1. There is a lack of information on the performance criteria of modified stabilised materials.

2. Up to 70% of rutting can be determined to the base layers.

3. The Austroads tensile fatigue criterion is overly conservative.
Objectives – For Project

1. Determine the performance benefits of cement modified aggregates, filling a gap identified by Austroads;

2. Validate the benefits of Foamed Bitumen stabilised aggregates (Dr Saleh and South Africans);

3. Refine the transition between modified (unbound) and bound (cemented) behaviour;

4. Review the appropriateness of the Austroads tensile strain criterion for bound aggregates.
1. Lab Tests - Permanent Strain RLT, Unconfined Compressive Strength (UCS) and Indirect Tensile Strength (ITS).


CAPTIF Test 1 Gradation

- First H40 load
- Second H40 load
- AP5 dust
- CAPTIF mix

Material too coarse
Material too fine
Recommended envelope for foam bitumen

Percentage passing (%)

Particle size (mm)
CAPTIF Test 1 ITS Results

![Graph showing indirect tensile strength (kPa) vs. foam bitumen content (%) for CAPTIF 1% Cement, Laboratory 1% Cement, and CAPTIF 0% Cement. A Gaussian curve is fitted to the ITS values at 1% cement. Key points include B12C10, B14C10, B28C10, and B22C00.](image_url)
### CAPTIF Test 1 RLT Results

<table>
<thead>
<tr>
<th>Stage</th>
<th>Permanent Deformation (µε)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
<td>( \sigma_c = 67 ) ( \sigma_d = 100 )</td>
</tr>
<tr>
<td>Stage 2</td>
<td>( \sigma_c = 42 ) ( \sigma_d = 100 )</td>
</tr>
<tr>
<td>Stage 3</td>
<td>( \sigma_c = 90 ) ( \sigma_d = 180 )</td>
</tr>
<tr>
<td>Stage 4</td>
<td>( \sigma_c = 140 ) ( \sigma_d = 330 )</td>
</tr>
<tr>
<td>Stage 5</td>
<td>( \sigma_c = 110 ) ( \sigma_d = 420 )</td>
</tr>
</tbody>
</table>

Deformation increases with bitumen content for 1% cement.

Sample fails at: B28C10
• Springston Formation Greywacke
• Alluvial
• Clay stabilised
• Clay PI = 6
• Mix SE = 26
CAPTIF Test 2 UCS, ITS Results

Soaked UCS (MPa)

- 1 C
- 1.5 C
- 2 C
- 3 C
- 4 C
- 6 C
- 2 L

Binder Content %

Soaked ITS (KPa)

- 1 C
- 1.5 C
- 2 C
- 3 C
- 4 C
- 6 C
- 2 L

Binder Content %
CAPTIF Test 2 RLT tests
Subgrade Construction

58m circumference
18.5m centerline diameter
Concrete tank
  - 1.5m deep
  - 4m Wide (top)
Imported Clay subgrade
Typical CBR 8%
Pivot steer roller for compaction
Accelerated Loading

Operated 24 hrs
Unmanned 7 days
20,000 cycles/day
100,000 ESA/week (including testing)
1 wheel path
6x 10m test sections
Realistic measured dynamic loads
Standard HCV axles
Steel suspension
Response Measurement

Strain

NI Emu System

3D Strain Measurement
NI Emu System

Section A - Unbound

Vertical Compressive Strain (Microstrain) vs Depth (m)

- Basecourse
- Subgrade

Depth (m)

0 100 200 300 400 500 600

Vertical Compressive Strain (Microstrain)

-0 -1000 -2000 -3000

New Zealand Government
Dynamic Load Measurement
Variation in Loading

Load Variation with Loading Cycles

- Load Variation from Static (kN)
- Station
Pavement Strength

Industry Standards

- Falling Weight Deflectometer
- GeoBeam (Automated Full Bowl Benkleman Beam)
Transverse Profilometer

- Referenced to concrete tank wall
- Used for layer profiles
- Used to define straight edge rutting and vertical surface deformation (VSD)
CAPTIF Test 1 Rutting results

Average VSD (mm) vs Load Cycles

Loads applied:
- 40 kN
- 50 kN
- 60 kN

Graph showing the relationship between Load Cycles and Average VSD for different samples (B12C10, B14C10, B28C10).
CAPTIF Test 2 Rutting results
Basic Analysis

\[ y = 0.0107x + 1.4367 \]

\[ R^2 = 0.9436 \]
Field Study
Determine the benefits of using cement- and/or lime-modified aggregates

- 1% cement reduced rutting and improve the rutting life of the pavement by 200–300%.
- But stiffness loss occurred during this testing.
- Presented a design methodology that can be used with initial laboratory data to estimate the initial improvement in rutting.
- Further research needed into the implications of this stiffness loss in cement-only materials.
- Presented a wider approach that included Arnold (2012) NZTA research to address the stiffness loss.
Validate the benefits of foamed bitumen/cement-stabilised aggregates in terms of increased performance

- foamed bitumen with cement reduced rutting and created a 500% improvement in rutting.
- without any loss of stiffness (fatigue) during the project.
- The design methodology presented in the report can also be used for foamed bitumen.
- Presented a wider approach, including Arnold (2012) NZTA research, which explained why stiffness loss was not observed.
Objective 3

Understand the continuum from unbound (no binder), modified (small amounts of binder) to bound (high amounts of binder) behaviour.

- Bound behaviour clearly occurred at 3–4% cement contents.
- At 3% cement contents in the field, classical fatigue failures were observed.
- At CAPTIF 4% cement showed little rutting but significant losses of stiffness and stiffness tended to a value observed at 1% cement.
- Prudent limit for at 2% cement contents, (a soaked ITS over 600KPa when mixed and tested in the lab).
Objective 4

Review the appropriateness of the Austroads tensile strain criterion for bound aggregates

- The CAPTIF test and field study suggested Austroads is inappropriate for New Zealand.
- The South African approach appears better.
- Materials with 4% cement, tested at CAPTIF, led to a 1000% increase in rutting life compared with the unbound pavement, however there was significant stiffness loss.
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Cement & Concrete Association of New Zealand
Fulton Hogan
Hiway Stabilizers

**Supporters**
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Roading New Zealand.
The Aggregate and Quarry Association.