Client’s Expectation – Consultant’s Intentions – Contractor’s Performance

For Pavement rehabilitation using Modification and/or Stabilisation

By: Thorsten Frobel

REAAA 2009 NZ Chapter Roadshow
12 - 18 August 2008
Overview

- History of Stabilisation Technology
- Stabilisation Working Group
- Client’s Expectation
- Consultant’s Intentions
- Contractor’s Performance
In 1943 a large scale upgrade of the Airforce Airfields led to a rapid development of Stabilisation Plant

Ref: “Ground modification with bituminous binders and cement”

Dr. Rudolf Bilfinger - 1943
Spreading of cement by bags or by agricultural spreader
Spreading of cement by spreaders
Stabilisation Plant during the 1940's

Progression from the agricultural hand mixers to stabilisers
Stabilisation Plant during the 1940's

Vögele’s mobile mixer – “Machine through Ground”

Front Drive
Cement Hopper
Mixing rotors
Pneumatic tyres for compaction
Reisser’s flow-through mixer – “Ground through Machine”
Reisser’s flow-through mixer – “Ground through Machine”
Stabilisation Plant since the 1970’s

Pneumatic Spreaders with grader type stabilisers
Stabilisation Plant since the mid 1990's

- Operator's panel: Setting of all working parameters
- Microprocessor: Printout of working data
- Water pump for foam generation
- Bitumen pump
- Measurement of added binders and water
- Control of pulsed nozzle cleaning function
- Measurement of the rate of advance
- Regulating pumps for binders and water
- Infeed for hot bitumen and spraybar
- Infeed for water and spraybar
- Powder storage and spreader
Stabilisation Plant since the mid 1990’s

Stabilisers with Water, Cement & Foamed Bitumen injection
2 – 3 % water in 180 °C hot bitumen causes the bitumen to expand 10 to 20 times its original volume.

The increased surface area makes it possible to mix hot bitumen with cold and damp aggregates.
Foamed Bitumen injection

Spraybar with 16 nozzles where hot bitumen is foamed in an expansion chambers and sprayed directly onto the milled material.
Progress !!!!!
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NZ Stabilisation Working Group (SWG)

- Foamed Bitumen Working Group – RNZ Pavements committee
- Stabilisation Working Group – RNZ, NZ CCA

- Series of Specs, Notes & Guidelines in final stages
- RNZ Technical Note #1: FB Stabilisation
- 3rd NZIHT Recycling & Stabilisation Conference
- TNZ B/5 Spec & Notes In-situ Modified layers
<table>
<thead>
<tr>
<th>Name</th>
<th>Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>David Alabaster</td>
<td>New Zealand Transport Agency</td>
</tr>
<tr>
<td>Ross Anthony</td>
<td>Works Infrastructure</td>
</tr>
<tr>
<td>Allen Browne</td>
<td>Hiway Stabilizers</td>
</tr>
<tr>
<td>Allan Tuck</td>
<td>Higgins</td>
</tr>
<tr>
<td>Thorsten Frobel</td>
<td>Fulton Hogan</td>
</tr>
<tr>
<td>William Gray</td>
<td>Opus International</td>
</tr>
<tr>
<td>John Hallett</td>
<td>Beca</td>
</tr>
<tr>
<td>Ken Hudson</td>
<td>CPG New Zealand</td>
</tr>
<tr>
<td>Alan Kirby</td>
<td>Cement and Concrete Assoc.</td>
</tr>
<tr>
<td>Ross Peploe</td>
<td>Bartley Consultants</td>
</tr>
<tr>
<td>Peter Rolls</td>
<td>McDonald’s Lime</td>
</tr>
<tr>
<td>Riaan Theron</td>
<td>GHD</td>
</tr>
<tr>
<td>Ref.</td>
<td>Document</td>
</tr>
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<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RNZ TN.1</td>
<td>RNZ Technical Note: Foamed Bitumen Stabilisation</td>
</tr>
<tr>
<td>TNZ B/5</td>
<td>Spec for In-Situ Stabilisation of Modified Pavement Layers</td>
</tr>
<tr>
<td>TNZ B/6</td>
<td>Spec for In-Situ Stabilisation of Strongly Bound Pavement Layers</td>
</tr>
<tr>
<td>TNZ B/7</td>
<td>Spec for In-Plant Stabilisation of Modified Materials</td>
</tr>
<tr>
<td>TNZ B/8</td>
<td>Spec for In-Plant Stabilisation of Strongly Bound Materials</td>
</tr>
<tr>
<td>TNZ B/9</td>
<td>Specification for Subgrade Stabilisation</td>
</tr>
<tr>
<td>TNZ M/15</td>
<td>Revision of the Specification of Lime for Stabilisation</td>
</tr>
<tr>
<td>TNZ T/16</td>
<td>Guideline: Mix Design for Stabilised Materials</td>
</tr>
<tr>
<td></td>
<td>Flowchart – from planning to execution of a rehabilitation project</td>
</tr>
<tr>
<td></td>
<td>RNZ Technical Note: Sealing on Stabilised layers</td>
</tr>
<tr>
<td></td>
<td>Watching Brief for TNZ B/5 specification</td>
</tr>
<tr>
<td></td>
<td>RNZ / NZTA Technical Training Roadshow: “Bring it to the people”</td>
</tr>
</tbody>
</table>
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- History of Stabilisation Technology
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“Quadruple S” – “Squad”

Smooth, Safe, Structurally sound, Sustainable
Client’s Expectation

Client is paying for a process:

- **Client’s Brief**
- **Network Modelling**
- **Investigation & Design**
- **Tender for Construction**
- **Road User Feedback**
- **Construction Phase**

Example of Road Rehabilitation Process
Flowchart for treatment selection of a AWPT including what binding agents to use

<table>
<thead>
<tr>
<th>Step</th>
<th>By whom</th>
<th>Purpose / Outcome</th>
<th>Where</th>
<th>Information gathered / Action</th>
<th>Literature / Manual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Level Investigation</td>
<td>Asset Manager / Network Engineer</td>
<td>To identify and prioritise treatment sections</td>
<td>Desktop</td>
<td>High Speed Data: Skid Resistance, Texture, Rutting, Roughness</td>
<td>State Highway Asset Management Manual SM020, August 2000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Desktop</td>
<td>RAMM data: Traffic data, Maintenance treatments and costs, Pavement structure (limited to some networks), Crash records, Geometrics</td>
<td></td>
</tr>
<tr>
<td>Initial Pavement Investigation</td>
<td>Asset Manager and / or Pavement Engineer</td>
<td>Determine most likely reasons of failure to determine suitable treatment</td>
<td><strong>Vehicle</strong> (30 - 50 kph) Network</td>
<td>Geological maps: Subgrade types</td>
<td>Draft NZ Supplement to Austroads Pavilion Rehabilitation - A Guide to the Design of Rehabilitation Treatment for Rural Roads (Austroads 2004)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Determine strength of existing pavement</td>
<td><strong>Specialised Equipment</strong></td>
<td>Economic Evaluation: Consider various treatments, Whole of life cycle costing (NPV calcs)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Visual inspection</strong></td>
<td>Map failure patterns: Cracking, Rutting, Flushing, Potholes, Identify Natural drainage paths, Map drainage systems, Locate and map services</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Deflection testing</strong></td>
<td>FWD on high speed road (rural), Benkelman Beam on low speed road (urban), Ground Penetrating Radar (if available)</td>
<td></td>
</tr>
<tr>
<td>Step</td>
<td>By whom</td>
<td>Purpose / Outcome</td>
<td>Where</td>
<td>Information gathered / Action</td>
<td>Literature / Manual</td>
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<td>------------------------------</td>
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<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| Initial Treatment Options    | Pavement Engineer        | Consider various treatment options and decide on required testing                 | Desktop     | Decide on Subgrade strength from the deflection testing  
  Calculate design loading (ESA) from traffic data and required design life  
  Carry out initial pavement design (estimate) for various rehabilitation treatments using assumed pavement strengths  
  Economic evaluation (benefit cost and whole of life cost) for various treatments | Austroads Pavement Design Guide (APDG), NZ Supplement to APDG, SH Economic Evaluation Manual |
| Detailed Pavement Investigation | Laboratory Technician and Pavement Engineer | Determine actual pavement composition and subgrade strength | On site     | Test pit: Pavement layers - type (general) & thickness  
  Subgrade Strength - Scalar Penetrometer  
  In Laboratory: General tests: Pavement layers - type (classification & moisture content)  
  Subgrade strength - CBR | Draft NZ Supplement to Austroads Pavement Rehabilitation - A Guide to the Design of Rehabilitation Treatment for Rural Roads |
| Initial Pavement Design      | Pavement Engineer        | Reduce treatment options to one                                                   | Desktop     | Consider available resources (aggregates, asphalt plants, bitumen plants, etc.)  
  Consider various treatments  
  Carry out pavement design - CIRCLY analysis  
  Economic evaluation (whole of life costs) to decide on one treatment | Austroads Pavement Design Guide (APDG), NZ Supplement to APDG, SH Economic Evaluation Manual |
| Laboratory Mix Design Testing | Laboratory Technician    | Determine binder content and achievable strengths                                | Laboratory  | Optimum Binder content  
  Physical properties of the stabilised material | New Zealand Guideline for sampling and mix design testing for stabilisation of pavement layers |
| Final Pavement Design        | Pavement Engineer        | Verify the initial pavement design                                                | Desktop     | Vary assumptions made in the initial pavement design  
  Repeat CIRCLY analysis if changes have been made  
  Compile Pavement Design Report | Austroads Pavement Design Guide (APDG), NZ Supplement to APDG |
| Construction Quality Assurance | Contractor & Engineer    | Do the work to the specification                                                  | Site and Laboratory |  
  Check construction: Addition of chemical stabilising agents  
  Addition of bituminous stabilising agents  
  Stabilisation depth  
  Compaction  
  Surface shape  
  Crossfall  
  Degree of Saturation | NZTA Specifications:  
  eg. TNZ B/5: Specification for In-Situ Stabilisation of Modified Pavement Layers |
|                             |                          |                                                                                  |             | Check physical properties: Compare field and laboratory (mix design) strengths achieved | New Zealand Guideline for sampling and mix design testing for stabilisation of pavement layers (not yet included) |
Overview

- History of Stabilisation Technology
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At project level the consultant will:

- Carry out investigations
  - Test Pits, Site inspection, etc.
- Collect the necessary data
  - FWD, GPR, BB, RAMM, etc.

To determine the mode of failure, for example:

- Rutting due to Shallow Shear (e.g. loading and/or moisture)
- Rutting due to Inadequate Pavement (SG Strain)
- Cracking due to fatigue of bound layers (e.g. TAS)
Consultant’s Intentions
Decide on Rehabilitation options

Existing Pavement:
- Shallow Shear in Basecourse

Rehabilitated Pavement:
- Rip + Aggregate Overlay
- Modify with either Cement or Lime or Foamed Bitumen
Consultant’s Intentions
Decide on appropriate binders

<table>
<thead>
<tr>
<th>Material Quality</th>
<th>Approximate PI</th>
<th>Binder</th>
<th>Content %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basecourse</td>
<td>&lt; 5%</td>
<td>Cement only</td>
<td>1 - 2%</td>
</tr>
<tr>
<td>Good Sub-Base</td>
<td>5 - 15%</td>
<td>Cement only</td>
<td>1.5 - 2.5%</td>
</tr>
<tr>
<td>Poor Sub-Base</td>
<td>15 - 25%</td>
<td>Cement &amp; Lime (50:50)</td>
<td>2 - 3%</td>
</tr>
<tr>
<td>Cohesive Soil only</td>
<td>&gt; 25%</td>
<td>Lime only</td>
<td>3 - 4%</td>
</tr>
</tbody>
</table>
Inadequate Pavement strength

Overlay + Foamed Bitumen Stabilise

Cement Bound SB + crack mitigation layer
### Consultant’s Intentions
Decide on appropriate binders

<table>
<thead>
<tr>
<th>Existing Pavement layer</th>
<th>Pre-Treatment</th>
<th>Primary Binder</th>
<th>Secondary Binder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material Quality</td>
<td>Plasticity Index</td>
<td>Type</td>
<td>Content</td>
</tr>
<tr>
<td>Basecourse</td>
<td>&lt; 7%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Good Subbase</td>
<td>7% - 15%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Poor Subbase</td>
<td>15% - 25%</td>
<td>Lime</td>
<td>≈ 3%</td>
</tr>
</tbody>
</table>

**Foamed Bitumen Modification:**

| Basecourse | < 7% | - | - | Cement | 4% - 5% | - | - |
| Good Subbase | 7% - 15% | - | - | Cement | 4.5% - 5.5% | - | - |
| Poor Subbase | 15% - 25% | Lime | ≈ 3% | Cement | 4% - 5% | - | - |

**Cement Bound Subbase:**

| Basecourse | < 7% | - | - | Cement | 4% - 5% | - | - |
| Good Subbase | 7% - 15% | - | - | Cement | 4.5% - 5.5% | - | - |
| Poor Subbase | 15% - 25% | Lime | ≈ 3% | Cement | 4% - 5% | - | - |
Consultant’s Intentions
Compare Pavements - Economics

Pavement Rehabilitation Examples

Existing Pavement

Design Load (DESAR)

Specification

50 mm overlay + 200 Cement Modification

350 k

NZTA B/5

50 mm overlay + 200 Foamed Bitumen Modification

2 million

NZTA B/5

200 Cement Bound Subbase + 100 UBG crack mitigation layer

4 million

NZTA B/6
### Relevant Notes for Tender doc. are available as a guide for the consultant

<table>
<thead>
<tr>
<th>Layer</th>
<th>Binders</th>
<th>In-Situ</th>
<th>In-Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modified Basecourse &amp; Sub-base</td>
<td>Cement Lime Foamed B. B. Emulsion</td>
<td>NZTA B/5</td>
<td>NZTA B/7</td>
</tr>
<tr>
<td>Bound Sub-Base</td>
<td>Cement / Lime</td>
<td>NZTA B/6</td>
<td>NZTA B/8</td>
</tr>
<tr>
<td>Subgrade</td>
<td>Lime Cement</td>
<td>NZTA B/9</td>
<td>N/A</td>
</tr>
</tbody>
</table>
In-Plant Stabilisation

Mobile and Stationary Pugmill Mixing Plants are being used in New Zealand – NZTA B/7 and B/8
In-Plant Stabilisation

Static Pugmill Plants
Interaction between Pavement Design and Laboratory Mix Design Testing

**Pavement Design**
- APDG 6.2 Unbound Materials
- APDG 6.3 Modified Materials
- APDG 6.4 Cemented Materials

**Mix Design**
- RLTT
- RLTT, UCS or ITS
- ITS, RL-ITS or UCS

**Binder Content**
- [% by mass]

**UCS [MPa] or ITS [kPa]**
- X
- Y
- Z

**Lightly Bound**
- ??

**Cemented**
Add and Mix Stabilising Agent:

Lime

Cement + Water

Foamed Bitumen + Water

Cement + Foamed Bitumen + Water

Pulverise

Compact and Finishing
Used for determine optimum “foam-water” content and for the mix design by varying the bitumen content.
1. Planning and Preliminary Investigation / Design Phase

- Historical Data, FWD, HSD, etc.
- Small test pits – grading and PI
- Preliminary rehabilitation pavement design

2. Tender Documentation Phase

- Clause 9.1 – “Preparation of Surface” - provides for identified pre-work (digouts of soft spots, etc.)
- Cause 9.2 – “Supply and placing of imported aggregates”
- Clause 9.3 – “Pre-treatment – provides for pre-hoeing if required
- Clause 9.4 – “Stabilising” – specify depth (mm) and application rate(s) (kg/m2) – based on preliminary test pits

3. Construction Phase

- Larger test pits while services are installed and while TM is set up
- Any variation to the initial assumed tendered binder rates can be adjusted by Clause 9.5 & 9.6 - “E/O for cementitious and bituminous binders”

Use appropriate clauses in Tender document – no surprises
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Method based Specifications

Binders and Water are specified

Spreading controlled by the forward speed of the spreader

Binders / Water injection controlled by the forward speed of the stabiliser

Compaction & Finishing adopted from NZTA B/2 with some refinement and risk of unknown transferred to the client
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Addition of chemical stabilising agent</td>
<td>Mat test: ± 0.5 kg/m²</td>
</tr>
<tr>
<td></td>
<td>Avg. use: ± 2.5 %</td>
</tr>
<tr>
<td>Addition of bituminous stabilising agent</td>
<td>Flow meter: ± 5 %</td>
</tr>
<tr>
<td></td>
<td>Avg. use: ± 2.5 %</td>
</tr>
<tr>
<td>Stabilisation depth</td>
<td>- 5 mm and + 15 mm</td>
</tr>
<tr>
<td>Compaction</td>
<td>Mean: ≥ 98 % of target MDD</td>
</tr>
<tr>
<td></td>
<td>Min: ≥ 95 % of target MDD</td>
</tr>
<tr>
<td>Surface Shape</td>
<td>10 mm with 3 m straight edge</td>
</tr>
<tr>
<td>Crossfall</td>
<td>± 0.5 %</td>
</tr>
<tr>
<td>Degree of Saturation before sealing</td>
<td>&lt; 80%</td>
</tr>
</tbody>
</table>

Requirements on in-situ stabilised basecourse layer – NZTA B/5
Successful Applications of Stabilisation around NZ

SH - Hybrid Maintenance contracts

SH - PSMCs

Heavily trafficked urban arterial roads for various City Councils

(\textit{DUSTLESS} addition of cement)

Heavily stressed yards

Alpine SH with freeze / thaw distress

Thank you for your attention