NOTES TO SPECIFICATION FOR MANUFACTURE AND CONSTRUCTION OF PLANT MIXED MODIFIED PAVEMENT LAYERS

(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.

There are two plant mixed stabilised aggregate specifications:

- Plant mixed stabilisation of modified pavement layers (NZTA B/7:2012)
- Plant mixed stabilisation of bound sub-base layers (NZTA B/8:2012)

Before using plant modified 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 subbase and basecourse stabilisation, aiming at reducing moisture content, reducing water susceptibility; provide a homogeneous substrate for the pavement layers and to increase the shear strength of the material 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 NZTA B/8 :2012.

Because of the nature of the various binders that are described, the NZTA B/7 Specification tends towards a method-type specification as opposed to being performance based. This Specification is suitable for the stabilisation of subbase and/or a basecourse layer, both in new construction and in maintenance work of a substantial size, such as urban area-wide pavement treatments, or when insitu stabilisation is not suitable. It is therefore not generally suitable for application in maintenance patch-type operations.

The NZTA intends to provide an appropriate surface for the travelling public to use at all times. The Contractor should ensure that road users' vehicles are protected from deleterious effects of the binders used in construction at all times. Reasonable options for managing operations can include:

- stopping vehicles travelling on a freshly spread binder
- stopping vehicle movement on a wet surface slurry if speed restrictions alone cannot prevent splashing
- controlling the amount of water used in the construction process
- positive traffic control in accordance with COPTTM
- enhanced signage in advance of the site focusing on keeping vehicle speeds down
- construction of part of the carriageway at a time
- approved traffic detours of a reasonable length

The use of "cement/lime splashes clean your car" signs alone is not an acceptable practice.

2. TERMINOLOGY

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

Stabilisation

Any chemical or physical treatment of a road pavement material that enhances the engineering properties and thus the ability to perform its function in the pavement. 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 pavement.

This stabilisation type is adopted when it is desired to increase bearing capacity, increase stiffness and/or decrease moisture susceptibility while at the same time maintaining 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-only treatment should be used with materials which have a plasticity index (PI) of less than 10.

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 materials with plastic or swelling fines. 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. However hydrated lime is in the form of a fine dust requiring careful handling.

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.

Plant Modified Aggregate Mixing

Plant modified aggregate mixing is the process where a purpose built mixing plant is able to handle stockpiled aggregate in multiple bins, allowing blending of aggregate. The plant is able to feed a continuous pugmill type mixing chamber by weighing predetermined aggregate proportions and mixing these with a predetermined binder in the form of lime or cement from silo's; and/or bitumen emulsion, or hot bitumen to produce foamed bitumen from tanks, or road units. The plant modified aggregate is supplied in a ready to use state at optimum moisture content therefore further adjustment to the mixed aggregate should not be necessary. Modern plants are micro-processor controlled and when properly calibrated are highly versatile, accurate, and reliable.

Plant Modified Aggregate Construction

Plant modified aggregate construction is the process where the plant mixed aggregate is usually transported from the mixing plant, in close proximity to the work site, and materials supplied into a paver for laying OR transported and spread onto the formation for grader laying. Compaction and shaping are carried out as a normal construction process within the confines of the specification.

3. MATERIALS

As defined above, plant mixed modification is used to improve the physical properties, primarily shear strength, of the aggregate supplied for the pavement. These materials may be premium quarry supplied, marginal quarry supplied, or materials salvaged from an existing formation, OR a blend of these materials. One can and should however, make sure that the treated material, will exhibit targeted characteristics of a subbase or basecourse, depending on what is being supplied.

Proposed Materials for Construction

To ensure that adequate information is available to design the pavement and to draft a tender document, a preliminary investigation of the proposed alignment OR existing road must be carried out. This investigation is outside the scope of the TNZ B/7 Specification.

The intentions of the designer's objectives, outcomes and end results must be made clear to all parties involved with the contract.

Sources of aggregate may be specified or left to the contractor to source depending on the nature of the contract. Options may include;

- Material won from the site as reclaimed pavement or suitable won processed rock
- Marginal material deemed suitable from a quarry source
- Premium material to a nominated specification sourced from a quarry

As a minimum materials should 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 should be detailed in the Project Specifications. The choice of stabilising agent or combination of stabilising agents is outside the scope of this Specification and should be determined by a testing and compatibility programme.

4.1.1 Lime

Lime should be specified as either Calcium Oxide or Calcium Hydroxide. All lime supplied should comply with NZTA M/15 Specification.

4.1.2 Cement

Cement that is suspected of not being stored in a way that protects it from deterioration should 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% must not be used.

Types GB and LH cement with loss of ignition test result greater than determined by the cement manufacturer must 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% S04, refer to the "Britpave" Technical Guideline Stabilisation for sulphate bearing soils.

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 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 by accommodating the mixing and supply process without the break.

5. WATER

Caution and common sense need to be exercised when sourcing water other than 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 water ways and salts could be found in waterways that are close to oceans and are under tidal influence. If water is sourced from these water ways and/or there is a suspicion of potential contamination, then that water shall be used in the mix design ITS test. The results of these ITS tests shall be greater than 90% of the results from the ITS test carried out with the same material using water from a public water supply.

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

7. CONSTRUCTION

Optional Trial Section for Basecourse Layer

Prior to commencing with the full construction of the specified plant mixed paver/grader laid pavement layer, the Contractor should, if specified, construct a trial section of a modified basecourse layer on the proposed alignment, to demonstrate the capability of the Contractor to construct the pavement layer in accordance with the specification. This is particularly important on larger projects. The trial section must be constructed with the same materials and equipment as those intended for use by the Contractor for the pavement layer, and should also demonstrate the methods proposed for joint construction.

An initial trial section of not less than 100m in length should be constructed in one continuous operation for testing and approval. This is a hold point and unless there are any deficiencies in the trial section, the Contractor can proceed with full construction of the modified basecourse pavement subject to acceptable testing results, tolerances and surface finish without segregation. In the event of deficiencies in the trial section, the Contractor must remove the previous trial section and construct a further trial section which will again be regarded as the initial trial section.

The designer needs to be given the adequate time period to review the Quality assurance test results and any other testing that may be required.

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 and Rain

These weather conditions can cause curing problems and excessive dust with trafficking, if the formation is allowed to dry back . At the mixing site transfer of cementitious materials between road units and silo's and silo's and mixing plant require careful control.

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

Plant mixing units are generally well set up to provide dustless capability (i.e. does not create dust) by controlled transfer of materials, and a controlled mixing process.

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 should review the density achieved at that time and approve the kind of remedial action to be taken.

7.2 Before Mixing and Laying commences

7.2.1 Initial Laboratory Testing

Where a mix design already exists, the Contractor should use representative samples of the granular material to be used in the stabilised pavement layer, and to carry out laboratory tests according to NZS 4402: 1986 Test 4.1.3 to confirm the OWC and likely MDD targets for the expected mix which includes the cement stabilising agent.

7.2.2 Surface preparation

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.

7.3 Plant Batching and Mixing

Mixing is done at a suitable location by means of a mixing plant. The specified materials and water need to be thoroughly mixed at the mixing plant by a continuous mixing process with a suitable pugmill type mixer. The process of introducing the various materials should produce a final mix that is consistent with the required proportions. The aggregate and cement/lime proportions are measured by mass. The bituminous materials are measured by adjusted volume or mass of the residual bitumen content.

The plant must be calibrated. The aggregate cold feed bins require calibration after relocating the mixing plant prior to construction, then monthly during construction.

7.3.1 Handling and addition of aggregate

The project specifications will detail the materials to be plant mix modified

7.3.2 Addition of lime and/or cement

Cement

Cement or lime content is specified as a percentage mass to dry mass of aggregate. In practice cement or lime is added to stock piled aggregate which contains water.

$$\%\ Corrected\ Cement\ Content = \frac{\%\ Specified\ Cement\ Content\ By\ Dry\ Weight}{1 + \dfrac{Aggregate\ Stock\ Pile\ \%\ Water\ Content}{100}}$$

Lime

A similar calculation is carried out for the addition of Lime, plus allowance needs to be made for the purity or Grade of the Lime.

$$\%\ CorrectedLime\ Content = \frac{\%\ SpecifiedLimeContent\ ByDryWeight}{1+\frac{AggregateStockPile\ \%\ Water\ Content}{100}} * 100 / AvailableLime$$

Where "available lime" in the equation above may be assumed at 85 unless specific tests have been carried out to determine the actual lime oxide content.

7.3.4 Addition of water

The water in the pug mill plant should be controlled by using a pumping and metering system to regulate the application in relation to mass of material being modified. The pumping system must be calibrated to deliver within a tolerance of +/- 5% by volume. Particular care is necessary to prevent any proportion of the modified material from excessive wetting or dryness. This is controlled by the provision of readily checking the quantity of water by flow meter per the rate of flow for a continuous mixing plant. Control of the stockpiled material is necessary to prevent drying or segregation.

Bitumen Emulsion

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 mixing

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%, W_{Emu} and B_{Emu} are 0.4 x 3% = 1.2% and 0.6 x 3% = 1.8% respectively.**

To achieve the specified densities and degree of saturation requirements the water content during compaction should be in the range of 90% to 100% of the material's optimum water content (OWC). Monitoring of the water content of the stockpile and the mixed

aggregate should be carried out during the course of the mixing operation using methods which can determine the water content quickly, such as the microwave method. With the knowledge of the water contents and rolling characteristics during compaction, judgement should be used to adjust the water added to the mix at the mixing plant. The OWC of the mixed material shall also be determined by NZS 4402: 1986 Test 4.1.3 (New Zealand Vibrating Hammer Compaction Test).

This is important to use field experience and tests to make suitable plant mixing changes with water content to assist with the layability. Material, type of binder and weather etc can all influence this.

7.3.5 Mixed material testing

During construction, the Contractor shall take a pair of representative samples of material at the plant and shall have these samples prepared into a pair of compaction moulds for each day's mixing (preferably on site to avoid changes in moisture content). The freshly mixed material must be allowed to cure for one hour before compacting in the moulds at NZ Vibrating Hammer Compaction in the laboratory. Specimens should be tested in accordance to NZTA T/19.

The designer will need to be assured that the layer has achieved the design strength before the construction of the next layer. In combination with the lab ITS testing, testing should be carried out for the final layer strength after the curing period, (e.g. Benkelman beam or FWD). The testing should be specified in the project specification and scheduled in the tender documents.

Should the testing indicate that the layer has not met the design strength, it will be imperative that all of the QA Plan requirements have been met during construction before the failure to meet the design strength becomes a potential design issue.

7.3.6. Grading of plant mix

During the placing of the plant mix sample bags will be taken on site to ensure aggregate gradings comply with specified grading requirements. Wet sieve analysis will be completed within 4 hours of mixing to ensure all particle sizes can be washed off prior to cementing.

7.4 Loading, Transportation and Discharge

The mixed material should be loaded directly onto the trucks used for transporting the material. To reduce segregation, loading from the mixing plant conveyor belt direct into the trucks must be end on and commence at the front of the truck loading against the truck deck headboard or a false tray headboard. The truck progresses forward at least three times during the loading cycle ensuring each new drop is coned up tightly of the face of the previous drop.

Care must be taken to prevent excessive loss or gain of moisture between the time when the materials are mixed and when they are placed and compacted on the road. Where necessary, trucks must have protective covers to prevent any significant change in water content. The water content during compaction should be close to optimum such that the compaction operation achieves the specified density requirements.

7.5. Construction of Modified Pavement Layers

Immediately prior to spreading either by paver or grader the underlying subgrade or subbase layer, as appropriate, shall be moistened and kept moist to prevent a bone dry interface but not excessively wet.

7.5.1 Placement of modified materials

The plant mix material shall be spread by a mechanical paver or by truck tailgate or bottom dump truck over the underlying subgrade or subbase layer. This should be done to full lane width including shoulder or from edge of channel to centre line of alignment in which a longitudinal construction joint can be formed. The aggregate is spread to such a thickness as will comply with the thickness shown on the contract drawings after final compaction.

Trucks loading the paver must be operated to prevent segregation of the modified material in the hopper of the paver. Tailings are run out in front of the paver on the layer below. The paver must be fitted with cast off blades which front the pusher tracks to sweep these tailings away from the unpaved surface.

The paver should be operated such that segregation of the modified material does not occur. Keeping the paver hopper full, folding hopper wings only as required, and keeping the hopper gates opened high enough is all good practice. The object is to run the paver as continuously as possible, running the augers so that the outer edges of the auger paver side plates and area in front of the screed are kept full of material. The paver type must be fitted with a vibrating screed capable of thoroughly compacting the material and striking it off to a smooth dense surface.

7.5.3 Joints

At the end of each day's work, or when operations are delayed or stopped for more than one hour, a construction joint with an inclined rough face at less than 45 degrees from the vertical should be made in thoroughly compacted material, at right angles to the centre line of the road. Cutting back into thoroughly compacted material should also apply to longitudinal joints unless the two adjacent runs are paved in the same day.

Additional mixture must not be placed until the construction joint has been constructed.

7.6 Compaction

Before the plant mixing operation is undertaken, the Contractor should take representative samples of the granular basecourse material to be used in the modified pavement layer, and carry out laboratory tests according to NZS 4402: 1986 Test 4.1.3 to determine the OWC and likely MDD targets for the expected modified mix which includes the stabilising agents.

Trial Section

During compaction of any trial section, the Contractor should undertake density tests for the purpose of confirming that the laboratory derived MDD can be achieved on site, and for determining the minimum, and possibly the maximum number of roller passes required to achieve MDD. If the laboratory MDD is achieved on site then the laboratory derived MDD can be set as the target MDD. If the laboratory derived MDD is not achieved the target MDD should be agreed by the Engineer (this should be a hold point). Retesting the laboratory derived MDD and/or revising the roller sequence may be required to agree a new target value.

Following the compaction of any trial section, the Contractor should measure the moisture content using an IANZ endorsed NDM (Nuclear Density Meter). The Contractor should sample the modified basecourse immediately below the NDM and determine the true water content to NZS 4402:1986 Test 2.1. It is expected that the NDM measured moisture content will be higher than the laboratory tested water content due to the NDM incorrectly counting hydrogen in the cement as water. The difference should be used to correct all NDM field measured water contents and subsequent calculated dry densities.

$$Corrected\ Insitu\ Dry\ Density = \frac{NDM\ Wet\ Density}{1 + \frac{\%NDM\ Water\ Content - \Delta W}{100}}$$

Where:

$$\Delta W = \%\ NDM\ Water\ Content - \%\ Laboratory\ Water\ Content$$

The spread mixture should be compacted at or near the same optimum moisture content as that in the plant. Not more than one hour should elapse between the time of starting the mixing process and that of starting to compact the material.

From the time when the stabilising agent, aggregate and water are added together and mixed, not more than the time limits in Section 7.1.2 should elapse until the final compaction has been completed. Compaction equipment should be adequate for obtaining the specified density within the specified time limits.

8. ACCEPTANCE CRITERIA OF THE CONSTRUCTED LAYER

8.1 Compaction

The objective of the compaction process is to ensure that the modified subbase/basecourse layer is compacted to a uniform, dense, stable condition. The procedure for determining the MDD, OWC targets and the number of roller passes to achieve MDD at OWC for the layer shall be as described below;

The initial compaction should be carried out with plant which will achieve a stability suitable for subsequent compaction without causing undue displacement (shoving) of the material or deformation of the layer. The rolling pattern must be so designed as to retain the shape of the layers. The compaction equipment and techniques must be capable of producing the specified surface finish and density without any interruption.

The compaction target (MDD) at the laboratory determined optimum water content should be achieved by the minimum necessary number of passes of the compaction plant. Field compaction must be achieved by compaction equipment only and not by traffic.

Moisture Content

During construction of the modified pavement layer, the Contractor should check water contents over the mat using an IANZ endorsed NDM. The NDM measured water contents must be corrected as described in NZS 4402. Should there be a difference between the insitu water content and the OWC for the material being modified, the Contractor must determine the amount of water to be added or subtracted at the pugmill mixing plant. From then on during the compaction process, the Contractor should measure both insitu water contents and dry density achievements to quantify the ongoing compaction achievements on site. The layer should not be slushed or over wetted. And any water added during or after the compaction process, should be to prevent surface dryback, and be carefully controlled as excessive application of water can not be allowed.

Target Maximum Dry Density

During construction following the trial OR first run, the target maximum dry density (MDD) for the modified material should be agreed by the Contractor and Engineer using the test data obtained from the laboratory testing before construction, and the insitu density testing of the trial run during construction.

The laboratory based target optimum water content (OWC) and target maximum dry density (MDD) should be determined for the modified subbase/ basecourse layer at minimum frequency of one OWC/MDD test per 5000 m^2 of material modified. If the aggregate source, processing method, or modified materials are expected to change then a new OWC and target MDD should be determined.

8.2 Construction tolerances

With this type of pavement layer there can be no remedial grading after the time limitations set out in 7.1.2 of the Specification. Also clause 8.2.2 very tightly controls the vertical tolerances and final layer depth after trimming so that the design depth is the minimum to be achieved. Any surface level or shape defects or damage of any nature, occurring during the construction or maintenance of the pavement layer before the overlaying layers are constructed, shall be made good by re-stabilising the layer with the addition of a suitable stabilising agent as directed by the Engineer.

8.4 Protection and Maintenance before Sealing

The Contractor should have prepared the surface for sealing in accordance with clause 8.4 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 8.5. Generally with materials requiring hydration this requirement is easily met, providing construction water is tightly controlled.

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 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%.

CURING MEMBRANE

Formation

If the completed modified layer is left open unnecessarily during the day, gross changes can occur in strength because of the drying effects of the wind and sun. In this case, the surface of the completed layer must be water mist sprayed to maintain dampness as interim curing until the final bituminous membrane curing layer is applied or overlaid with another layer.

Before applying the curing membrane, the Contractor should advise the Engineer that the modified basecourse surface has been prepared in accordance with the specified surface finish requirements, although final sweeping may not have been performed. The Engineer should be given the opportunity to inspect the finished surface area.

Water Content

Water content testing of the modified subbase/basecourse must be carried out in lots similar to pavement density testing. The degree of saturation (DOS) for each lot should be determined by testing stratified randomly selected areas at a frequency of at least one test per 500 m^2. There should be a minimum of five tests per lot. If the maximum insitu DOS for the lot is not less than 90%, prior to applying the curing membrane, a DOS test for that lot should be repeated. The membrane curing coat must not be applied until the maximum insitu DOS falls below 90%. Modified subbase/basecourse pavement layer compaction test results may be used for DOS purposes, where the Engineer is satisfied that the water content has not had a chance to significantly increase between testing and applying the membrane curing coat (i.e. it has not rained or mist spray watering has not flooded the pavement surface). The DOS should be calculated using the standard geotechnical volumetric equation and the laboratory tested solid density of particles.

$$DOS = \frac{Corrected\ \ NDM\ \ Dry\ \ Density \times Corrected\ \ NDM\ \ \%\,Water}{1 - \dfrac{Corrected\ \ NDM\ \ Dry\ \ Density}{Solid\ \ Density\ \ Of\ \ Particle}}$$

Correction of the NDM dry density and water content is discussed in a previous section of this specification.

Curing

The modified basecourse pavement layer should be cured with CMS-1 emulsified bitumen complying with ASTM D2397-02 (Cationic Emulsified Bitumen) as a primer seal coat. The Contractor should be responsible for designing the application rate of the prime coat in accordance with Austroads

Sprayed Sealing Guide. A modified subbase layer can be cured by maintaining in a damp condition OR by the application of the overlying basecourse layer.

The curing membrane should be sprayed onto the completed layer within 24 hours of paving. Before applying the curing membrane the surface of the modified basecourse layer must be thoroughly swept cleaned to produce a mosaic surface finish as described below. The final surface should be slightly damp immediately prior to applying the curing membrane. The curing membrane should be blinded out with a sparse sprinkling of Grade 5 sealing chip complying with TNZ M/6: 2004 (Sealing Chip) to prevent pickup on construction machinery tyres OR by the application of a permanent seal coat if specified.

The modified basecourse surface finish should present a tightly consolidated surface when swept in which the large aggregate is held in place with a matrix of smaller aggregates, the smaller aggregate is held firmly in place by fine material, and the matrix does not displace under sweeping. The standard of sweeping should be sufficient to remove all loose aggregate, dirt, dust, silt, and deleterious matter. Any areas on the modified basecourse surface which are open or segregated must be either blinded out with compacted crusher fines prior to applying the prime coat or an additional prime coat sprayed prior to an asphaltic or spray seal final surfacing.

Maintaining the Formation

The Contractor must cure, protect and maintain the completed modified subbase/ basecourse layer until the final surfacing is applied. In addition to curing the modified layer by emulsion primer seal, maintenance should include the immediate repair of any damage to or defects in the layer, and shall be repeated as often as it is necessary for keeping the layer constantly intact and in a good condition. Any effects or damage of any nature, occurring during the construction or maintenance of the pavement layer before the final seal coat is applied, must be made good immediately by the Contractor.

8.5 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. Please note the importance of angular running course to cut excess fines from the surface.

Traffic must not be allowed onto any completed and cured layer unless unavoidable with construction traffic. In order to keep the paver/grader operating as continuously as possible, unloaded delivery trucks may be permitted to run on adjacent unsealed subbase/basecourse runs. Any final chip sealed surface must not be applied until the complete length of modified basecourse material has been placed, compacted and cured.

If rutting or potholes occur in the pavement, it should be fixed by re-stabilising the layer with the addition of a suitable crushed aggregate and stabilising agent as detailed elsewhere in this specification

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 or angular 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 modified pavement layer should be of a uniform consistency. All coarse segregated areas must be removed. The edges of such areas that are so formed should be painted with a slurry of cement and water. The holes shall then be backfilled with modified granular material compacted to the required density and finished off to the required level. Such patches must be cured. Any portion of the pavement layer which does not meet the specified requirements should be corrected by approved methods at the Contractor's cost.

10 BASIS OF PAYMENT

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

At times mix designs or pavement designs have not been carried out at the time of tendering. In these situations the designer will typically specify an assumed depth, binder content and materials properties being envisaged for stabilisation. These are defined as the scheduled amounts.

The design binder contents and/or depth may however change from the scheduled content. In these cases it is practical to have the extra or lesser amount of design binder priced. The quantity shall be calculated by the difference between the scheduled theoretical total amount of binder scheduled in clause 10.4, and the amount calculated with the new design binder content as follows:

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

Where:

Q EO or EU	-	Extra or lesser binder quantity	[tonne]
A_{Sched}	-	Scheduled area at tender	[m^2]
A_{Act}	-	Design Actual area stabilised	[m^2]
B_{Sched}	-	Scheduled application rate	[kg/m^2]
B_{Act}	-	Design application rate	[kg/m^2]

And

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

and

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

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/m^3]
D_{Act}	-	Design 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 BP116. 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.nzipubs.html

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- Higgins Contractors Ltd.
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- Bartley Consultants Ltd.
- Beca Consultants
- CPG New Zealand Ltd.
- MWH New Zealand Ltd.

- **GHD Ltd.**
- **Opus International Consultants.**

APPENDIX 1

IMPORTED AGGREGATE PROJECT SPECIFICATION

Scope

This Appendix sets out requirements for the imported aggregate.

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, greater 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			