

Procedures for Design and Indirect Tensile Strength Testing of Modified and Bound Pavement Materials

1 SCOPE

This document sets out procedures for determining an optimised blend of aggregate and binders for the stabilisation of pavements.

The preparation of the aggregate and the preparation, curing and testing of test specimens mixed with cement, lime, foamed bitumen and/or bitumen emulsion are covered.

The purpose of this document is to provide a standardised procedure to assist the pavement designer in determining the optimum type and quantity of binder(s) used for stabilising. It is the intention of this document to produce test specimens that closely replicate post construction field densities.

This document also covers the production, sampling and strength testing of the stabilised aggregates in the field to confirm the improved properties.

Due to the close interaction between the laboratory staff and the pavement designer, herein referenced as “the design engineer”, the areas where the design engineer is required to give direction or be consulted are identified in the text of the document. The laboratory staff shall seek the required direction and instruction from the design engineer.

2 RELATED DOCUMENTS

Reference is made in this procedure to the following documents.

- (a) Standards New Zealand NZS 4407 Methods of Sampling and Testing Road Aggregates
- (b) Standards New Zealand NZS 4402 Methods of Testing Soils for Civil Engineering Purposes
- (c) NZTA M1 Specification for Roading Bitumens
- (d) NZTA M1-A Performance Specification for Asphalt Binders

3 APPARATUS

3.1 In addition to the apparatus required by referenced test methods, the following is required:

- (a) A sample divider of the multiple slot type - riffle box as specified in NZS 4407, Part 2, clause 2.7.3;
- (b) A moisture-curing room capable of maintaining a relative humidity of 95% to 100% and a temperature of 21 ± 2 °C or suitable individual plastic bags to hold specimens and carriers in an airtight condition in the water bath in (c) below;
- (c) A suitable water bath with thermostatic control capable of maintaining a temperature of 21 ± 2 °C
- (d) Callipers to measure the length and diameter of test specimens with a reach of at least 150mm and jaws at least 75mm long, accurate to 0.5mm
- (e) Indirect Tensile Strength test apparatus as detailed in section 8 of this specification
- (f) A loading machine with a moveable head or base that travels at a uniform (not pulsating) rate of 1 ± 0.1 mm/min (or 50.8 ± 0.1 mm/min for foamed bitumen mix design).
- (g) Silicone oil or grease
- (h) Drying Oven in accordance with NZS 4407, clause 1.6.2

- 3.2 Equipment for mixing of stabilised materials in the laboratory shall be one of the following:
- (i) Mechanical Pugmill type mixer (e.g. Wirtgen WLM30) – for all mixes
 - (j) Planetary type mechanical mixer (e.g. Hobart type mixer) – cement and/or lime only
 - (k) Concrete type mixer – cement and/or lime only

Hand mixing can be used for cement and/or lime only

4 AGGREGATE PREPARATION AND TESTING

- 4.1 Sampling and blending of the existing pavement layers and surfacing and/or imported aggregates shall be carried out in accordance with the design engineer's requirements.
- 4.2 Carry out the following aggregate characterisation tests, unless waived by the design engineer, as follows:
- (a) Determine water content of the sample using NZS 4407 Test 3.1.
 - (b) Determine the particle size distribution of the aggregate sample(s) as received in accordance with NZS 4407, Test 3.8.1.
 - (c) Determine the plasticity index (PI) in accordance with NZS 4407, Test 3.4. If the Liquid Limit (LL), determined by the Cone Penetrometer is greater than 50%, then determine the Plasticity Index using NZS 4402, Test 2.4.
 - (d) Consult the design engineer at this stage with regard to ongoing testing for material improvement, including adjustment of plasticity (if required) or adjustment of aggregate particle size distribution (if required).
 - (e) All mix design testing is carried out with a maximum particle size of the aggregate of 37.5mm. If the aggregate, or the aggregate after adjustment of the particle size distribution, is greater than 37.5mm then the portion retained on the 37.5mm sieve shall be removed and discarded
 - (f) Calculate the theoretical percentage passing each test sieve following removal of the fraction retained on the 37.5mm sieve. Note that binder contents will be calculated as a percentage of the sample passing the 37.5 mm sieve and reported as percent by dry mass.
- 4.3 Adjusting Aggregate Particle Size Distribution
- (a) On the basis of the particle size distribution determined in 4.2, the design engineer will determine if adjustment of the particle size distribution is required. Any adjustment will be done by the addition of other aggregate materials. This may be required if the sample is gap-graded, or requires modification with another material.
 - (b) If aggregates are added to modify the particle size distribution then the particle size distribution shall be calculated for the blend.
- 4.4 Aggregate Pre-treatment
- (a) If required the design engineer will direct requirements for aggregate pre-treatment based on the plasticity index.
 - (b) Addition of binders for pre-treatment, if required, shall be in accordance with Equation 5.1 and Equation 5.2.
- 4.5 Optimum Water Content and Maximum Dry Density
- (a) After any correction of the particle size distribution and/or the plasticity, determine the Optimum Water Content and Maximum Dry Density in accordance with NZS 4402, Test 4.1.3 for the fraction passing the 37.5 mm sieve.

5 TEST PROCEDURE FOR CEMENT AND/OR LIME STABILISED MATERIALS

5.1 Use the following procedure to manufacture stabilised materials at several binder contents as directed by the design engineer using cement and/or lime for the binder.

5.2 Prepare aggregate subsamples using the following procedure:

- (a) If required sieve the bulk sample over 37.5 mm sieve and discard the material retained on the 37.5mm sieve.
- (b) Split the sieved sample into appropriate sub samples in accordance with NZS 4407, Part 2, clause 2.7.3. Allow for at least 5 test specimen and 2 moisture content determinations (soaked and dry) per binder content
- (c) Use one of the sub samples to determine the water content using NZS 4407 test 3.1.
- (d) Determine the dry mass of the other sub-samples sample, to the nearest 1g, using Equation 5.1:

$$M_{\text{dry}} = M_{\text{sample}} / \left(1 + \left(\frac{W_{\text{sample}}}{100}\right)\right) \dots \text{Equation 5.1}$$

Where M_{Dry} = mass of the dry sample (g)

M_{Sample} = mass of the wet sample (g)

W_{Sample} = moisture content of the wet sample, (% by mass)

- (e) Determine the required amount of binder, to the nearest 1g, using Equation 5.2:

$$M_{\text{binder}} = \frac{C_{\text{add}}}{100} \times M_{\text{dry}} \dots \text{Equation 5.2}$$

Where M_{Binder} = mass of binder (lime or cement) to be added [g]

C_{add} = percentage of lime or cement required [% by mass]

M_{Dry} = dry mass of sample [g]

- (f) Determine the percentage of water to be added for optimum mixing purposes using Equation 5.3 (note that this may be an estimated OWC). Then determine the mass of the water to be added to the sample, to the nearest 1g, using Equation 5.4.

$$W_{\text{add}} = W_{\text{owc}} - W_{\text{sample}} \dots \text{Equation 5.3}$$

$$M_{\text{water}} = \left(\frac{W_{\text{add}}}{100}\right) \times (M_{\text{dry}} + M_{\text{binder}}) \dots \text{Equation 5.4}$$

Where: W_{add} = water to be added to sample (% by mass)

W_{OWC} = optimum water content of aggregate (% by mass)

W_{Sample} = moisture content of the moist sample (% by mass)

M_{Water} = mass of water to be added (g)

M_{Dry} = dry mass of sample (g)

M_{Binder} = mass of binder (hydrated lime or cement) to be added (g)

5.3 Prepare mixtures of the aggregate subsamples with the binder using the following procedure:

- (a) Place each sub sample prepared as described in 5.2 above in a suitable mixing container.
- (b) For each of the binder contents, thoroughly mix the aggregate and binder; thereafter add water to reach desired water content as determined in section 4.5 (or estimated) and mix until uniform in a suitable mixing container. Care must be taken to avoid loss of binder and moisture during mixing. If the sample is to be stabilised with lime and cement, add the lime first or simultaneously if a blend is specified.
- (c) After mixing the binders with the aggregate, visually check the moisture content and correct it to compensate for the possible drying effects of the binder. Record the addition of water to the nearest 1g.
- (d) Compact test samples within 10 minutes after mixing the binder(s) with the aggregate.

5.4 Compaction of test specimens

- (a) Representatively divide the subsample into a number of portions corresponding to the number of compacted specimens required, i.e. five, plus an extra sample for determination of the water content.
- (b) Determine the water content of the subsample using NZS 4407, Test 3.1 and record as $W_{\text{Compaction}}$. Use this value as w in NZS 4402 4.1.3.5 (b) to calculate the specimen dry density after compaction.
- (c) For each binder content manufacture a minimum of five test specimens in accordance with NZS 4402 Test 4.1.3 using the specified 152mm mould. Resulting samples shall be 126 ± 10 mm high. The mould should be very lightly greased to aid in sample extraction.
- (d) Determine the density of the compacted test specimen ($DD_{\text{Compaction}}$) in accordance with NZS 4402 Test 4.1.3.

6 TEST PROCEDURE FOR BITUMEN STABILISED MATERIALS

6.1 Use the following test procedure to manufacture stabilised materials at several binder contents and including active filler as directed by the design engineer using bitumen or emulsified bitumen as the binder.

6.2 Binders

- (a) The binder shall be bitumen conforming to NZTA M1 or M1-A specification or emulsified bitumen unless otherwise directed by the design engineer.
- (b) If bitumen is the binder use M1 80/100 penetration grade, or M1-A PG 64S (or near equivalent). If another grade or source of bitumen is used then carry out a foaming optimisation test as described in section 10.
- (c) If emulsified bitumen is the binder, use bitumen emulsion manufactured with bitumen conforming to M1 unless otherwise directed by the design engineer. The emulsified bitumen used for this mix design testing shall be specifically formulated for stabilisation and shall break during the sample mixing and compaction process.

6.3 Prepare aggregate subsamples using the following procedure:

- (a) If necessary sieve the bulk sample over 37.5 mm sieve and discard the material retained on the 37.5mm sieve
- (b) Split the sieved subsample into appropriate sub samples in accordance with NZS 4407 clause 2.7.3. Allow at least 4 test specimen and 2 moisture content determination (soaked and dry) per binder content
- (c) Use one of the sub samples to determine the water content using NZS 4407 test 3.1 and record as $W_{\text{subsample}}$.
- (d) Calculate the dry mass of the other sub samples, to the nearest 1g, using Equation 6.1:

$$M_{\text{dry}} = M_{\text{sample}} / \left(1 + \left(\frac{W_{\text{sample}}}{100} \right) \right) \dots \dots \dots \text{Equation 6.1}$$

Where:

- M_{Dry} = mass of the dry sample (g)
 M_{Sample} = mass of the wet sample (g)
 W_{Sample} = moisture content of the wet sample (% by mass)

- (e) Determine the required amount of active filler (lime or cement), to the nearest 1g, using Equation 6.2:

$$M_{\text{filler}} = \frac{C_{\text{add}}}{100} \times M_{\text{dry}} \dots \dots \dots \text{Equation 6.2}$$

Where:

- M_{filler} = mass of active filler (lime or cement) to be added (g)
 C_{add} = percentage of active filler required (% by mass)
 M_{Dry} = dry mass of sample (g)

6.4 Determination of the percentage of water to be added:

- (a) The foamed bitumen and bitumen emulsion have different states, being in a foamed and liquid state respectively. Bitumen emulsion normally consists of 30% to 40% water and therefore the aggregate subsample requires less addition of water to achieve the optimum water content for compaction purposes.
- (b) Use the procedure in 6.4.1 to determine the mass of water to add to the aggregate subsample if the binder is foamed bitumen.
- (c) Use the procedure in 6.4.2 to determine the mass of water to add to the aggregate subsample if the binder is emulsified bitumen.

6.4.1 Determination of the mass of water to add for a foamed bitumen binder

- (a) Determine the percentage of water to be added for optimum mixing purposes using Equation 6.3. Then determine the mass of the water to be added, to the nearest 1g, to the sample using Equation 6.4

$$W_{\text{add}} = (P_{\text{owc}} \times W_{\text{owc}}) - W_{\text{sample}} \dots\dots\dots \text{Equation 6.3}$$

$$M_{\text{water}} = \left(\frac{W_{\text{add}}}{100} \right) \times (M_{\text{dry}} + M_{\text{binder}}) \dots\dots\dots \text{Equation 6.4}$$

Where:

W_{add}	=	water to be added to sample (% by mass)
P_{owc}	=	percentage of OWC to achieve optimum mixing water content (see note below), (%)
W_{owc}	=	optimum water content(% by mass)
W_{sample}	=	moisture content of moist sample (% by mass)
M_{water}	=	mass of water to be added (g)
M_{dry}	=	dry mass of the sample (g)
M_{binder}	=	mass of binder (lime or cement) to be added (g)

Note:

The optimum mixing water content of aggregates before treating with foamed bitumen is generally in the order of 85% to 95% (P_{owc}) of the OWC, depending on the type of aggregate. Judgement is required in defining the optimum water content for various materials. Refer to the Notes for guidance.

6.4.2 For Bitumen Emulsion

- (a) Determine the percentage of water to be added for optimum mixing purposes using Equation 6.5. Then determine the mass of the water to be added to the sample, to the nearest 1g, using Equation 6.6:

$$W_{\text{add}} = W_{\text{owc}} - B_{\text{Eadd}} - W_{\text{sample}} \dots\dots\dots \text{Equation 6.5}$$

$$M_{\text{water}} = \left(\frac{W_{\text{add}}}{100} \right) \times (M_{\text{dry}} + M_{\text{binder}}) \dots\dots\dots \text{Equation 6.6}$$

Where:

W_{add}	=	water to be added to sample (% by mass)
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- W_{OWC} = optimum water content (% by mass)
- BE_{Add} = bitumen emulsion added (% by mass)
- W_{Sample} = moisture content of moist sample (% by mass)
- M_{Water} = mass of water to be added (g)
- M_{Dry} = dry mass of the sample (g)
- M_{Binder} = mass of binder (lime or cement) to be added (g)

6.5 Aggregate Pre-treatment if required.

(a) Where pre-treatment of the sample is proposed as part of construction methodology (i.e. to mitigate high plasticity) the testing shall replicate this with the proposed binder(s) and a corresponding conditioning period prior to preparation of test specimens. The binder quantity shall be calculated as per 6.6 and preparation, curing and testing as per this method. The conditioning period shall be as instructed by the design engineer (typically 24 hours).

6.6 Determine the amount of bituminous binder to be added to the aggregate

- (a) Use the procedure of 6.6.1 if the binder is foamed bitumen.
- (b) Use the procedure of 6.6.2 if the binder is emulsified bitumen.

6.6.1 Procedure for foamed bitumen binder:

(a) Determine the mass of foamed bitumen to be added using Equation 6.7:

$$M_{bitumen} = \left(\frac{B_{add}}{100} \right) \times (M_{dry} + M_{cement}) \dots \dots \dots \text{Equation 6.7}$$

Where:

- B_{add} = foamed bitumen content (% by mass)
- $M_{Bitumen}$ = mass of foamed bitumen to be added (g)
- M_{Dry} = dry mass of the sample (g)
- M_{Cement} = mass of lime or cement to be added (g)

6.6.2 For Bitumen Emulsion

(a) Determine the mass of emulsified bitumen to be added using Equation 6.8:

$$M_{emul} = \left(\frac{B_{add}}{B_{emul}} \right) \times (M_{dry} + M_{binder}) \dots \dots \dots \text{Equation 6.8}$$

Where:

- B_{add} = bitumen content (% by mass)
- B_{emul} = bitumen content of the emulsion (% by mass)
- $M_{emulsion}$ = mass of emulsified bitumen to be added (g)
- M_{dry} = dry mass of the sample (g)
- M_{binder} = mass of lime or cement to be added (g)

6.7 Mixing the bituminous binders with the aggregate

- (a) Use the procedure of 6.7.1 if the binder is foamed bitumen.
- (b) Use the procedure of 6.7.2 if the binder is emulsified bitumen.

6.7.1 Mixing Foamed Bitumen with the aggregate

- (a) Prepare the laboratory foamed bitumen apparatus in accordance with the manufacturers recommended procedures
- (b) Heat the bitumen to the target temperature well in advance of adding the foamed bitumen.
- (c) Calibrate the bitumen flow, Q_{Bitumen} , prior to injection by weighing the amount of bitumen discharged at various timer settings, usually in the range of 2 to 8 seconds at 2 second increments.
- (d) Determine the timer setting for the bitumen content on the FB lab unit using Equation 6.9:

$$T = \left(\frac{M_{\text{bitumen}}}{Q_{\text{Bitumen}}} \right) \dots \dots \dots \text{Equation 6.9}$$

Where:

T = time to be set on the laboratory foamed bitumen apparatus unit[s]

M_{Bitumen} = mass of foamed bitumen to be added (g)

Q_{Bitumen} = bitumen flow rate for the FB lab unit (g/s)

- (e) Place sub-sample into pug-mill mixer and mix with active filler and water until uniform
- (f) Add the foamed bitumen within 10 minutes of adding the active filler
- (g) Start the pug-mill mixer and allow it to mix for at least 20 seconds before injecting the required mass of Foamed Bitumen into the pug-mill mixer. Continue mixing for a further 60 seconds after the Foamed Bitumen has been injected into the pug-mill mixer. Immediately after mixing, transfer the Foamed Bitumen treated material into a suitable container and seal.
- (h) Compact the test samples within 10 minutes after mixing the binder(s) with the aggregate.
- (i) Repeat the above steps to manufacture additional points as directed by the design engineer.

Note:

The expansion and half-life of the foamed bitumen are critical to the final mix. Thus, if the pugmill jams or doesn't operate continuously during the injection or the following 30 seconds, then the sample must be rejected and a new sample prepared.

6.7.2 Mixing Bitumen Emulsion with the aggregate

- (a) Thoroughly mix the sample and active filler (M_{filler}) in the mixing bowl before adding the required amount of water (M_{water}) and mix until uniform. Proceed to adding the bitumen emulsion within 10 minutes of the addition of active filler or as directed by the design engineer.
- (b) Add the required amount of emulsified bitumen (M_{emulsion}) to the mixing bowl and mix until uniform.

- (c) Commence the compaction of test samples within 10 minutes after mixing the emulsified binder with the aggregate.

6.8 Compaction of test specimens

- (a) Representatively divide the subsample into a number of portions corresponding to the number of compacted specimens required plus an extra sample for determination of the water content.
- (b) Determine the water content of the subsample using NZS 4407 , test 3.1 and record as $W_{\text{compaction}}$. Use this value as w in NZS 4402 4.1.3.5 (b) to calculate the specimen dry density after compaction.
- (c) For each binder content, manufacture a minimum of five test specimens in accordance with NZS 4402, Test 4.1.3, New Zealand Vibrating hammer using the specified mould. Resulting samples shall be 126 ± 10 mm high. The mould should be very lightly greased to aid in sample extraction.
- (d) Determine the density of the compacted test specimen ($DD_{\text{compaction}}$) in accordance with NZS 4402 Test 4.1.3.

Notes:

For major projects the design engineer may direct additional sets of specimens to be compacted at target densities to assess the impact on ITS properties of reduced density.

Specimen compaction using the Servopac gyratory compaction apparatus may also be specifically permitted by the design engineer.

7 SPECIMEN CURING

7.1 Curing cycle for dry test specimens

- (a) Cover the mould with a damp cloth (e.g. Hessian) and allow 24 ± 2 hours curing in a sealed plastic bag at $21^\circ\text{C} \pm 2^\circ\text{C}$. A water bath is a suitable means of maintaining the curing temperature. Remove the test specimens from the moulds either by dismantling the split moulds or, if ordinary moulds are used, extrude the specimens carefully with an extrusion jack, avoiding distortion to the compacted test specimen. Reject and discard the specimen if any visual distortion is observed.
- (b) Oven cure the dry test samples (two per binder content) for 72 ± 2 hours, in a sealed plastic bag at a temperature of $40^\circ\text{C} \pm 2.5^\circ\text{C}$.
- (c) Remove the test specimens from the oven. Store the sealed test specimens in the water bath at $21^\circ \pm 2^\circ\text{C}$ for 24 ± 2 hours.

7.2 Curing cycle for soaked test specimens

- (a) Cover the mould with a damp cloth (e.g. Hessian) and allow 24 ± 2 hours curing in a sealed plastic bag at $21^\circ\text{C} \pm 2^\circ\text{C}$. A water bath is a suitable means of maintaining the curing temperature. Remove the test specimens from the moulds either by dismantling the split moulds or, if ordinary moulds are used, extrude the specimens carefully with an extrusion jack, avoiding distortion to the compacted test specimen. Reject and discard the specimen if any visual distortion is observed.
- (b) Oven cure the test specimens (two per binder content) for 72 ± 2 hours, in an individual sealed plastic bag at a temperature of $40^\circ\text{C} \pm 2.5^\circ\text{C}$.
- (c) Remove the test specimens from the oven. Remove the plastic bag and soak the specimens in water at neutral pH (not in a bath used for curing concrete cubes) for 24 ± 2 hours at $21^\circ\text{C} \pm 2^\circ\text{C}$. Remove the specimens from the water bath and allow the specimens to drain for no longer than 15 minutes prior to testing.

7.3 Determination of the of the test specimen dry density

- (a) Determine the mass of the specimen to the nearest 1g and record as M_{specimen} .
- (b) Determine the height of the specimen to the nearest 1mm by measuring it using callipers at four equidistant locations around its circumference. Calculate the mean specimen height and record as H_{mean} .
- (c) Determine the diameter of the specimen to the nearest 1mm by measuring using callipers at four equidistant locations around its circumference. Calculate the mean specimen diameter and record as D_{mean} .
- (d) Calculate the specimen volume using Equation 7.1:

$$V_{\text{specimen}} = \frac{\pi \times D_{\text{mean}}^2}{4} \times H_{\text{mean}} \dots \dots \dots \text{Equation 7.1}$$

- (e) Calculate the specimen density using Equation 7.2

:

$$D_{\text{specimen}} = \frac{M_{\text{specimen}}}{V_{\text{specimen}}} \times \frac{100}{(W_{\text{ts}} + 100)} \times 1000 \text{ (kg/m}^3\text{)} \dots \dots \dots \text{Equation 7.2}$$

Where: W_{ts} = Moisture content of aggregate after Indirect Tensile Strength testing (%)

- (f) Exclude from further testing any specimen whose bulk density differs from the mean bulk density of all four specimens by more than 5%. For this reason, prepare 5 specimens and discard the sample with the bulk density furthest from the mean.

7.4 Determine the Indirect Tensile Strength (ITS) for the dry and soaked specimens using the procedure of section 8.

8 DETERMINATION OF INDIRECT TENSILE STRENGTH

8.1 The Indirect Tensile Strength (ITS) is determined by measuring the ultimate load to failure of a test specimen that is subjected to a constant rate of 1 ± 0.1 mm/min (or 50.8 ± 0.1 mm/min for foamed bitumen mix design) on its diametrical axis.

8.2 Apparatus

- (a) Loading machine with a moveable head or base that travels at a uniform (not pulsating) rate of 1.0 ± 0.1 mm/min (or 50.8 ± 0.1 mm/min for foamed bitumen mix design). The loading machine shall be equipped with a force-indicating device for axial load measurement up to 50 kN, and shall comply as regards to accuracy with the requirements of Grade 2.0 minimum of EN ISO 7500-1.
- (b) Loading jig which shall consist of two loading strips of hardened steel, 19 x 20 x 200 mm, with the 19 mm face ground concave to a radius of 76 ± 1 mm, together with a frame of suitable design to align the loading strips, and the load transfer ball bearing on top of the upper loading strip (see figure 5.1). The tolerance of the concave face width shall be 19 ± 0.5 mm.

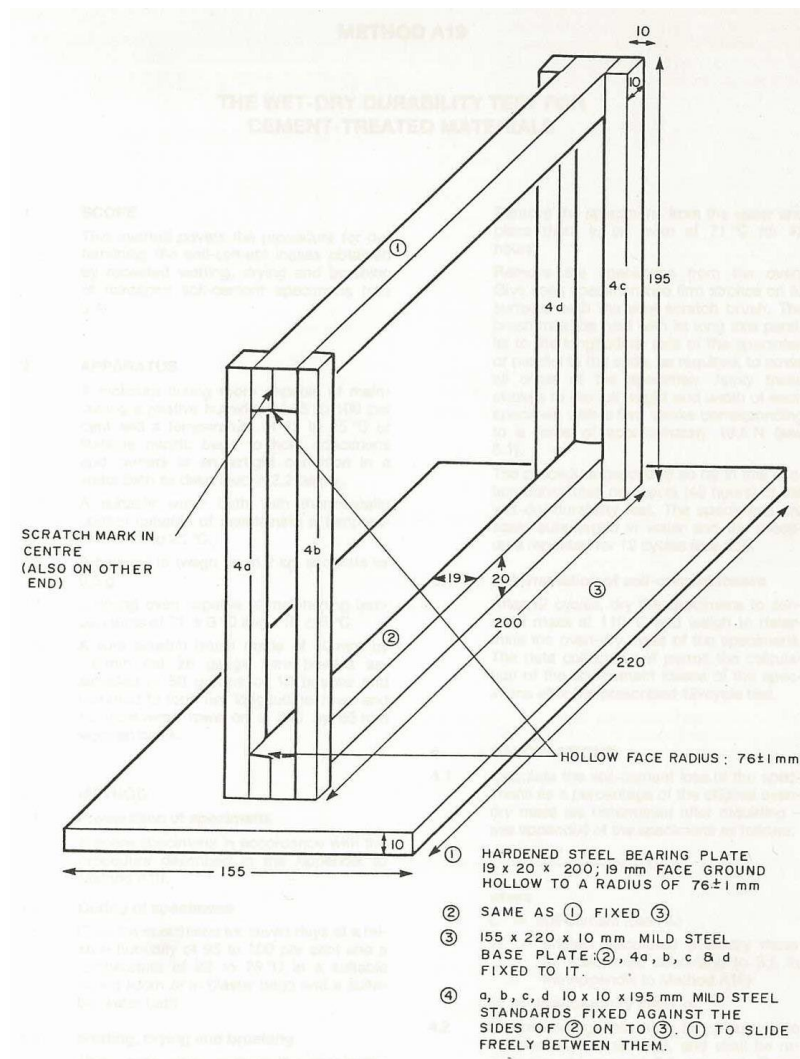


Figure 8.1: Example of Indirect Tensile Strength (ITS) Testing Equipment

8.3 Use the following process to determine the ITS:

- Place the test specimen into the loading jig such that the concave loading strips are parallel and centred on the vertical diametrical plane of the specimen.
- Place the load transfer plate on the top bearing strip and position the jig assembly into the loading machine centrally under the loading ram.
- Apply the load to the test specimen, without shock, at a rate of advance of 1.0 ± 0.1 mm/min (or 50.8 ± 0.1 mm/min for foamed bitumen mix design) until the maximum load is reached. Record the vertical displacement of the loading ram (mm) vs the applied load (kN), accurate to 0.02 mm and 0.1 kN respectively, for every 0.25mm vertical displacement.
- If the ultimate load exceeds 50 kN then report "ITS greater than the calculated ITS at 50kN"
- Immediately after testing the specimen, break it up and determine the moisture content in accordance with NZS 4407, Test 3.1.
- Calculate the ITS for each test specimen to the nearest 1 kPa using Equation 8.1:

$$ITS = 10^6 \times \frac{2 \times P}{\pi \times d \times h} \dots \dots \dots \text{Equation 8.1}$$

Where ITS = indirect tensile strength (kPa)
P = maximum applied load (kN)
h = average height of the test specimen (mm)
d = diameter of the test specimen (mm)

Note:

The testing agency may elect to undertake the bitumen sample ITS testing at a loading rate of 50.8 mm/min. A faster loading rate may be acceptable provided that a clear relationship between the two loading rates can be clearly demonstrated by the testing agency utilising bitumen treated materials and testing equipment that complies with the requirements of T19.

8.4 Determine the Tensile Strength Ratio (TSR) using the following procedure.

- (a) Calculate the mean ITS for the dry specimens using the results for at least two specimens for a specific binder content. Calculate the mean ITS for the soaked specimens using at least two specimens for a specific binder content.
- (b) Calculate the Tensile Strength Retained (TSR) using

$$TSR = \frac{ITS_{soaked}}{ITS_{dry}} \times 100 (\%) \dots \dots \dots \text{Equation 8.2}$$

Where ITS_{soaked} = the mean ITS for the soaked specimens (kPa)
 ITS_{dry} = the mean ITS for the dry specimens (kPa)

- (c) After determining the ITS, determine the moisture content using NZS 4407, Test 3.1 for each specific binder content dry and soaked condition.

9 REPORTING

9.1 Report the following:

- (a) Moisture content of the sample as received
- (b) If determined, the particle size distribution for the sample as received
- (c) If determined, the calculated particle size distribution of the aggregate fraction passing the 37.5mm sieve
- (d) If determined, the Plasticity Index
- (e) Any correction to the particle size distribution
- (f) Any pre-treatment to modify the source aggregate – including binder type and content(s) and conditioning period
- (g) Mould type (split/solid) and extrusion time if it deviates from this procedure
- (h) The Dry Density and Optimum Water Content.

Report for each set of test specimens:

- (i) Mixing method
- (j) If added, filler type and content.
- (k) Binder type and content(s). Lime is to be reported in terms of Calcium Oxide or Calcium Hydroxide.
- (l) Water content at the time of compaction
- (m) Water content at the time of strength testing (after curing)
- (n) Density before ITS testing
- (o) ITS Loading rate (mm/min)
- (p) Soaked ITS and dry ITS to the nearest kPa.
- (q) ITS vs. Strain (every 0.25mm) and the maximum ITS.
- (r) Tensile Strength Retained (TSR) to the nearest whole number
- (s) Load versus Deflection plot if specified
- (t) Any departures from this procedure.

10 CHECKING AND OPTIMISING THE FOAMED BITUMEN CHARACTERISTICS IN THE LABORATORY

10.1 Frequency of checking the Foamed Bitumen Characteristics

This procedure shall be carried out if one of the following factors changes:

- (a) Bitumen grade or source
- (b) Change in foaming agent (if used)
- (c) If elapsed time exceeds 3 months from last Foamed Bitumen characteristics check

10.2 Method of Optimising the Foamed Bitumen Characteristics

- (a) Heat the bitumen to the required temperature, typically 180°C, and maintain that temperature for at least 5 minutes before commencing with foamed bitumen production. At this point foaming agents can be added.
- (b) For each temperature required, measure the foaming characteristics at water injection ranging from 2% to 4% by mass of the bitumen, in increments of 0.5%. If necessary, the range shall be increased until optimum properties are achieved.
- (c) Set the time on the laboratory foaming unit's timer to discharge 500g of bitumen according to Equation 10.1.
- (d) For each point, allow 500g of foamed bitumen to discharge into a 20 litre steel bucket.
- (e) Using a dipstick that is calibrated for a steel bucket of 275 mm diameter and 500 g of bitumen, measure the maximum expansion achieved in the bucket. This is recorded as the expansion ratio.
- (f) Using a stopwatch, measure the time in seconds that the foamed bitumen takes to dissipate to half of its maximum volume. Half-life is measured from the time the foamed bitumen nozzle shuts off until the foamed bitumen has achieved half its maximum volume. This is recorded as the foamed bitumen's half-life.
- (g) Repeat the above procedure twice or until similar readings are achieved for each water injection rate.
- (h) Plot a graph of the expansion ratio versus half-life for all the foaming water contents as shown in Figure 6.2 below.
- (i) Repeat steps (a) to (h) at a bitumen temperature of 170°C.

$$T_{\text{set}} = \frac{M_{\text{bit}}}{Q_{\text{bit}}} \dots \dots \dots \text{Equation 10.1}$$

Where:

T_{set} = injection time (s)

M_{bit} = mass of bitumen (normally 500g) (g)

Q_{bit} = bitumen flow (g/s)



Figure 10.1: Foam Measuring Equipment

The optimum water addition and minimum temperature required for the production of foamed bitumen is that point where both the expansion and half-life is balanced and is above the specified amounts (refer to NZTA B5 and NZTA B7).

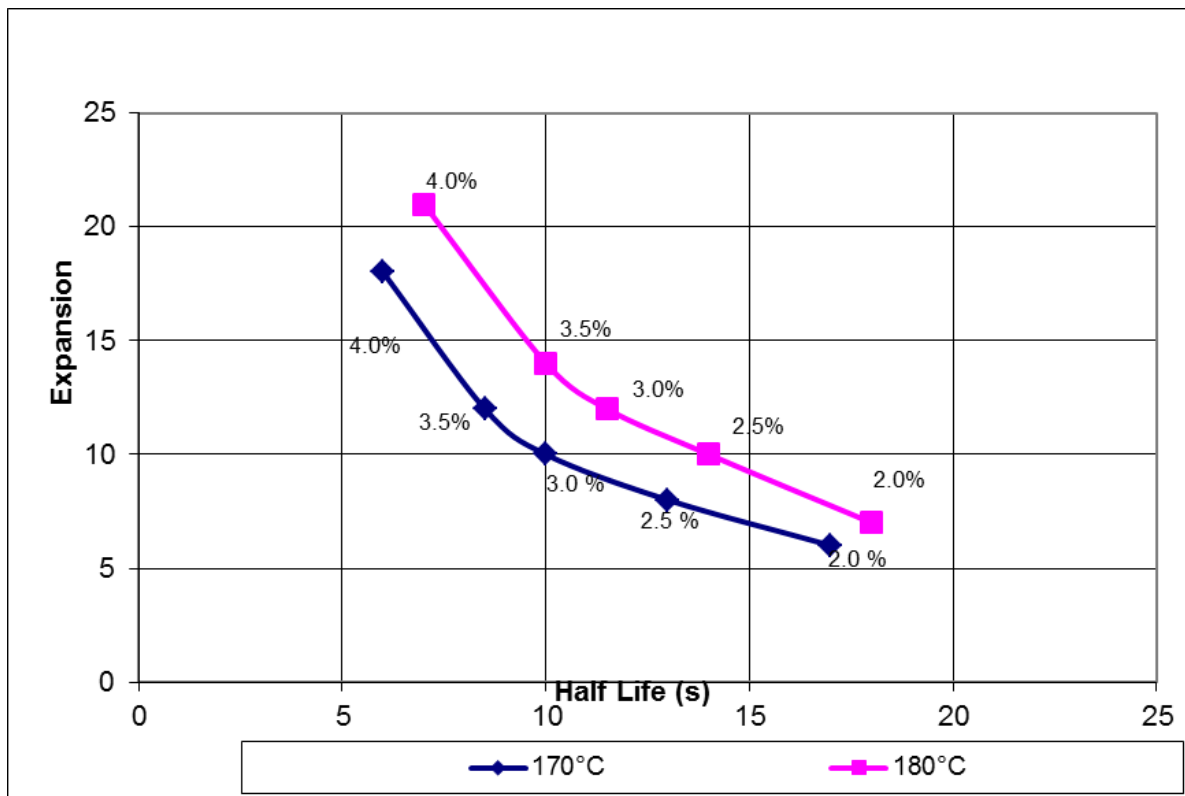


Figure 10.2: Example of the relationship between expansion and half-life

Note: The points plotted are percentage foaming water by weight.

11 APPENDIX: PRODUCTION AND CONSTRUCTION SAMPLING AND TESTING

11.1 Scope

This section covers the field sampling and strength testing of the stabilised aggregates that have been mixed with cement, lime, foamed bitumen and/or bitumen emulsion to confirm that design parameters have been achieved during construction.

11.2 Sampling of the mixed Aggregates

11.2.1 Carry out the sampling of the mixed aggregate in accordance with NZS 4407, Part 2. In particular, depending on the method of mixing, follow the clauses below:

- (a) In-Situ mixing process – clause 2.4.8.1 except that the sampling of the modified material shall be carried out before compaction (i.e. from behind the in-situ stabiliser but before the primary compactor).
- (b) In-Plant process – clause 2.4.6 Sampling from Stockpiles

11.2.2 All sampling shall take place within 5 minutes of mixing with the binding agent(s). Place the sample in an airtight container to ensure no loss of moisture content. No additional water is to be added to the sample. Compact the field sample into the mould as soon as possible and no later than 1 hour after mixing with the binders in the field.

11.3 Maximum Particle Size

If the stabilised aggregate is an AP40 then no scalping shall be done. If the stabilised aggregate is larger than AP40 then sieve the field sample through the 37.5mm sieve while ensuring that all fine material that may adhere to the sieve is brushed off the sieve into the “passing” sample. Discard the material retained on the 37.5mm sieve.

11.4 Moisture Content of Field Sample

Determine the “as received” moisture content in accordance with NZS 4407, Test 3.1 from a sub-sample of the site sample.

11.5 Manufacture and testing of the test specimens

Follow the steps using clauses from this specification as follows:

- (a) Sieve the aggregate sample over the 37.5mm sieve and discard the portion retained on the 37.5mm sieve in accordance with 4.2(e)
- (b) Manufacture the test specimens in accordance with 5.4
- (c) Cure the test specimens in accordance with 7.1
- (d) Determine the dry density in accordance with 7.3
- (e) Determine the Tensile Strength Retained using 7.4
- (f) Report the test results in accordance with 9