1 Purpose

This section of the *Materials Testing Manual* provides guidance for construction materials testing facilities on the use of test methods for the following:

- testing of stabilised materials (Sections 3 to 7)
- storage of additives in the laboratory (Section 8).

This guidance reflects departmental experience and is intended to assist testing facilities in performing testing complying with requirements of the relevant test methods, documents referenced below and the relevant Technical Specifications.

2 Referenced documents

The documents referenced by this part of the Materials Testing Manual are shown below:

a) *Pavement Rehabilitation Manual*, Queensland Department of Transport and Main Roads, April 2012

b) *Guide to Pavement Technology Part 4D: Stabilised Materials*, Austroads, 2019

c) *Geotechnical Site Investigations*, Standards Australia, AS 1726-2017, Section 6.1 – Soil description and classification


3 Testing of materials for insitu cement or cementitious blend stabilisation

3.1 Introduction

This section outlines the process for:

- sampling and characterising host soil
- design procedure to determine the relationship between unconfined compressive strength and stabilising agent content
- determining working time, and
- measuring the properties of cement treated materials in the field.

This section supports the application of the following departmental documents:

- Technical Specification, MRTS07B *Insite Stabilised Pavements using Cement or Cementitious Blends*
In the remainder of this document, the term cement can mean both cement and cementitious blends (that is, combinations of pozzolanic material; such as fly ash, slag and so on, and cement and/or lime).

This process is also applicable to materials stabilised using slow setting additives such as lime / fly ash and lime slag although these require a longer curing time before testing, usually 28 days.

### 3.2 Background

Insitu cement or cementitious blend stabilisation is a mobile process, during which cement is added to an existing pavement and mixed with a purpose-designed road recycler.

It is essential with all stabilisation work that materials are thoroughly assessed and their reactions with the specific binder to be used in the stabilisation process be properly validated by laboratory testing before any field work commences. Stabilised pavement materials should be tested to determine their quality and uniformity.

The summary of the categories and characteristics of the various types of stabilised materials typically adopted by Transport and Main Roads are shown in the *Guide to Pavement Technology Part 4D: Stabilised Materials*, Austroads, Table 2.1.

### 3.3 Sampling and characterisation

#### 3.3.1 General

Sample the section under consideration at appropriate intervals to identify material properties and uniformity using the sampling methods in Table 3.3.1. Use of a soil classification system such as the unified soils classification system can assist in identifying the soil types.

For characterisation, bulk samples of 10 – 50 kg will be required, depending on the maximum particle size of the material. For mix design, an additional bulk sample of 90 – 120 kg will be required.

It may be necessary to sample the pavement in a manner that simulates both the mixing and the disruption caused by using up to three passes of a stabiliser. A bobcat or excavator fitted with a profiling / milling head can simulate this mixing. Mill a lateral trench using three passes retaining all the material for the sample. Do not test this material as part of the characterisation of the pavement; retain this material for the mix design in Section 3.4.

Do not sample materials excluded from the works during construction, such as sprayed surfacing, asphalt or stabilised patches. Before commencing any sampling, obtain clarification of excluded areas.

Sample any material to be imported to add to the pavement for insitu stabilisation at its source, usually a quarry, to obtain a representative sample of the material.

*Table 3.3.1 – Test methods used to sample materials*

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling – machine excavated pit or trench</td>
<td>AS 1289.1.2.1</td>
<td>Sampling and preparation of soils – disturbed samples</td>
</tr>
<tr>
<td>Sampling from stockpile</td>
<td>Q060</td>
<td>Representative sampling of soils, crushed rock and aggregates</td>
</tr>
<tr>
<td>Sampling for stabilisation testing – plant excavation</td>
<td>Q061</td>
<td>Spot sampling of soils, crushed rock and aggregates</td>
</tr>
</tbody>
</table>
3.3.2 Classification

Undertake particle size distribution and Atterberg limits testing using test methods listed in Table 3.3.2 on the samples. Use the results of particle size distribution, Atterberg limits and visual classification to classify the material sampled and to gain a preliminary assessment of the type of stabilisation suitable samples tested. Refer to Guide to Pavement Technology Part 4D: Stabilised Materials, Austroads, Table 2.4 or Pavement Rehabilitation Manual, Table 4.9 for details. These results are also used to select representative samples for further testing.

Table 3.3.2 – Test methods used to classify materials

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle Size Distribution (Grading)</td>
<td>Q103A</td>
<td>Particle size distribution of soil – wet sieving</td>
</tr>
<tr>
<td>Atterberg limits (liquid limit, plastic limit, plasticity index and linear shrinkage)</td>
<td>Q104A or D</td>
<td>Liquid limit of soil</td>
</tr>
<tr>
<td></td>
<td>Q105</td>
<td>Plastic limit and plasticity index of soil</td>
</tr>
<tr>
<td></td>
<td>Q106</td>
<td>Linear shrinkage of soil</td>
</tr>
</tbody>
</table>

3.3.3 Deleterious materials

This is usually not an issue for materials obtained from quarries or existing pavement materials originally obtained from quarries or pits. If there is a concern about the quality of the materials, then testing for deleterious materials as detailed in Section 7.3.2 may be undertaken with the limits in Table 7.3.2 adopted.

3.4 Mix design procedure

This stage is to establish the target cement content for the host soil using the design test methods in Table 3.4.

Table 3.4 – Test methods used for design

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unconfined Compressive Strength (UCS)</td>
<td>Q115</td>
<td>Unconfined compressive strength of stabilised materials</td>
</tr>
<tr>
<td></td>
<td>Q135A</td>
<td>Addition of stabilising agents</td>
</tr>
<tr>
<td></td>
<td>Q135B</td>
<td>Curing of moulded specimens of stabilised materials</td>
</tr>
<tr>
<td>Capillary rise</td>
<td>Q125D</td>
<td>Capillary rise of stabilised material</td>
</tr>
<tr>
<td>Allowable working time</td>
<td>Q136A</td>
<td>Working time of stabilised materials</td>
</tr>
</tbody>
</table>

3.4.1 Cement and supplementary cementitious materials

Where required, cement complying with the requirements of AS 3972: General purpose and blended cements is used laboratory testing. Source the cement directly from suppliers. Do not use bagged supply from hardware stores / building suppliers, as the age and condition of the cement unknown. Instructions for the storage and use of cement are included in Section 8.
Source supplementary cementitious materials (fly ash, slag, silica fume and so on) directly from suppliers and keep dry in air tight containers. While they do not deteriorate with age, discard after 12 months, as the sample may no longer represent the materials currently supplied.

3.4.2 Lime

Where required hydrated lime, complying with the requirements of Technical Specification MRTS23 Supply and Delivery of Quicklime and Hydrated Lime for Road Stabilisation, is to be used exclusively in laboratory testing. Source the hydrated lime directly from suppliers. Do not use bagged supplies from hardware stores / building suppliers, as the age and condition of the lime is unknown. Instructions for the storage and use of lime are included in Section 8.

Obtain a certificate with the available lime index ($x_{AL}$) from the supplier for the batch of lime. As an alternative, sample the lime and forward the sample to a laboratory to determine the available lime index. Forward the available lime index certificate, along with other results of testing for the mix design procedure.

Do not use quicklime in the laboratory because of safety concerns, and the need to exercise very tight control over moisture during moulding. If complete hydration of the quicklime does not occur before compaction, carbonation and localised expansion can occur.

3.4.3 Water

Water sources classified by the relevant water authority as ‘potable water’ do not require any testing. Where other water is used, such as site water, dam water and so on, it shall comply with the requirements in Technical Specification, MRTS07B Insitu Stabilised Pavements using Cement or Cementitious Blends, Clause 6.5 Water quality.

3.4.4 Imported material

Where required imported material, use material complying with the requirements of Technical Specification MRTS05 Unbound Pavements in laboratory testing. Source the material directly from the nominated quarry. Add the imported material to the representative samples for the UCS design in proportions nominated by the designer.

3.4.5 UCS test analysis

Use the UCS test to determine the stabilising agent target content. Compact at least three test portions (minimum three specimens at each) at a range of cement contents. The range of cement contents should straddle the target strength with at least one portion below the target strength and one portion above the target strength. Compact additional portions, if required, to straddle the required target strength. The user of the data must be able to interpolate and not extrapolate.

There is a significant influence by density of the strength of all compacted soil. A 1% reduction in relative compaction can reduce the UCS by 5%. Small density variations can easily mask the effects of other variables such as cement content and curing conditions.

Since compacted density has a direct influence on UCS, variation in compaction moisture must be limited. Suggested limit for achieved moisture content are:

$$Achieved\ moisture\ content = target\ moisture\ content ± 0.3\ percentile\ units$$

Condition the cement / soil mixture using short-term conditioning, that is, the cement / soil mixture is to condition in an airtight container for 45 minutes before further mixing and compaction.
A standard curing regime comprising moist curing at 23 ± 2°C for seven days has been adopted as detailed in Test Method Q135B.

All specimens are to be tested using the standard UCS Test Method Q115.

Plot the UCS data versus cement content and determine the cement content corresponding to the target strength (MPa). In Figure 3.4.5, the cement content corresponding with the target strength of 1.5 MPa would be the optimum cement content of 1.65%.

**Figure 3.4.5 – Cement content v UCS**

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### 3.4.6 Allowable working time

The allowable working time for cement stabilised materials is 2 hours as detailed in Technical Specification MRTS07B *Insitu Stabilised Pavements using Cement or Cementitious Blends*, Clause 8.4 *Allowable working time* unless specified in the annexure to this Technical Specification.

Alternatively, the allowable working time may be determined as detailed in Technical Specification MRTS07B *Insitu Stabilised Pavements using Cement or Cementitious Blends*, Clause 8.4 *Allowable working time* using Test Method Q136A.

To determine the allowable working time, undertake the test to determine the allowable working time for the stabilising agent and host soil. Compact specimens with a one hour delay and determine the dry density and UCS to establish a reference MDD and reference UCS. Further specimens are compacted with a delay between mixing and compaction, which for cements will typically be 1, 2, 4, 6 and 8 hours.

These delays reduce the achieved MDD and UCS due to the cement hydrating and reacting with the host soil, reducing the moisture content and increasing the friction between particles. These effects inhibit the reorientation of particles during compaction and therefore reduce the achieved MDD. The lower density also reduces the achieved UCS.

The allowable working time is defined as the delay time that produces a 3% reduction in achieved MDD (that is, 100% to 97%); or a 20% reduction in achieved UCS (that is, 100% to 80%), whichever is the shorter delay time.
Plot the maximum dry density (MDD) versus time delay and the UCS versus time delay for the cement content and determine the delay at 0.97 of one hour delay MDD \((0.97 \times 2.200 = 2.134)\) and 0.80 of one hour delay UCS \((0.80 \times 1.5 = 1.2)\). In Figure 3.4.6, the delays corresponding 0.97 MDD and 0.80 UCS are five and four hours respectively. Therefore, the allowable working time would be four hours.

**Figure 3.4.6 – MDD / UCS v delay**

3.5 **Field testing - compliance**

Undertake field testing to ensure that specification requirements, such as cement content, relative compaction, moisture content and unconfined compressive strength are achieved using the test methods in Table 3.5.

**Table 3.5 – Test methods used for compliance**

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spread rate</td>
<td>Q719</td>
<td>Field spread rate of solid stabilising agents – fabric mat</td>
</tr>
<tr>
<td>Compacted density</td>
<td>Q141A</td>
<td>Compacted density of soils and crushed rock (nuclear gauge)</td>
</tr>
<tr>
<td></td>
<td>Q141B</td>
<td>Compacted density of soils and crushed rock (sand replacement)</td>
</tr>
<tr>
<td>Reference density</td>
<td>Q142A</td>
<td>Dry density-moisture relationship (standard compaction)</td>
</tr>
<tr>
<td></td>
<td>Q144A</td>
<td>Assignment of maximum dry density and optimum moisture content for soils and crushed rock</td>
</tr>
<tr>
<td>Relative Compaction</td>
<td>Q140A</td>
<td>Relative compaction of soils and crushed rock</td>
</tr>
<tr>
<td>Allowable working time</td>
<td>Q136A</td>
<td>Working time for stabilised materials</td>
</tr>
</tbody>
</table>
3.5.1 Cement content

For in situ stabilisation, a simple mat test is used to measure stabilising agent content. Place one or more 1 m² mats to catch the discharge from the spreader.

3.5.2 Compacted density and reference density

Use nuclear gauge technique for cement modified / stabilised materials provided a wet density and moisture content bias is determined as detailed in the Nuclear Gauge Testing Manual. Use of the sand replacement test for measuring in situ density is an alternative, but it is more destructive to the finished pavement.

Measure the reference density using the traditional dry density – moisture relationship test. Complete the sampling and compaction of the reference density sample before the allowable working time for the material has elapsed. A project / material specific allowable working time is determined for each project.

The inherent variability of in situ stabilised materials usually means the employment of a testing regime of one-for-one testing. Such testing involves taking a sample from each in situ density location and determining a reference density.

3.5.3 Moisture content of stabilised material

Monitoring and adjustment of the moisture content of the stabilised critical to the performance of the finished pavement.

The moisture ratio of the stabilised material after the final wet incorporation of stabilising agent pass but before compaction should be in the range specified in as detailed in Technical Specification MRTS07B Insitu Stabilised Pavements using Cement or Cementitious Blends, Clause 8.8 Product standards.

As a minimum frequency, the relative moisture ratio of stabilised materials is assessed at each test location for compaction tests.

3.6 Field testing - verification

Undertake field testing to ensure that design requirement, unconfined compressive strength is achieved using the test method in Table 3.6.

**Table 3.6 – Test methods used for verification**

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>UCS</td>
<td>Q115</td>
<td>Unconfined compressive strength of compacted materials</td>
</tr>
</tbody>
</table>

3.6.1 Field UCS

The UCS test provides additional information on expected field performance relative to design. Mould the field mixed material at field moisture content using standard compaction effort. Cure the moulded specimens under standard conditions prior to testing.

When sampling and making UCS specimens in the field it is assumed the in situ moisture content will be close to the optimum moisture content of the material. If not, then the achieved dry density and dry density ratio will be likely to be well below the target. This will mean the UCS results for the samples will be lower than target due to the moisture and density being lower than the targets. Therefore, care is required in interpreting these results.
4 Testing of materials for plant-mixed cement or cementitious blend stabilisation

4.1 Introduction

This section outlines the process for:

a) sampling and characterising host soil
b) design procedure to determine the relationship between unconfined compressive strength and stabilising agent content, and
c) measuring the properties of cement treated materials at the production plant and in the field.

This section supports the application of the following departmental documents:

• MRTS08 Plant-Mixed Heavily Bound (Cemented) Pavements
• MRTS10 Plant-Mixed Lightly Bound Pavements.

In the remainder of this document, the term cement can mean both cement and cementitious blends (that is, combinations of pozzolanic material; such as fly ash, slag and so on, and cement and/or lime).

This process is also applicable to materials stabilised using slow setting additives such as lime / fly ash and lime slag although these require a longer curing time before testing, usually 28 days.

4.2 Background

Plant-mixed cement stabilisation involves stationary pugmill mixing of cement with an unbound granular material sourced from quarrying or reclaimed construction material. The quality of unbound granular pavement materials used in plant mixing typically conforms to unbound granular specifications for particle size distribution, plasticity and source rock hardness. The stabilised material is delivered to the site in trucks and then paved or spread, compacted, shaped and cured in preparation for the placement of the overlying layers.

It is essential with all stabilisation work that materials are thoroughly assessed and their reactions with the specific binder to be used in the stabilisation process be properly validated by laboratory testing before any field work commences. Stabilised pavement materials should be tested to determine their quality and uniformity.

The summary of the categories and characteristics of the various types of stabilised materials typically adopted by Transport and Main Roads are shown in the Guide to Pavement Technology Part 4D: Stabilised Materials, Austroads, Table 2.1.

4.3 Sampling and characterisation

The material to be used must be sampled to ensure compliance with the relevant specification using the sampling method in Table 4.2. For characterisation, bulk samples of 10 – 50 kg will be required, depending on the maximum particle size of the material. For mix design, an additional bulk sample of 90 – 120 kg will be required. Use the sampling methods in Table 4.2.

Table 4.2 – Test methods used to sample materials

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling from stockpile</td>
<td>Q060</td>
<td>Representative sampling of soils, crushed rock and aggregates</td>
</tr>
</tbody>
</table>
4.3.1 Classification

Undertake particle size distribution and Atterberg limits testing using test methods listed in Table 4.3.1 on the samples. Use the results of particle size distribution, Atterberg limits and visual classification to classify the material sampled and to gain a preliminary assessment of the type of stabilisation suitable samples tested. Refer to Guide to Pavement Technology Part 4D: Stabilised Materials, Austroads, Table 2.4 or Pavement Rehabilitation Manual, Table 4.9 for details. These results are also used to select representative samples for further testing.

Table 4.3.1 – Test methods used to classify materials

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle Size Distribution (Grading)</td>
<td>Q103A</td>
<td>Particle size distribution of soil – wet sieving</td>
</tr>
<tr>
<td>Atterberg limits (Liquid limit, plastic limit, plasticity index and linear shrinkage)</td>
<td>Q104A or D</td>
<td>Liquid limit of soil</td>
</tr>
<tr>
<td></td>
<td>Q105</td>
<td>Plastic limit and plasticity index of soil</td>
</tr>
<tr>
<td></td>
<td>Q106</td>
<td>Linear shrinkage of soil</td>
</tr>
</tbody>
</table>

4.3.2 Deleterious materials

This is usually not an issue for materials obtained from quarries or existing pavement materials originally obtained from quarries or pits. If there is a concern about the quality of the materials, then testing for deleterious materials as detailed in Section 7.3.2 may be undertaken with the limits in Table 7.3.2 adopted.

4.4 Mix design procedure

This stage is to establish the target cement content for the host soil.

Use the design test methods in Table 4.4.

Table 4.4 – Test methods used for design

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unconfined Compressive Strength (UCS)</td>
<td>Q115</td>
<td>Unconfined compressive strength of stabilised materials</td>
</tr>
<tr>
<td></td>
<td>Q135A</td>
<td>Addition of stabilising agents</td>
</tr>
<tr>
<td></td>
<td>Q135B</td>
<td>Curing of moulded specimens of stabilised materials</td>
</tr>
<tr>
<td>Capillary rise</td>
<td>Q125D</td>
<td>Capillary rise of stabilised material</td>
</tr>
<tr>
<td>Allowable working time</td>
<td>Q136A</td>
<td>Working time of stabilised materials</td>
</tr>
</tbody>
</table>

4.4.1 Cement and supplementary cementitious materials

Where required, cement complying with the requirements of AS 3972: General purpose and blended cements is used laboratory testing. Source the cement directly from suppliers. Do not use bagged supply from hardware stores / building suppliers, as the age and condition of the cement unknown. Instructions for the storage and use of cement are included in Section 8.
Source supplementary cementitious materials (fly ash, slag, silica fume and so on) directly from suppliers and keep dry in air tight containers. While they do not deteriorate with age, discard after 12 months, as the sample may no longer represent the materials currently supplied.

4.4.2 Lime

Where required hydrated lime, complying with the requirements of Technical Specification MRTS23 Supply and Delivery of Quicklime and Hydrated Lime for Road Stabilisation, is to be used exclusively in laboratory testing. Source the hydrated lime directly from suppliers. Do not use bagged supplies from hardware stores / building suppliers, as the age and condition of the lime is unknown. Instructions for the storage and use of lime are included in Section 8.

Obtain a certificate with the available lime index \( x_{AL} \) from the supplier for the batch of lime. As an alternative, sample the lime and forward the sample to a laboratory to determine the available lime index. Forward the available lime index certificate, along with other results of testing for the mix design procedure.

Do not use quicklime in the laboratory because of safety concerns, and the need to exercise very tight control over moisture during moulding. If complete hydration of the quicklime does not occur before compaction, carbonation and localised expansion can occur.

4.4.3 Water

Water sources classified by the relevant water authority as ‘potable water’ do not require any testing. Where other water is used, such as site water, dam water and so on, it shall comply with the requirements in Technical Specifications MRTS10 Plant-Mixed Lightly Bound Pavements, Clause 6.5 Water quality or MRTS08 Plant-Mixed Heavily Bound (Cemented) Pavements, Clause 6.5 Water quality.

4.4.4 UCS test analysis

The UCS testing for the mix design is undertaken as detailed in Technical Specification, MRTS08 Plant-Mixed Heavily Bound (Cemented) Pavements, Clause 7 Mix design or MRTS10 Plant-Mixed Lightly Bound Pavements, Clause 7 Mix design. The testing involves the compaction of at least three test portions (minimum three specimens at each) at a range of cement contents. Where an upper and lower UCS limit applies, such as lightly bound materials, then the range of cement contents should straddle this range and have one portion below the minimum limit and one portion above the maximum limit. Compact additional portions, if required, to straddle the required range. The user of the data must be able to interpolate and not extrapolate.

There is a significant influence by density of the strength of all compacted soil. A 1% reduction in relative compaction can reduce the UCS by 5%. Small density variations can easily mask the effects of other variables such as cement content and curing conditions.

Since compacted density has a direct influence on UCS, variation in compaction moisture must be limited. Suggested limits for achieved moisture content are:

\[
\text{Achieved moisture content} = \text{target moisture content} \pm 0.3 \text{ percentile units}
\]

Condition the cement / soil mixture using short-term conditioning, that is, the cement / soil mixture is to condition in an airtight container for 45 minutes before further mixing and compaction.
A standard curing regime comprising moist curing at 23 ± 2°C for seven days for heavily bound material and seven and 28 days for lightly bound material has been adopted as detailed in Test Method Q135B.

All specimens are to be tested using the standard UCS Test Method Q115.

### 4.4.5 Allowable working time

The allowable working time for cement stabilised materials is four hours as detailed in Technical Specification MRTS08 Plant-Mixed Heavily Bound (Cemented) Pavements, Clause 8.2.3 Allowable working time or MRTS10 Plant-Mixed Lightly Bound Pavements, Clause 8.2.3 Allowable working time.

Alternatively, the allowable working time may be determined for heavily bound or lightly bound materials using Test Method Q136A. An example of the process for determining the allowable working time is detailed in Section 3.4.6.

### 4.5 Production testing - compliance

Undertake production testing to ensure that specification requirements, such as cement content and unconfined compressive strength are in compliance using the test methods in Table 4.5.

**Table 4.5 – Test methods used for compliance**

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement content</td>
<td>Q134</td>
<td>Stabilising agent content – heat of neutralisation</td>
</tr>
<tr>
<td>Reference density</td>
<td>Q142A</td>
<td>Dry density-moisture relationship (standard compaction)</td>
</tr>
<tr>
<td></td>
<td>Q144A</td>
<td>Assignment of maximum dry density and optimum moisture content for soils and crushed rock</td>
</tr>
<tr>
<td>Unconfined compressive strength</td>
<td>Q115</td>
<td>Unconfined compressive strength of compacted materials</td>
</tr>
</tbody>
</table>

#### 4.5.1 Cement content

For plant-mixed stabilisation, the Heat of Neutralisation test is a rapid low-cost field test. Samples of both the un-stabilised material and the stabilising agent are required prior to performing this test.

#### 4.5.2 Reference density

The plant-mixed stabilised materials are uniform, which allows the use of testing regime using an assigned reference density. Such testing involves taking a sample from the quarry stockpile and adding the target additive content to the materials and determining a reference density. An initial value based on the average of six tests is used. This is then updated every 10,000t using one new test and calculating a rolling average.

#### 4.5.3 Production UCS

The UCS test is a compliance test for plant-mixed materials. Use the reference density results (MDD/OMC) for the material to determine the wet mass per layer using the process as detailed in Test Method Q145A. mould the material at the ‘as produced’ moisture content using standard compaction effort. Cure the moulded specimens under standard conditions prior to testing.
4.6 Field testing - compliance

Undertake field testing to ensure that specification requirements, such as relative compaction are in compliance using the test methods in Table 4.6.

**Table 4.6 – Test methods used for compliance**

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compacted density</td>
<td>Q141A</td>
<td>Compacted density of soils and crushed rock (nuclear gauge)</td>
</tr>
<tr>
<td></td>
<td>Q141B</td>
<td>Compacted density of soils and crushed rock (sand replacement)</td>
</tr>
<tr>
<td>Relative Compaction</td>
<td>Q140A</td>
<td>Relative compaction of soils and crushed rock</td>
</tr>
</tbody>
</table>

4.6.1 Compacted density

Use nuclear gauge technique for cement modified / stabilised materials provided a wet density and moisture content bias is determined as detailed in the *Nuclear Gauge Testing Manual*. Use of the sand replacement test for measuring insitu density is an alternative, but it is more destructive to the finished pavement.

5 Testing of materials for insitu foamed bitumen stabilisation

5.1 Introduction

This section outlines the process for:

a) sampling and characterising host soil

b) design procedure to determine the properties of material stabilised with foamed bitumen and a secondary stabilising agent, and

c) measuring the properties of foamed bitumen stabilised materials in the field.

This section supports the application of the following departmental documents:

- MRTS07C *Insitu Stabilised Pavements using Foamed Bitumen*

5.2 Background

Insitu foamed bitumen stabilisation is a mobile process of mixing bitumen (in a foamed state), the primary stabilising agent, and a secondary stabilising agent, usually hydrated lime, into pavement materials, with the intention of improving the strength and moisture resistance of the existing unstabilised material(s). The purpose of the bitumen (in conjunction with the secondary stabilising agent) is to achieve a strong yet flexible pavement layer compared to other stabilisation treatments, such as those using cement.

The aim is to provide a material that:

- has enough strength for early trafficking, assessed using minimum initial modulus
- is strong and flexible, assessed using minimum three day cured modulus, and
- is able to withstand inundation, assessed using minimum three day soaked modulus and minimum retained modulus.
The summary of the categories and characteristics of the various types of stabilised materials typically adopted by Transport and Main Roads are shown in the Guide to Pavement Technology Part 4D: Stabilised Materials, Austroads, Table 2.1.

The design limits for insitu stabilised materials are shown in the Pavement Rehabilitation Manual, Transport and Main Roads in Tables 4.13, 4.14 and 4.15.

5.3 Sampling and characterisation

Sample the section under consideration at appropriate intervals to identify material properties and uniformity using the sampling methods in Table 5.3. Use of a soil classification system such as the unified soils classification system can assist in identifying the soil types.

For characterisation, bulk samples of 10 – 50 kg will be required, depending on the maximum particle size of the material. For mix design, an additional bulk sample of 70 – 90 kg will be required.

It may be necessary to sample the pavement in a manner that simulates both the mixing and the disruption caused by using up to three passes of a stabiliser. A bobcat or excavator fitted with a profiling / milling head can simulate this mixing. Mill a lateral trench using three passes retaining all the material for the sample. Do not test this material as part of the characterisation of the pavement; retain this material for the mix design in Section 5.4.

Materials excluded from the works during construction, such as sprayed surfacing, asphalt or stabilised patches. Before commencing any sampling, obtain clarification sampling of materials.

Sample any material to be imported to add to the pavement for insitu stabilisation at its source, usually a quarry, to obtain a representative sample of the material.

Table 5.3 – Test methods used to sample materials

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling – machine excavated pit or trench</td>
<td>AS 1289.1.2.1</td>
<td>Sampling and preparation of soils – disturbed samples</td>
</tr>
<tr>
<td>Sampling from stockpile</td>
<td>Q060</td>
<td>Representative sampling of soils, crushed rock and aggregates</td>
</tr>
<tr>
<td>Sampling for stabilisation testing – plant excavation</td>
<td>Q061</td>
<td>Spot sampling of soils, crushed rock and aggregates</td>
</tr>
</tbody>
</table>

5.3.1 Classification

Undertake particle size distribution and Atterberg limits testing using test methods listed in Table 5.3.1 on the samples. Use the results of particle size distribution, Atterberg limits and visual classification to classify the material sampled and to gain a preliminary assessment of the type of stabilisation suitable samples tested. Refer to Guide to Pavement Technology Part 4D: Stabilised Materials, Austroads, Table 2.4 or Pavement Rehabilitation Manual, Table 4.9 for details. These results are also used to select representative samples for further testing.

Additional requirements for materials that are suitable for stabilisation are detailed in Pavement Rehabilitation Manual, Clause 4.9.8.4.1 Suitability of materials to be stabilised – general.

Table 5.3.1 – Test methods used to classify materials

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Particle Size Distribution (Grading)

<table>
<thead>
<tr>
<th>Test Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q103A</td>
<td>Particle size distribution of soil – wet sieving</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q104A or D</td>
<td>Liquid limit of soil</td>
</tr>
<tr>
<td>Q105</td>
<td>Plastic limit and plasticity index of soil</td>
</tr>
<tr>
<td>Q106</td>
<td>Linear shrinkage of soil</td>
</tr>
</tbody>
</table>

### Atterberg limits

- Liquid limit
- Plastic limit
- Plasticity index
- Linear shrinkage

<table>
<thead>
<tr>
<th>Test Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q120B</td>
<td>Organic content of soil – loss on ignition</td>
</tr>
<tr>
<td>AS 1289.4.2.1</td>
<td>Determination of the sulfate content of a natural soil and the sulfate content of the groundwater</td>
</tr>
</tbody>
</table>

### Deleterious materials

This is usually not an issue for materials obtained from quarries or existing pavement materials originally obtained from quarries. However, materials need to be free of organic or other deleterious materials. The water-soluble sulfate content must not exceed 1.9 g of sulfate (expressed as SO₄) per litre.

Use the test methods in Table 5.3.2 to identify deleterious materials.

#### Table 5.3.2 – Test methods used to identify deleterious materials

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic content</td>
<td>Q120B</td>
<td>Organic content of soil – loss on ignition</td>
</tr>
<tr>
<td>Sulfate content</td>
<td>AS 1289.4.2.1</td>
<td>Determination of the sulfate content of a natural soil and the sulfate content of the groundwater</td>
</tr>
</tbody>
</table>

### Mix design

This stage of the procedure is to establish the suitability of stabilising the host material with foamed bitumen. Perform this with samples prepared at 70% OMC, with 3.0% bitumen and 2.0% lime. If the host material is suitable it may, for larger projects, be appropriate to perform further testing to optimise the bitumen and lime contents.

Use the design test methods in Table 5.4.

#### Table 5.4 – Test methods used for design

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resilient modulus</td>
<td>Q139</td>
<td>Resilient modulus of stabilised material – indirect tensile method</td>
</tr>
<tr>
<td></td>
<td>Q138A</td>
<td>Preparation and compaction of laboratory mixed foamed bitumen stabilised material</td>
</tr>
<tr>
<td></td>
<td>Q138B</td>
<td>Preparation and compaction of field mix foamed bitumen stabilised material</td>
</tr>
<tr>
<td></td>
<td>Q135C</td>
<td>Curing moulded specimens of foamed bitumen stabilised material</td>
</tr>
<tr>
<td>Compacted density and moisture content</td>
<td>Q147B</td>
<td>Compacted density of stabilised material – vacuum saturation</td>
</tr>
<tr>
<td>Optimum moisture content</td>
<td>Q142A</td>
<td>Dry density-moisture relationship (standard compaction)</td>
</tr>
<tr>
<td>Available lime</td>
<td>AS 4489.6.1</td>
<td>Lime index – available lime</td>
</tr>
<tr>
<td>Dynamic viscosity</td>
<td>AS 2341.2</td>
<td>Determination of dynamic (coefficient of shear) viscosity by flow through a capillary tube</td>
</tr>
</tbody>
</table>
5.4.1 Lime

Hydrated lime, complying with the requirements of Technical Specification MRTS23 Supply and Delivery of Quicklime and Hydrated Lime for Road Stabilisation, is to be used exclusively in laboratory testing. Source the hydrated lime directly from suppliers. Do not use bagged supplies from hardware stores/building suppliers, as the age and condition of the lime is unknown. Instructions for the storage and use of lime are included in Section 8.

Obtain a certificate with the available lime index (x_{AL}) from the supplier for the batch of lime. As an alternative, sample the lime and forward the sample to a laboratory to determine the available lime index. Forward the available lime index certificate, along with other results of testing for the mix design procedure. This allows the lime content to be adjusted for a different quality of lime as detailed in Technical Specification, MRTS07C Insitu Stabilised Pavements using Foamed Bitumen, Clause 6.3 Stabilising agents.

Do not use quicklime in the laboratory because of safety concerns, and the need to exercise very tight control over moisture during moulding. If complete hydration of the quicklime does not occur before compaction, carbonation and localised expansion can occur.

5.4.2 Supplementary cementitious materials

Source supplementary cementitious materials (fly ash, slag, silica fume and so on) directly from suppliers and keep dry in air-tight containers. While they do not deteriorate with age, discard after 12 months, as the sample may no longer represent the materials currently supplied.

5.4.3 Bitumen

Use Class 170 bitumen for all foamed bitumen designs. Check each batch of bitumen for viscosity before use. A sample of the batch should be foamed, and the foaming apparatus adjusted to provide expansion ratio of at least 10 and a half-life of at least 20 seconds. This will usually require a foaming water content of 3.0%, however this should be optimised for each batch of bitumen. A foaming additive (satisfactory performance has been observed by Inter-foam and Terric 311) may be required to foam the bitumen, additional foaming trials will be required to determine the optimum addition rate for the foaming additive.

5.4.4 Water

Where other water is used, such as site water, dam water and so on, it shall comply with the requirements in Technical Specification MRTS07C Insitu Stabilised Pavements using Foamed Bitumen, Clause 6.4 Water.

5.4.5 Imported material

Where required imported material, use material complying with the requirements of Technical Specification MRTS05 Unbound Pavements in laboratory testing. Source the material directly from the nominated quarry. Add the imported material to the representative samples for the resilient modulus testing in proportions nominated by the designer.
5.4.6  Resilient modulus

The resilient modulus is determined by performing a resilient modulus test on a minimum of three specimens prepared at a single bitumen and lime content. These are usually prepared at 70% OMC, with 3.0% bitumen content and lime content between 1.5 to 2.0% as detailed in Test Method Q138A.

A standard curing and testing regime is undertaken as detailed in Test Method Q135C and the specimens are then tested as detailed in Test Method Q139 to determine the initial modulus, three day cured modulus and three day soaked modulus. The compacted density and moisture content of the specimens may be determined as detailed in Test Method Q147B.

5.4.7  Analysis

If the results obtained from the resilient modulus testing comply with the specific design limits from the Pavement Rehabilitation Manual, Transport and Main Roads in Tables 4.13, 4.14 and 4.15, then the host material can be stabilised using the moisture condition, bitumen content and lime content from Section 5.4.6.

5.4.8  Optimisation

For large projects, it may be worthwhile to conduct further design testings, varying the bitumen and lime contents to optimise bitumen and lime contents.

5.4.9  Allowable working time

The allowable working time for in situ stabilised materials is 6.5 hours as detailed in Technical Specification MRTS07C Insitu Stabilised Pavements using Foamed Bitumen, Clause 8.4 Allowable working time unless specified the annexure to this specification.

5.5  Field testing - compliance

Undertake production testing to ensure compliance with the specification for properties such as bitumen content, hydrated lime content and relative moisture ratio using the test methods in Table 5.5.

Table 5.5 – Test methods used for compliance

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spread rate</td>
<td>Q719</td>
<td>Field spread rate of solid stabilising agents – fabric mat</td>
</tr>
<tr>
<td>Bitumen content</td>
<td>Q118</td>
<td>Bitumen content of stabilised material</td>
</tr>
<tr>
<td>Compacted density</td>
<td>Q141A</td>
<td>Compacted density of soils and crushed rock (nuclear gauge)</td>
</tr>
<tr>
<td></td>
<td>Q141B</td>
<td>Compacted density of soils and crushed rock (sand replacement)</td>
</tr>
<tr>
<td>Reference density</td>
<td>Q142A</td>
<td>Dry density – moisture relationship (standard compaction)</td>
</tr>
<tr>
<td></td>
<td>Q144A</td>
<td>Assignment of maximum dry density and optimum moisture content for soils and crushed rock</td>
</tr>
<tr>
<td>Relative Compaction</td>
<td>Q140A</td>
<td>Relative compaction of soils and crushed rock</td>
</tr>
</tbody>
</table>
5.5.1 Lime content

For insitu stabilisation, a simple mat test is used to measure stabilising agent spread rate. Place one or more 1 m² mats to catch the discharge from the spreader.

5.5.2 Bitumen content

Measure the bitumen content using a solvent extraction method. Normally the testing is performed in a specialised laboratory.

5.5.3 Compacted density and reference density

Use nuclear gauge technique for cement modified / stabilised materials provided a wet density and moisture content bias is determined as detailed in the Nuclear Gauge Testing Manual. Use of the sand replacement test for measuring in situ density is an alternative, but it is more destructive to the finished pavement.

Measure the reference density using the traditional dry density – moisture relationship test. Complete the sampling and compaction of the reference density sample before the allowable working time for the material has elapsed. A project / material specific allowable working time is determined for each project.

The inherent variability of insitu stabilised materials usually means the employment of a testing regime of one-for-one testing. Such testing involves taking a sample from each insitu density location and determining a reference density.

5.5.4 Moisture content of stabilised material

Monitoring and adjustment of the moisture content of the stabilised material is critical to the performance of the finished pavement.

The moisture ratio of the stabilised material after the final wet incorporation pass but before compaction, should be in the range specified in as detailed in Technical Specification MRTS07C Insitu Stabilised Pavements using Foamed Bitumen, Clause 8.8 Product standards.

As a minimum frequency, the relative moisture ratio of stabilised materials is assessed at each test location for compaction tests.

5.6 Field testing - verification

Undertake testing to verify that particular design parameters, such as resilient modulus are in compliance, and where necessary fine-tune the design and production processes using the test methods in Table 5.6.

Table 5.6 – Test methods used for verification

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resilient modulus</td>
<td>Q139</td>
<td>Resilient modulus of stabilised material – indirect tensile method</td>
</tr>
<tr>
<td></td>
<td>Q138B</td>
<td>Preparation and compaction of field mix foamed bitumen stabilised material</td>
</tr>
<tr>
<td></td>
<td>Q135C</td>
<td>Curing moulded specimens of foamed bitumen stabilised material</td>
</tr>
<tr>
<td>Compacted density and moisture content</td>
<td>Q147B</td>
<td>Compacted density of stabilised material – vacuum saturation</td>
</tr>
</tbody>
</table>
5.6.1 Field modulus

The resilient modulus test provides additional information on expected field performance relative to design. Mould the field mixed material at field moisture content as detailed in Test Method Q138B. Cure the moulded specimens under standard conditions prior to testing as detailed in Test Method Q135C. Test the specimens as detailed in Test Method Q139 to determine the initial modulus, three day cured modulus and three day soaked modulus. The compacted density and moisture content of the specimens may be determined as detailed in Test Method Q147B.

When sampling and making resilient modulus specimens in the field, assume the insitu moisture content will be close to the target moisture content of the material. If not, then the achieved dry density and dry density ratio will vary from the design. Therefore, care is required in interpreting these results.

6 Testing of materials for plant-mixed foamed bitumen stabilisation

6.1 Introduction

This section outlines the process for:

a) sampling and characterising host soil
b) design procedure to determine the properties of material stabilised with foamed bitumen and a secondary stabilising agent, and
c) measuring the properties of foamed bitumen stabilised materials at the production plant and in the field.

This section supports the application of the following departmental documents:


6.2 Background

Plant-mixed foamed bitumen stabilisation involves stationary pugmill mixing of bitumen (in a foamed state), the primary stabilising agent, and a secondary stabilising agent, usually hydrated lime, into pavement materials, with the intention of improving the strength and moisture resistance of the existing un-stabilised material(s). The purpose of the bitumen (in conjunction with the secondary stabilising agent) is to achieve a strong yet flexible pavement layer compared to other stabilisation treatments, such as those using cement. The aim is to provide a material that:

- has enough strength for early trafficking, assessed using minimum initial modulus
- is strong and flexible, assessed using minimum three day cured modulus, and
- is able to withstand inundation, assessed using minimum three day soaked modulus and minimum retained modulus.

The summary of the categories and characteristics of the various types of stabilised materials typically adopted by Transport and Main Roads are shown in the Guide to Pavement Technology Part 4D: Stabilised Materials, Austroads, Table 2.1.
6.2.1 Laboratory trial

A laboratory trail must be undertaken as specified in Technical Specification MRTS09 *Plant-Mixed Pavement Layers Stabilised using Foamed Bitumen*, Clause 7.4.1, with the stabilised materials complying with the requirements in Tables 5.2.2(a) and 5.2.2(b) of the Technical Specification.

6.2.2 Plant production trial

The nominated mix from Section 6.2.1 is then produced at the proposed production plant and sampled and tested as specified in Technical Specification MRTS09 *Plant-Mixed Pavement Layers Stabilised using Foamed Bitumen*, Clause 7.4.2, with produced material complying with the requirements in Table 5.2.2(b) of the Technical Specification.

6.3 Sampling and characterisation

Sample the section under consideration at regular intervals to identify material types and changes within any material using the sampling methods listed in Table 6.3. For characterisation, bulk samples of 10 – 50 kg will be required, depending on the maximum particle size of the material. For mix designs, an additional bulk sample of 70 – 90 kg will be required.

For plant-mixed stabilisation, sample the material at its source, usually a quarry, to obtain a representative sample of the material to be used.

**Table 6.3 – Test methods used to sample materials**

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling – machine excavated pit or trench</td>
<td>AS 1289.1.2.1</td>
<td>Sampling and preparation of soils – disturbed samples</td>
</tr>
<tr>
<td>Sampling from stockpile</td>
<td>Q060</td>
<td>Representative sampling of soils, crushed rock and aggregates</td>
</tr>
</tbody>
</table>

6.3.1 Classification

Undertake particle size distribution and Atterberg limits testing using test methods listed in Table 6.3.1 on the samples. Use the results of particle size distribution, Atterberg limits and visual classification to classify the material sampled and to gain a preliminary assessment of the type of stabilisation suitable samples tested. Refer to *Guide to Pavement Technology Part 4D: Stabilised Materials*, Austroads, Table 2.4 or *Pavement Rehabilitation Manual*, Table 4.9 for details. These results are also used to select representative samples for further testing.


**Table 6.3.1 – Test methods used to classify materials**

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle Size Distribution (Grading)</td>
<td>Q103A</td>
<td>Particle size distribution of soil – wet sieving</td>
</tr>
<tr>
<td>Atterberg limits (Liquid limit, plastic limit, plasticity index and linear shrinkage)</td>
<td>Q104A or D</td>
<td>Liquid limit of soil</td>
</tr>
<tr>
<td></td>
<td>Q105</td>
<td>Plastic limit and plasticity index of soil</td>
</tr>
<tr>
<td></td>
<td>Q106</td>
<td>Linear shrinkage of soil</td>
</tr>
</tbody>
</table>
6.3.2 Deleterious materials

This is usually not an issue for materials obtained from quarries. The water-soluble sulfate content must not exceed 1.9 g of sulfate (expressed as SO₃) per litre.

Use the test method in Table 6.3.2 to identify deleterious materials.

**Table 6.3.2 – Test methods used to identify deleterious material**

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfate content</td>
<td>AS 1289.4.2.1</td>
<td>Determination of the sulfate content of a natural soil and the sulfate content of the groundwater</td>
</tr>
</tbody>
</table>

6.4 Mix design

This stage of the procedure is to establish the suitability of stabilising the host material with foamed bitumen. Perform this with samples prepared at 70% OMC, with 3.0% bitumen and 2.0% lime. If the host material is suitable it may, for larger projects, be appropriate to perform further testing to optimise the bitumen and lime contents. Use the design test methods in Table 6.4.

**Table 6.4 – Test methods used for design**

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resilient modulus</td>
<td>Q139</td>
<td>Resilient modulus of stabilised material – indirect tensile method</td>
</tr>
<tr>
<td></td>
<td>Q138A</td>
<td>Preparation and compaction of laboratory mixed foamed bitumen stabilised material</td>
</tr>
<tr>
<td></td>
<td>Q138B</td>
<td>Preparation and compaction of field mix foamed bitumen stabilised material</td>
</tr>
<tr>
<td></td>
<td>Q135C</td>
<td>Curing moulded specimens of foamed bitumen stabilised material</td>
</tr>
<tr>
<td>Compacted density and moisture content</td>
<td>Q147B</td>
<td>Compacted density of stabilised material – vacuum saturation</td>
</tr>
<tr>
<td>Optimum moisture content</td>
<td>Q142A</td>
<td>Dry density-moisture relationship (standard compaction)</td>
</tr>
<tr>
<td>Available lime</td>
<td>AS 4489.6.1</td>
<td>Lime index – available lime</td>
</tr>
<tr>
<td>Dynamic viscosity</td>
<td>AS 2341.2</td>
<td>Determination of dynamic (coefficient of shear) viscosity by flow through a capillary tube</td>
</tr>
<tr>
<td>Sulfate content of groundwater</td>
<td>AS 1289.4.2.1</td>
<td>Determination of the sulfate content of a natural soil and the sulfate content of the groundwater</td>
</tr>
<tr>
<td>Expansion ratio and half-life</td>
<td>AG:PT/T301</td>
<td>Determining the foaming characteristics of bitumen</td>
</tr>
</tbody>
</table>

6.4.1 Lime

Hydrated lime, complying with the requirements of Technical Specification MRTS23 Supply and Delivery of Quicklime and Hydrated Lime for Road Stabilisation, is to be used exclusively in laboratory testing. Source the hydrated lime directly from suppliers. Do not use bagged supplies from hardware stores / building suppliers, as the age and condition of the lime is unknown. Instructions for the storage and use of lime are included in Section 8.
Obtain a certificate with the available lime index ($\text{AL}_{x}$) from the supplier for the batch of lime. As an alternative, sample the lime and forward the sample to a laboratory to determine the available lime index. Forward the available lime index certificate, along with other results of testing for the mix design procedure. This allows the lime content to be adjusted for a different quality of lime as detailed in Technical Specification MRTS09 *Plant-Mixed Pavement Layers Stabilised using Foamed Bitumen*, Clause 6.2 Stabilising agents.

Do not use quicklime in the laboratory because of safety concerns, and the need to exercise very tight control over moisture during moulding. If complete hydration of the quicklime does not occur before compaction, carbonation and localised expansion can occur.

### 6.4.2 Supplementary cementitious materials

Source supplementary cementitious materials (fly ash, slag, silica fume and so on) directly from suppliers and keep dry in air tight containers. While they do not deteriorate with age, discard after 12 months, as the sample may no longer represent the materials currently supplied.

### 6.4.3 Bitumen

Use Class 170 bitumen for all foamed bitumen designs. Check each batch of bitumen for viscosity before use. A sample of the batch should be foamed and the foaming apparatus adjusted to provide expansion ratio of at least 10 and a half-life of at least 20 seconds. This will usually require a foaming water content of 3.0%, however this should be optimised for each batch of bitumen. A foaming additive (satisfactory performance has been observed by Inter-foam and Terric 311) may be required to foam the bitumen, additional foaming trials will be required to determine the optimum addition rate for the foaming additive.

### 6.4.4 Water

Where other water is used, such as site water, dam water and so on, it shall comply with the requirements in Technical Specification MRTS09 *Plant-Mixed Pavement Layers Stabilised using Foamed Bitumen*, Clause 6.3 Water.

### 6.4.5 Resilient modulus

The resilient modulus is determined by performing a resilient modulus test on a minimum of three specimens prepared at a single bitumen and lime content. These are usually prepared at 70% OMC, with 3.0% bitumen content and lime content between 1.5 to 2.0% as detailed in Test Method Q138A. A standard curing and testing regime is undertaken as detailed in Test Method Q135C and the specimens are then tested as detailed in Test Method Q139 to determine the initial modulus, three day cured modulus and three day soaked modulus. The compacted density and moisture content of the specimens may be determined as detailed in Test Method Q147B.

### 6.4.6 Analysis

If the results obtained from the resilient modulus testing comply with the requirements of *Guide to Pavement Technology Part 4D: Stabilised Materials*, Austroads in Table 5.9 then the host material can be stabilised using the moisture condition, bitumen content and lime content from Section 6.4.5.

### 6.4.7 Optimisation

For large projects, it may be worthwhile to adjust the bitumen and lime contents to find an optimal bitumen / lime content.
6.4.8 Allowable working time

The allowable working time for plant-mixed materials is eight hours as detailed in Technical Specification MRTS09 Plant-Mixed Pavement Layers Stabilised using Foamed Bitumen, Clause 8.6 Allowable working time unless specified the annexure to this specification.

6.5 Production testing – compliance

Undertake product testing to ensure compliance with the specification for properties such as bitumen content, hydrated lime content and relative moisture ratio using the test methods in Table 6.5.

**Table 6.5 – Test methods used for production compliance**

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference density</td>
<td>Q142A</td>
<td>Dry density-moisture relationship (standard compaction)</td>
</tr>
<tr>
<td></td>
<td>Q144A</td>
<td>Assignment of maximum dry density and optimum moisture content for soils and crushed rock</td>
</tr>
<tr>
<td>Relative moisture ratio</td>
<td>Q250</td>
<td>Relative moisture content of soils and crushed rock</td>
</tr>
<tr>
<td>Allowable working time</td>
<td>Q136B</td>
<td>Working time for stabilised materials</td>
</tr>
</tbody>
</table>

6.5.1 Lime content

For plant-mixed materials, the lime content is controlled using load cells on the lime bins to measure the amount of lime added to the material.

6.5.2 Bitumen content

For plant-mixed materials, control of the bitumen content using flow meters to measure the amount of bitumen added to the material.

6.5.3 Moisture content of feed stockpile and stabilised material

Monitoring and adjustment of the moisture content of the feed stockpiles and stabilised material stockpiles is critical to the performance of the final pavement.

The relative moisture ratio of the feed stockpile and stabilised material stockpile should be in the range specified in as detailed in Technical Specification MRTS09 Plant-Mixed Pavement Layers Stabilised using Foamed Bitumen, Clause 8.9.6 Relative Moisture Ratio of Feed Stockpiles (RMR FSP) or Clause 9.8 Relative Moisture Ratio Foamed Bitumen (RMR FB) respectively.

6.5.4 Reference density

Measure the reference density using the traditional dry density – moisture relationship test. Complete the sampling and compaction of the reference density sample before the allowable working time for the material has elapsed.

The plant-mixed stabilised materials are uniform, which allows the use of testing regime using an assigned reference density. Such testing involves taking a sample from the quarry stockpile and adding the target additive content to the materials and determining a reference density. An initial value based on the average of six tests is used. This is then updated every 10,000t using one new test and calculating a rolling average.
However, if this is not possible, employ a testing regime of one-for-one testing. Such testing involves taking a sample of uncompacted material from each insitu density location and determining a reference density.

6.6 Production testing – verification

Undertake testing to verify that particular design parameters, such as resilient modulus are in compliance, and where necessary fine-tune the design and production processes using the test methods in Table 6.6.

Table 6.6 – Test methods used for verification

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resilient modulus</td>
<td>Q139</td>
<td>Resilient modulus of stabilised material – indirect tensile method</td>
</tr>
<tr>
<td></td>
<td>Q138B</td>
<td>Preparation and compaction of field mix foamed bitumen stabilised material</td>
</tr>
<tr>
<td></td>
<td>Q135C</td>
<td>Curing moulded specimens of foamed bitumen stabilised material</td>
</tr>
<tr>
<td>Compacted density and moisture content</td>
<td>Q147B</td>
<td>Compacted density of stabilised material – vacuum saturation</td>
</tr>
</tbody>
</table>

6.6.1 Field modulus

The resilient modulus test provides additional information on expected field performance relative to design. Mould the field mixed material at field moisture content as detailed in Test Method Q138B. Cure the moulded specimens under standard conditions prior to testing as detailed in Test Method Q135C. Test the specimens as detailed in Test Method Q139 to determine to determine the initial modulus, three day cured modulus, three day soaked modulus, seven day cured modulus, seven day soaked modulus, 14 day cured modulus and 14 day soaked modulus. The compacted density and moisture content of the specimens may be determined as detailed in Test Method Q147B.

When sampling and making resilient modulus specimens in the field, assume the insitu moisture content will be close to the target moisture content of the material. If not, then the achieved dry density and dry density ratio will vary from the design. Therefore, care is required in interpreting these results.

6.7 Field testing - compliance

Undertake field testing to ensure compliance with the specification for properties such as relative moisture ratio and relative compaction are achieved using the test methods in Table 6.7.

Table 6.7 – Test methods used for compliance

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compacted density</td>
<td>Q141A</td>
<td>Compacted density of soils and crushed rock (nuclear gauge)</td>
</tr>
<tr>
<td></td>
<td>Q141B</td>
<td>Compacted density of soils and crushed rock (sand replacement)</td>
</tr>
<tr>
<td>Relative Compaction</td>
<td>Q140A</td>
<td>Relative compaction of soils and crushed rock</td>
</tr>
</tbody>
</table>
6.7.1 Compacted density and reference density

Use nuclear gauge technique for cement modified / stabilised materials provided a wet density and moisture content bias is determined as detailed in the Nuclear Gauge Testing Manual. Use of the sand replacement test for measuring insitu density is an alternative, but it is more destructive to the finished pavement.

7 Testing of materials for lime stabilisation

7.1 Introduction

This section outlines the process for:

a) sampling and characterising host soil

b) design procedure to determine the relationship between unconfined compressive strength and stabilising agent content, and

c) measuring the properties of lime treated materials in the field.

This section supports the application of the following departmental documents:

- MRTS07A Insitu Stabilised Subgrades using Quicklime or Hydrated Lime
- MRTS23 Supply and Delivery of Quicklime and Hydrated Lime for Road Stabilisation
- Pavement Rehabilitation Manual, Section 4.9.7.

7.2 Background

Insitu treatment of clay subgrades is a mobile process, during which lime, which has been either previously hydrated or hydrated on site by adding water (slaking), into a subgrade and mixed with a purpose-designed road recycler to increase subgrade strengths. This may be done to modify the subgrade (that is, usually achieve a temporary strength gain) or it may be added to stabilise it (that is, achieve a permanent increase in strength). In the case of the latter sufficient lime must be added to ensure that these strength gains are permanent.

The summary of the categories and characteristics of the various types of stabilised materials typically adopted by Transport and Main Roads are shown in the Guide to Pavement Technology Part 4D: Stabilised Materials, Austroads, Table 2.1.

For modification, the changes to soil properties result from an initial ionic exchange that results in flocculation of the clay particles. Modification occurs with addition of relatively low amounts of lime to a soil. This will have dramatic effect on the soil and improve workability and increased shear strength. It will however increase the permeability of the soil.

For stabilisation, adding increased amounts of lime that produces a pozzolanic reaction between the silica and alumina in the clay minerals and the calcium hydroxide in the lime. Permanent and ongoing reactions occur when sufficient lime is added, these reactions produce a flexible layer with decreased permeability and a significant increase in shear strength.

For further details, refer to Section 4.9.7 of the Pavement Rehabilitation Manual.
7.3 Sampling and characterisation

Sample the section under consideration at appropriate intervals to identify material properties and uniformity using the sampling methods in Table 7.3. Use of a soil classification system such as the unified soils classification system can assist in identifying the soil types.

For characterisation, bulk samples of 10 – 50 kg will be required, depending on the maximum particle size of the material. For mix design, an additional bulk sample of 70 – 90 kg will be required.

Table 7.3 – Test methods used to sample materials

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling – machine excavated pit or trench</td>
<td>AS 1289.1.2.1</td>
<td>Sampling and preparation of soils – disturbed samples</td>
</tr>
</tbody>
</table>

7.3.1 Classification

Undertake particle size distribution and Atterberg limits testing using test methods listed in Table 7.3.1 on the samples. Use the results of particle size distribution, Atterberg limits and visual classification to classify the material sampled and to gain a preliminary assessment of the type of stabilisation suitable samples tested. Refer to Guide to Pavement Technology Part 4D: Stabilised Materials, Austroads, Table 2.4 or Pavement Rehabilitation Manual, Table 4.9 for details. These results are also used to select representative samples for further testing.

Refer to Pavement Rehabilitation Manual, Section 4.9.7 and Technical Specification MRTS07A Insitu Stabilised Subgrades using Quicklime or Hydrated Lime, Clause 8.7.2 Removal and disposal of material not suitable for stabilisation for more details.

Table 7.3.1 – Test methods used to classify materials

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle Size Distribution (Grading)</td>
<td>AS 1289.3.6.1</td>
<td>Particle size distribution of soil – wet sieving</td>
</tr>
<tr>
<td></td>
<td>AS 1289.3.6.3</td>
<td>Particle size distribution of soil – hydrometer</td>
</tr>
<tr>
<td>Atterberg limits (Liquid limit, plastic limit, plasticity index and linear shrinkage)</td>
<td>AS 1289.3.1.1 or 3.1.2</td>
<td>Liquid limit of soil</td>
</tr>
<tr>
<td></td>
<td>AS 1289.3.2.1 and 3.3.1</td>
<td>Plastic limit and plasticity index of soil</td>
</tr>
<tr>
<td></td>
<td>AS 1289.3.4.1</td>
<td>Linear shrinkage of soil</td>
</tr>
</tbody>
</table>

7.3.2 Deleterious materials

Testing for deleterious materials includes the determination of sulfate, organic content and ferrous oxide contents using the test methods listed in Table 7.3.2. Organic matter interferes with the hydration process as well as competing for available stabilising agent – water paste. Sulfates can also interfere with pozzolanic reactions due to the formation of very expansive hydrates, which if formed after compaction, can result in heave. Ferrous oxide can also interfere with pozzolanic reactions; however, there are no specific limits in the literature at this stage. Recent experience has indicated that contents greater than 10% have a deleterious effect on stabilised materials. Seek advice for ferric oxide values greater than 2%.
Materials must not exceed the deleterious materials limits shown in MRTS07A *Insitu Stabilised Subgrades using Quicklime or Hydrated Lime*, Table 6.1 *Deleterious material limits*.

Additionally, any new material incorporated into the works shall not have deleterious materials exceeding the limits specified in Technical Specification MRTS07A *Insitu Stabilised Subgrades using Quicklime or Hydrated Lime*, Clause 6.1 *New material to replace material not suitable for stabilisation*.

**Table 7.3.2 – Test methods used to identify deleterious materials**

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic content</td>
<td>Q120B</td>
<td>Organic content of soil – loss on ignition</td>
</tr>
<tr>
<td>Sulfate content</td>
<td>AS 1289.4.2.1</td>
<td>Determination of the sulfate content of a natural soil and the sulfate content of the groundwater</td>
</tr>
<tr>
<td>Ferrous oxide (FeO)</td>
<td>In-house*</td>
<td>Determination of ferrous iron by acid digestion</td>
</tr>
</tbody>
</table>

* Private analytical laboratories will use in-house methods based on classical techniques.

**7.4 Mix design procedure**

This procedure is used to establish the reactivity of the host soil with lime and to establish whether pozzolanic reactions will occur to produce substantial strength. It is essential that long-term pozzolanic bonds are formed and that the resulting soil matrix is sufficiently coherent to ensure long term durability. A densely bonded matrix is less susceptible to moisture, and has improved resistance to carbonation, leaching of lime or erosion.

Use the design test methods in Table 7.4.

**Table 7.4 – Test methods used for design**

<table>
<thead>
<tr>
<th>Property</th>
<th>Test method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lime demand</td>
<td>Q133</td>
<td>Lime demand of soil</td>
</tr>
<tr>
<td>Unconfined Compressive Strength (UCS)</td>
<td>Q115</td>
<td>Unconfined compressive strength of stabilised materials</td>
</tr>
<tr>
<td></td>
<td>Q135A</td>
<td>Addition of stabilising agents</td>
</tr>
<tr>
<td></td>
<td>Q135B</td>
<td>Curing of moulded specimens of stabilised materials</td>
</tr>
<tr>
<td>Capillary rise</td>
<td>Q125D</td>
<td>Capillary rise of stabilised material</td>
</tr>
<tr>
<td>Available lime</td>
<td>AS 4489.6.1</td>
<td>Lime index – available lime</td>
</tr>
</tbody>
</table>

**7.4.1 Lime**

Where required hydrated lime, complying with the requirements of Technical Specification MRTS23 *Supply and Delivery of Quicklime and Hydrated Lime for Road Stabilisation*, is to be used exclusively in laboratory testing. Source the hydrated lime directly from suppliers. Do not use bagged supplies from hardware stores / building suppliers, as the age and condition of the lime is unknown. Instructions for the storage and use of lime are included in Section 8.

Obtain a certificate with the available lime index \([x_{AL}]\) from the supplier for the batch of lime. As an alternative, sample the lime and forward the sample to a laboratory to determine the available lime index. Forward the available lime index certificate, along with other results of testing for the mix design procedure. This allows the lime content to be adjusted for a different quality of lime as detailed in
Technical Specification MRTS07A Insitu Stabilised Subgrades using Quicklime or Hydrated Lime, Clause 6.2 Stabilising agent.

Do not use quicklime in the laboratory because of safety concerns, and the need to exercise very tight control over moisture during moulding. If complete hydration of the quicklime does not occur before compaction, carbonation and localised expansion can occur.

7.4.2 Water

Where other water is used, such as site water, dam water and so on, it shall comply with the requirements in Technical Specification MRTS07A Insitu Stabilised Subgrades using Quicklime or Hydrated Lime, Clause 6.3 Water.

7.4.3 Lime demand

Measure the quantity of lime required to satisfy cation exchange and short-term reactions using the Lime Demand (LD) test. The lime demand is undertaken to obtain the minimum lime content and is not the target content for the design process. In Figure 7.4.3, the lime demand value as defined in Test Method Q133 is 4.0%.

Figure 5.4.3 – Lime demand curve

There should be a significant lime demand. Obtaining lime demands of 2.0 to 2.5% is possible with non-reactive materials (dry fine sand).

This test is a good starting point for determining the optimum lime content; however, it does not establish whether pozzolanic reactions will occur to produce long-term strength gains.

7.4.4 UCS

Use the unconfined compressive strength (UCS) to assess the reactivity of the host soil and select a lime content, which will ensure long-term durability. Undertake UCS tests at a range of lime contents commencing with 0% lime. Suggested lime contents are:

0, LD-2, LD, LD+2, and LD+4
The target conditions for compaction of the UCS specimens will be 97% MDD and 100% OMC for subgrade materials. There is a significant influence by density of the strength of all compacted soil. A 1% reduction in relative compaction can reduce the UCS by 5%. Small density variations can easily mask the effects of other variables such as lime content and curing conditions.

Since compacted density has a direct influence on UCS, variation in compaction moisture must be limited. Suggested limits for achieved moisture content are:

\[
\text{Achieved moisture content} = \text{target moisture content} \pm 0.3 \text{ percentile units}
\]

A standard curing regime comprising moist curing at 23 ± 2ºC for 28 days has been adopted as detailed in Test Method Q135B.

The lime / soil mixture should be conditioned using long-term conditioning (amelioration), that is, where the lime / soil mixture is subjected to light compaction followed by overnight conditioning in an air-tight container, followed by break-up, mixing and compaction.

All specimens are to be tested using the standard UCS Test Method Q115.

7.4.5 Analysis

In order to establish the reactivity of the soil, compare the UCS at 0% lime to that of the lime demand content and assess it against the following criteria:

\[
\begin{array}{|c|c|}
\hline
\text{Condition} & \text{Reactive / Non-reactive} \\
\hline
\text{UCS at LD} - \text{UCS at 0% Lime} & \leq 0.35 \text{ MPa non-reactive soil} \\
\text{UCS at LD} - \text{UCS at 0% Lime} & > 0.35 \text{ MPa reactive soil} \\
\hline
\end{array}
\]

Non-reactive soils are generally not suitable for lime stabilisation. For reactive soils, plot the UCS data versus lime content and determine the lime content corresponding to a UCS of 1.5 MPa will be the target stabilising agent (lime) content.

Where there is a range of lime contents corresponding to a UCS of 1.5 MPa, undertake capillary rise testing at LD+2 and LD+4. Use the lime content with the slowest capillary rise as the target stabilising agent (lime) content.

7.4.6 Allowable working time

The allowable working time for lime-stabilised materials is 48 hours as detailed in Technical Specification MRTS07A Insitu Stabilised Subgrades using Quicklime or Hydrated Lime, Clause 8.4 Allowable working time unless specified the annexure to this specification.

7.5 Field testing - compliance

Undertake field control testing to ensure that particular design parameters, such as lime content, relative compaction and unconfined compressive strength are achieved using the test methods in Table 7.5.
Table 7.5 – Test methods used for compliance

<table>
<thead>
<tr>
<th>Property</th>
<th>Test method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spread rate</td>
<td>Q719</td>
<td>Field spread rate of solid stabilising agents – fabric mat</td>
</tr>
<tr>
<td>Compacted density</td>
<td>Q141A</td>
<td>Compacted density of soils and crushed rock (nuclear gauge)</td>
</tr>
<tr>
<td></td>
<td>Q141B</td>
<td>Compacted density of soils and crushed rock (sand replacement)</td>
</tr>
<tr>
<td>Reference density</td>
<td>Q142A</td>
<td>Dry density-moisture relationship (standard compaction)</td>
</tr>
<tr>
<td>Relative Compaction</td>
<td>Q140A</td>
<td>Relative compaction of soils and crushed rock</td>
</tr>
<tr>
<td>Relative moisture ratio</td>
<td>Q250</td>
<td>Relative moisture content of soils and crushed rock</td>
</tr>
<tr>
<td>Allowable working time</td>
<td>Q136A</td>
<td>Working time for stabilised materials</td>
</tr>
</tbody>
</table>

7.5.1 Lime content

For insitu stabilisation, a simple mat test is used to measure stabilising agent spread rate. Place one or more 1 m² mats to catch the discharge from the spreader. This test is suitable for both powdered lime and lime slurries.

7.5.2 Compacted density and reference density

Use nuclear gauge technique for cement modified / stabilised materials provided a wet density and moisture content bias is determined as detailed in the Nuclear Gauge Testing Manual. Use of the sand replacement test for measuring insitu density is an alternative, but it is more destructive to the finished surface.

Measure the reference density using the traditional dry density – moisture relationship test. Complete the sampling and compaction of the reference density sample before the allowable working time for the material has elapsed.

The inherent variability of insitu stabilised materials usually means the employment of a testing regime of one-for-one testing. Such testing involves taking a sample from each insitu density location and determining a reference density.

7.5.3 Moisture content of stabilised material

Monitoring and adjustment of the moisture content of the stabilised critical to the performance of the finished subgrade.

The moisture ratio of the stabilised material after the final wet incorporation of stabilising agent pass but before compaction should be in the range specified in as detailed in Technical Specification MRTS07A Insitu Stabilised Subgrades using Quicklime or Hydrated Lime, Clause 8.8 Product standards.

As a minimum frequency, the relative moisture ratio of stabilised materials is assessed at each test location for compaction tests.
7.6 Field testing - verification

Undertake testing to verify that particular design parameters, such as unconfined compressive strength are achieved using the test methods in Table 7.6.

Table 7.6 – Test methods used for verification

<table>
<thead>
<tr>
<th>Property</th>
<th>Test method</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field UCS</td>
<td>Q115</td>
<td>Unconfined compressive strength of compacted materials</td>
</tr>
</tbody>
</table>

7.6.1 Field UCS

The UCS test provides additional information on expected field performance relative to design. Mould the field mixed material at field moisture content using standard compaction effort. Cure the moulded specimens under standard conditions prior to testing.

When sampling and making UCS specimens in the field it is assumed the insitu moisture content will be close to the optimum moisture content of the material. If not, then the achieved dry density and dry density ratio will be likely to be well below the target. This will mean the UCS results for the samples will be lower than target due to the moisture and density being lower than the targets. Therefore, care is required in interpreting these results.

8 Storage of additives in the laboratory

8.1 Lime

8.1.1 Importance of proper storage

The term ‘Lime’ is used to describe two different products, ‘quicklime’ (CaO) and the hydrated form ‘Hydrate’ (Ca(OH)₂). Quicklime is normally in a pebble or granular form while hydrate is a fine white powder. Each of these will react with products in the atmosphere and degenerate with age. With proper handling, the degeneration can be held to a minimum. It is important to keep all lime dry and in airtight containers. If lime is exposed to moisture or CO₂, the following reactions can occur.

\[
\text{CaO} + \text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2
\]

\[
\text{Ca(OH)}_2 + \text{CO}_2 \rightarrow \text{CaCO}_3
\]

8.1.2 Storage

It is best to obtain no more than a one – two month supply of lime at a time.

Upon receipt, the total supply should be transferred from bags into airtight “stock” containers, Ergotainers are recommended. The date received should be marked on each container.

It is helpful to “tap” the full containers on the ground to achieve some degree of lime settling. This compaction will help limit atmospheric exposure of the lime below the surface.

A smaller “lab” container is needed to hold the lime used in day-to-day testing.

The lab container must also be airtight and should hold a one – two week supply. The use of a lab container avoids exposing the lime supply to the atmosphere and limits the number of times a stock container must be opened. The stock container only needs to be opened a couple of times a month rather than daily.
These care measures are important for both quicklime and hydrate. The presence of moisture catalyses carbonation, so it is especially important for hydrate, which inherently contains moisture.

Lime in the stock container should be discarded 12 weeks after it is received.

8.1.3 Use / sampling

Each time lime is transferred from the stock container to a lab container the top 10 – 20 mm of lime in the stock container should be discarded. When lime is added to the lab container the date should be marked on the container.

Before each testing job, the top 10 – 20 mm of lime should be discarded from the lab container.

Prior to transferring lime from the stock container to the lab container, all lime remaining in the lab container should be discarded.

No container should be left open when not being used. If the lab container is to be unused for more than 10 minutes, close it tight.

Lime in the lab container should be discarded if it has been in the lab container for more than 14 days.

If care is taken to follow these storage methods, and stock is rotated often, the lime quality should remain at acceptable levels.

8.2 Cement

8.2.1 Importance of proper storage

The term cement is used to describe General Purpose Portland cement or GP cement. It can also mean other forms of cementitious blended consisting of combinations of pozzolanic material and cement and or lime. Cement will react with moisture in the air and hydrate, this will reduce the efficacy of the cement with age. With proper handling, the hydration can be held to a minimum. It is important to keep cement dry and in airtight containers.

8.2.2 Storage

It is best to obtain no more than a one – two month supply of cement at a time.

Upon receipt, the total supply should be transferred from bags into airtight “stock” containers, Ergotainers are recommended. The date received should be marked on each container.

It is helpful to “tap” the full containers on the ground to achieve some degree of cement settling. This compaction will help limit atmospheric exposure of the cement below the surface.

A smaller “lab” container is needed to hold the cement used in day-to-day testing.

The lab container must also be airtight and should hold a one – two week supply. The use of a lab container avoids exposing the cement supply to the atmosphere and limits the number of times a stock container must be opened. The stock container only needs to be opened a couple of times a month rather than daily.

Cement in the stock container should be discarded 12 weeks after it is received.

8.2.3 Use / sampling

Each time cement is transferred from the stock container to a lab container the top 10 – 20 mm of cement in the stock container should be discarded. When cement is added to the lab container the date should be marked on the container.
Before each testing job, the top 10 – 20 mm of cement should be discarded from the lab container.

Prior to transferring cement from the stock container to the lab container, all cement remaining in the lab container should be discarded.

No container should be left open when not being used. If the lab container is to be unused for more than 10 minutes, close it tight.

Cement in the lab container should be discarded if it has been in the lab container for more than 14 days.

If care is taken to follow these storage methods, and stock is rotated often, the cement quality should remain at acceptable levels.