square meters cleared to the satisfaction of the Engineer.

10.2 Pretreatment (square meters)

Payment for each section of the works specified in the contract documents will be made on the specified area pre-treated by hoeing (m^2) to a specified depth (mm). Measurement shall be in area (m^2) of the finished dimensions of the pre-treated area as shown on the drawings or those directed and marked on site by the Engineer. In the case of the latter, the dimensions shall be agreed before stabilisation commences.

The scheduled rate shall include allowance for the supply and spreading/injecting of all water, pulverising, mixing, compacting, trimming and finishing, to the specified tolerances.

10.3 Stabilising (square metres)

Payment for each section of the works specified in the contract documents will be made on the specified area stabilised (m2) to a specified depth (mm) at a specified stabilising agent application rate (kg/m2). Measurement shall be in area (m^2) of the finished dimensions of the stabilised layer shown on the drawings or those directed and marked on site by the Engineer. In the case of the latter, the dimensions shall be agreed before stabilisation commences.

The scheduled rate shall include allowance for the supply and spreading/injecting of all specified stabilising agents, water, pulverising, mixing, compacting, trimming and finishing, to the specified tolerances including protecting and maintaining the work as specified and including the curing.

10.4 Extra over or under for the supply and spreading of stabilising agents

Payment for each section of the works specified in the contract documents will be made on the extra or lesser amount of the stabilising agent required. Measurement shall be in tonnes (t).

The scheduled rate shall include allowance for supply and cartage of the stabilising agents.