Maximising outcomes with material testing
Our values, our diversity

Customers first
Unleash potential
Be courageous
Ideas into action
Empower people

diversity
inspire create innovate
50% of our construction costs are for the materials we purchase

95% of TMR compliance testing now conducted by private industry.

The Contractor selects who provides this testing, and also pays for it.

This testing market is worth about $60 million
Testing low strength pavement materials

1. Some areas there are no economic sources of pavement materials that meet TMR specifications.
2. Low strength materials are available, which perform quite satisfactorily, if handled correctly (Western Queensland Best Practice Guidelines)
3. But the more they are worked, generally the worse they perform.
What does this mean for testing?

Two issues

1. The sample must represent the approximate makeup of the material at the time it is utilised in a pavement

2. The more a sample is worked, the more it degrades, there is generally no achievable final state.
What are these materials?

The test methods in use were developed specifically for low strength Sandstones, or as they have become known, “Winton Sandstones”.

The methodology may be appropriate for other low strength materials.

Where there is no local knowledge available - Geotechnical advice should be sought.
Why use these materials?

Not by choice!

In many areas of western Queensland there are no, or only limited, rock sources or natural gravel / loam deposits.

Cost of hauling better quality materials can be prohibitive.

What about design?
Traditionally pavements made of these low cost materials were 150mm subbase, 150mm base.
Sandstone
Sandstone
Sandstone
Sandstone
White rock
White rock
White rock
White rock
Sample preparation Q101E

Materials sourced from the pit must have a preparation process that mimics the breakdown caused by winning and placing the material on the road.

1. Q101E was originally developed as part of a suite of District test methods specifically to get consistent results from local low strength material known as Sandstone, later to become known as Winton sandstone (regardless of the area it was sourced).

2. All Material that has not been subjected to compaction in a pavement is pre-treated utilising this test method before testing.
Material Quality testing

Materials used in pavements are generally subjected to a suite of tests to prove their “quality”, this series of tests is Grading and Atterbergs (Liquid Limit, Linear shrinkage and Plastic index).

Low strength materials are subjected to only

• 1pt liquid limit
• Linear shrinkage
Do the differences matter?

1. Failure to undertake the preparation process for a material sampled from a pit, will give incorrect OMC and MDD values, a linear shrinkage result 2% or more lower than what is eventually obtained in the pavement.

2. Failure to follow the process for conducting the liquid limit test will mean the test is not repeatable, and the Linear shrinkage result obtained can vary wildly from what is eventually obtained in the pavement.
Expanding nuclear gauge testing

- Fewer sand replacement tests
- Greater use of nuclear gauges
Test methods

Nuclear Gauge Testing Manual
  • 2003 gate open to greater range of use

MRTS04 finally changed 2012 to allow Hilf
History

Traditional practice

- Earthworks – Sand replacement
- Pavements – Nuclear gauge
  - (sand replacement used in small projects)

Specifications (from late 80’s)

- Older MRS 11.04, 11.05 allowed for the use of nuclear gauges in earthworks
New Options

Wet density biasing

• Shall be used in pavements
• May be used in earthworks
• Should used in stabilised works (plant or insitu)
  o (cement, cement/fly-ash, lime, lime/fly-ash, lime/slag, foamed bitumen and so on)

Moisture biasing

• Always used
New Options

Wet density biasing
- Sand replacement (Q111A or Q141B)
- Nuclear gauge (unbiased) (Q141A)
- Nuclear gauge (biased) (Q141A)

Insitu moisture content
- Sand replacement (Q111A or Q141B)
- Oven dry (Q102A)
- Nuclear gauge (biased) (Q141A)

Reference density
- HILF (1 for 1) (Q142C)
- MDR (1 for 1) (Q142A or Q110A)
- MDR (assigned) (Q144A or Q110F)
# Nuclear gauge use options

<table>
<thead>
<tr>
<th></th>
<th>Earthworks MRTS 03/04</th>
<th>Reinforced Soil Structure/Backfill MRTS 06</th>
<th>Stabilised Pavements MRTS 07/08</th>
<th>Unbound Pavements MRTS 05</th>
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<tr>
<td>MDR (std)</td>
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<tr>
<td>Q142A (A/B mould) (1/1)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Q144A (assigned value)</td>
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<td>?</td>
<td>?</td>
<td>✓</td>
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<tr>
<td>Q142C (A/B mould) (1/1)</td>
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<td>? (×)</td>
<td>? (×)</td>
<td>×</td>
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<tr>
<td>NG wet density biased (N03)</td>
<td>?</td>
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<td>✓</td>
<td>✓</td>
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<td>NG MC biased (N02)</td>
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<td>NG wet density unbiased (N01)</td>
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<td>? (×)</td>
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<td>Oven MC (Q102A)</td>
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<td>✓</td>
<td>? (×)</td>
<td>No</td>
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<tr>
<td>NG wet density unbiased (N01)</td>
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<td>?</td>
<td>? (×)</td>
<td>No</td>
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<tr>
<td>NG MC biased (N02)</td>
<td>?</td>
<td>?</td>
<td>? (×)</td>
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</tbody>
</table>
New Options Earthworks

Other considerations

- Uniform materials – assigned value (Q144A)
- HILF
- Are moisture ratio’s required (%OMC)
How reliable is my test result?

1. Test results are not precise values
2. Why is there variation in test results?
Measurement Uncertainty?

1. Performance of the measuring device/s.
2. Number of measurements.
3. Repeatability / Reproducibility of the activity.
4. Varies between Laboratories and dependant on equipment and skills used in that Laboratory for that instance of testing.
Examples of Uncertainty 1

<table>
<thead>
<tr>
<th>Property to be Tested</th>
<th>Method Number</th>
<th>Sensitivity (eg Repeatability/ Error)</th>
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</thead>
<tbody>
<tr>
<td>Moisture content</td>
<td>Q102A</td>
<td>Fine materials ±0.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medium grained materials ±0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coarse grained materials ±0.3</td>
</tr>
<tr>
<td>Moisture content</td>
<td>Q141A (Q112)</td>
<td>±1.0</td>
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<tr>
<td>Particle size distribution</td>
<td>Q103A</td>
<td>±3.5</td>
</tr>
<tr>
<td>Liquid limit</td>
<td>Q104A</td>
<td>±1.0</td>
</tr>
<tr>
<td></td>
<td>AS1289.3.9.1</td>
<td>±2.0</td>
</tr>
<tr>
<td>Plastic limit and plasticity index</td>
<td>Q105</td>
<td>±2.0</td>
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<tr>
<td></td>
<td>AS1289.3.3.1</td>
<td>±4.0</td>
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<tr>
<td>Linear shrinkage</td>
<td>Q106</td>
<td>±1.0</td>
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<tr>
<td></td>
<td>AS1289.3.4.1</td>
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Examples of Uncertainty 2

<table>
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<th>Property to be Tested</th>
<th>Method Number</th>
<th>Sensitivity (e.g., Repeatability/Error)</th>
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<tbody>
<tr>
<td>Dry density/moisture relationship (MDD/OMC)</td>
<td>Q142A (Q110A)</td>
<td>MDD ±2.0% of reported value OMC ±10.0% of reported value</td>
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<tr>
<td>Compacted density</td>
<td>Q141A (Q112)</td>
<td>MDD ±0.04 t/m³</td>
</tr>
<tr>
<td></td>
<td>Q141B (Q111A)</td>
<td></td>
</tr>
<tr>
<td>Relative compaction</td>
<td>Q140A (Q111C)</td>
<td>±2.5</td>
</tr>
<tr>
<td>Degree of saturation</td>
<td>Q146 (Q111D)</td>
<td>±10</td>
</tr>
<tr>
<td>California bearing ratio</td>
<td>Q113A 4pt AS1289.6.1.1 1pt</td>
<td>±50% of reported value</td>
</tr>
<tr>
<td></td>
<td>Q113C 1pt AS1289.6.1.1 1pt</td>
<td>±80% of reported value</td>
</tr>
<tr>
<td>Flakiness index</td>
<td>Q201A</td>
<td>±3</td>
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<tr>
<td>Ten percent fines value (wet)</td>
<td>Q205B</td>
<td>±30</td>
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<tr>
<td>Degradation factor</td>
<td>Q208B</td>
<td>±5</td>
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</tbody>
</table>
What about Characteristic Values?

1. Characteristic values are derived from multiple test results.
2. What is the measurement of uncertainty of a Characteristic Value?

Measure of Uncertainty of a Characteristic Value = Single Test MU \times \frac{1}{\sqrt{n}}

where n = number of tests used to determine the mean
What about Characteristic Values?

Measurement of Uncertainty
of a Characteristic Value = Single Test MU x \( \frac{1}{\sqrt{n}} \)

where \( n = \) number of tests used to determine the mean

Compacted density individual test MU is approx 1.5%

- If \( n = 3 \) then the CV mu is 0.87%
- If \( n = 9 \) then the CV mu is 0.5%
Importance of control charts

1. Control charts plot results against timeline
2. Show if process is in control or not
3. Highly valuable tool in interpreting test results
4. Gives a higher level of confidence
5. Allows informed decision making
What is a Control Chart?

- The charting of data from all individual test results in chronological order to determine if the process is under control.
- Include all data (even from failed lots)
- Avoid using Characteristic Values where possible.
Integrity of Private Testing Suppliers

% of Samples with Non Conformances

Plant 1
- Auditor Present
- No Auditor Present

Plant 2
- Auditor Present
- No Auditor Present

8 September 2017
Normal Distribution

1. Test results should show a normal distribution*. (Bell Curve)
2. Failure to do so is an indicator fraudulent activity might be occurring
Normal Distribution

1. Fairly typical histogram of compaction on a project.
Normal Distribution

1. Histogram of first 100 compaction results on a project.
2. Specification limit = 95%
Generation of test results

Why make up test results?

- Save time and money
- Cover up non conforming product
- Reduce / eliminate rework
- Reduce / eliminate applied financial penalties
- Pressure from Contractors
- Pressure from within the organisation (where testing is completed internally)
How wide spread is it?

We don’t know for sure but our results indicates it is a problem in some parts of the CMT industry.

- Many more defects are reported when surveillance officers are witnessing testing (1.5 to 2 times as many.)
- Raw counts in nuclear meters don’t match reported results
- Statistical analysis showing saw tooth “bell curves”
- Multiple instances of manufacturing test results uncovered
How are they doing it?

Until recently, it was thought “cheating” was being done manually by adjustment of numbers during testing. The previous examples are all thought to be simple manual adjustment.

- There have been rumours for many years of software systems that are back calculating raw data to support a desired test result, but we have never found evidence of it – until recently.
Cheating Software

3 different software systems discovered in last 12 months

- Queensland – January 2016
- Northern Territory – March 2016
- Victoria – May 2016
Qld - SuperDuper Dee4 V1.4.4

The software was Excel spreadsheet based, but very sophisticated.

- Version number
- Generates results for most TMR and AS test methods used for road construction compliance.
- Tracks resources so lab equipment can’t be in use for two tests at once
- Tracks staff so they are not “overused”
### CBR

<p>| | |</p>
<table>
<thead>
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<tr>
<td><strong>CBR - 2.5mm</strong></td>
<td><strong>90</strong></td>
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<tr>
<td>Load</td>
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<tr>
<td><strong>CBR - 5.0mm</strong></td>
<td><strong>120</strong></td>
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<tr>
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**Note:** Only input data in BLUE cells.

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<tbody>
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<td><strong>MDD</strong></td>
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<tr>
<td><strong>OMC</strong></td>
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<td>2</td>
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<tr>
<td><strong>Mould #</strong></td>
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<td>2</td>
</tr>
<tr>
<td><strong>Cure Moist</strong></td>
<td>3.9</td>
<td>2</td>
</tr>
<tr>
<td><strong>Top 30</strong></td>
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<td><strong>% Dry Density</strong></td>
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</tr>
<tr>
<td><strong>% Wet Density</strong></td>
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<td>2</td>
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<td><strong>Water Required</strong></td>
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<td>2</td>
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<td><strong>Date</strong></td>
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<td><strong>% Dry Density</strong></td>
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<tr>
<td><strong>% Wet Density</strong></td>
<td>100</td>
<td>2</td>
</tr>
</tbody>
</table>
Perspective?

Is this in wide spread use?
Is it being used to undercut CMT Suppliers doing the right thing?

We don’t know – but

Northern Territory government and NATA were given a copy of a different software system.

Then NATA came across yet another software system in Victoria.

3 different versions of this type of software are now known to exist.
Savings? (Jan 2016 prices)

- Gradings - $80 to 115
- Moisture content - $20
- 5pt liquid limit – $75 to 145
- 4pt soaked CBR - $350
- Field density – nuc $40 to 50 ; Sand $50 to 70
- Moisture Density relationship - $100 to 130

But peanuts compared to construction costs – one failed lot of asphalt can be worth $100,000
Our Obligations

We run a CMT Supplier registration system that requires the use of qualified and competent staff undertaking compliance testing in an ethical manner.

Firstly we do this to ensure the people of Queensland are getting what they are paying for. Not just the testing service, but of course the product.

Secondly we have an obligation to those whom follow our requirements, to ensure we do not enable / reward those whom do not (those whom cheat).
How do we meet our obligations?

By conducting surveillance and audit of CMT Suppliers to ensure ethical behaviour and competency.

Monitoring of test data on projects (control charts, statistical analysis).

Not accepting quotes for testing significantly under normal market rates.

Ensuring any compliance testing done is only by approved CMT suppliers.

We must try and protect CMT Suppliers from undue influence.
National Association of Testing Authorities
NATA

• Conducts 3 yearly technical assessments.

• Sets experience and qualification requirements

CMT industry is highly casualised with some facilities having 100% staff turnover in 12 months.
Surveillance = Risk Management

• To manage risk you need to:
  ✓ Identify & understand the risk
  ✓ Determine who is responsible
  ✓ Plan to mitigate the possible consequences of that risk
MoU TMR and NATA

• TMR working and sharing data with NATA.
• NATA accreditation in TMR specifications.
• Joint audit regime.
• NATA sanctions apply to all testing a facility may undertake for any client.
How do we deal with this?

- Conditions applied to Registration
- Suspension of Registration
- Reporting issues to NATA
- Joint audits with NATA
- Forming relationship with Industry Body - AGTA
- Protecting CMT Suppliers who do the right thing, by acting on those who do the wrong thing.
BUT –
it all comes down to Contract Administrators

Description:
General fill Final lift - (Embankment A) Ch 9860 - 10040

Location: Compliance test results failure.

Severity: ☑ Minor

Related Parties: Environmental or Conditions

Action: ☑ Use as is

3rd Party Approval Req’d?: ☑ Yes

Description of Non Conformance
Compaction CV failure 91.8%, As Per MRTS04 - Table 15.3-B – Density requirements which is CV = 95%
Field Moisture Content being a factor in some results cause of failure of CV.

Corrective Action: (What immediate action will be taken to correct the work)
Leave as is - Area will be reworked by another others at a later date.

Preventative Action: (What action will be taken to prevent it from reoccurring)
Ensure sufficient compaction of layers to comply with MRTS4 Table 15.3-B – Density requirements, also monitor moisture content of material during compaction works.

Raised By - Signature

Internally Approved (sign.)

Print Name:  

Date: 16/8/2017 

Approval Comments: