Waterproofing of natural materials to improve bearing capacity

An investigation into testing the in capillary rise of water into a soil with the use of soil stabilisation

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Supporting Organisations

AustraBlend®

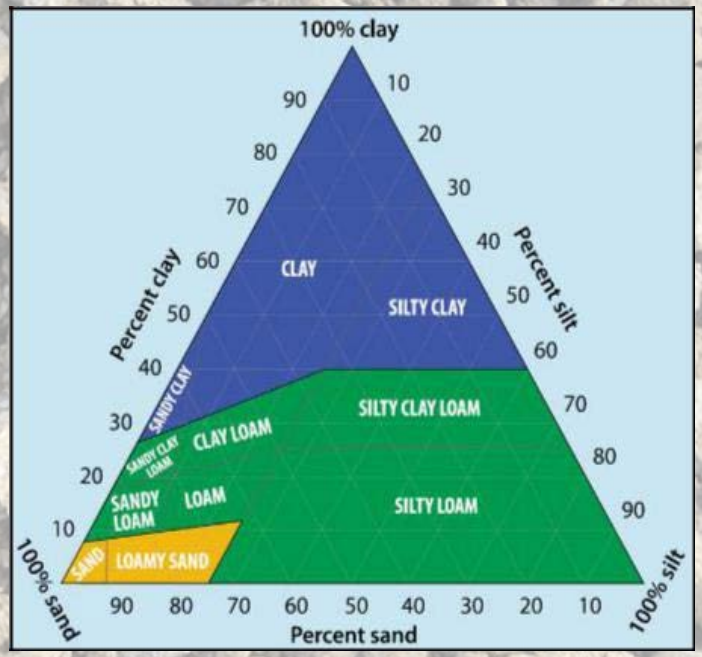
Brisbane City Council

Pavement Management Services

University of the Sunshine Coast
Queensland, Australia

Principles of Soil Stabilisation

- Various methods for modifying the properties of a soil to improve its engineering performance.
- Most common application being in the construction of road pavements
- Take advantage of unsuitable material
- Transform soil to conform to the standards.
- Corrective treatment unsuitable soils
- Preventive measure against adverse conditions



Project Overview

- The University of the Sunshine Coast was approached by Consolid Australia to evaluate two products for the beneficiation of subgrade materials in road constructions
- A bench top study and laboratory evaluation was conducted in 2015 by Sam Fitzpatrick
- This Laboratory result concluded that there was merit in the products and should proceed to a field trial
- A pilot study site was conducted at the Brisbane City Council's Bracalba Quarry to trial and investigate the products and their benefits in the field
- Pavement testing was used to analysis the performance of the site
- The site was installed with Moisture gauges to monitor the fluctuation in moisture

Consolid System

The CONSOLID System encompasses the use of CONSOLID 444 and SOLIDRY. This method is recommended for wet clayey/silty soil and flooded areas

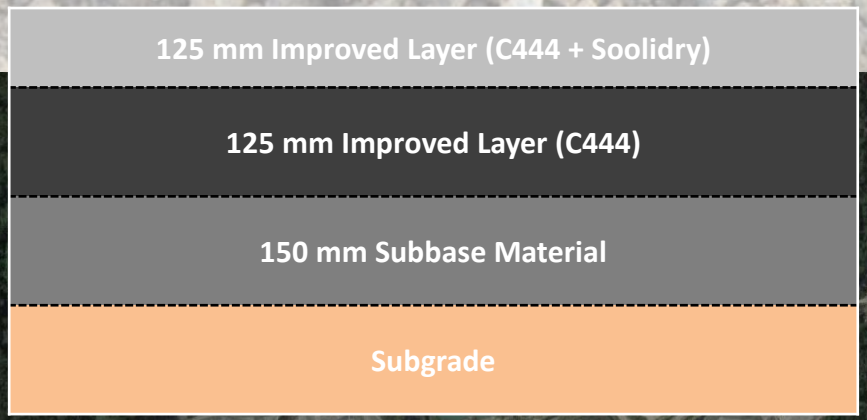
- Consolid 444 (C444)
  - Reduced resistance to compaction
  - Reduced rising of capillary water
  - Reduced permeability
  - Mixed with water
  - Applied at a rate of 0.4 to 0.8 L/m3
- Solidry
  - Applied to the top of the pavement, pre-treated with C444
  - Dry powdered product and is applied at a rate of 0.5 to 1% by weight of soil
- Effective uses
  - Pavements
  - Air dried soil bricks
  - Erosion control

Consolid 444 solution

Solidry powder

Site Location

Trial Site Pavement Profile



Control Site Pavement Profile

- Description
  - The Site is located at the Bracalba Quarry, Daguilar, Queensland (West of Caboolture between Caboolture and Woodford)
  - The road is primarily used as an access road for entry to and from the quarry site
- Trial site
  - Utilized as the entry to the quarry site
  - Treated with Consolid system (C444 + Solidry)
  - Length: 30 m
  - Width: 8 m
- Control site
  - Utilized as the exit from the quarry site
  - Untreated and undisturbed high quality (2.1) granular material
  - Length: 30 m
  - Width: 8 m

The Trial site and Control site are situated parallel to each other.

Material Treatment

Road Construction

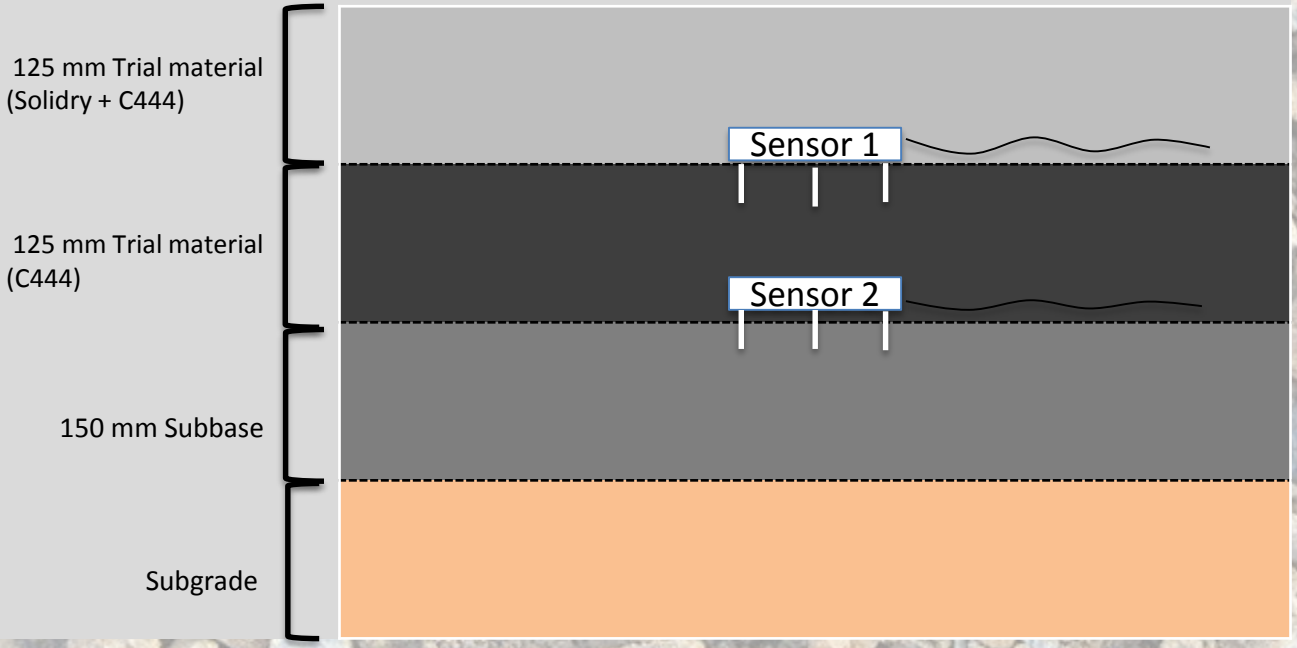
Final Product

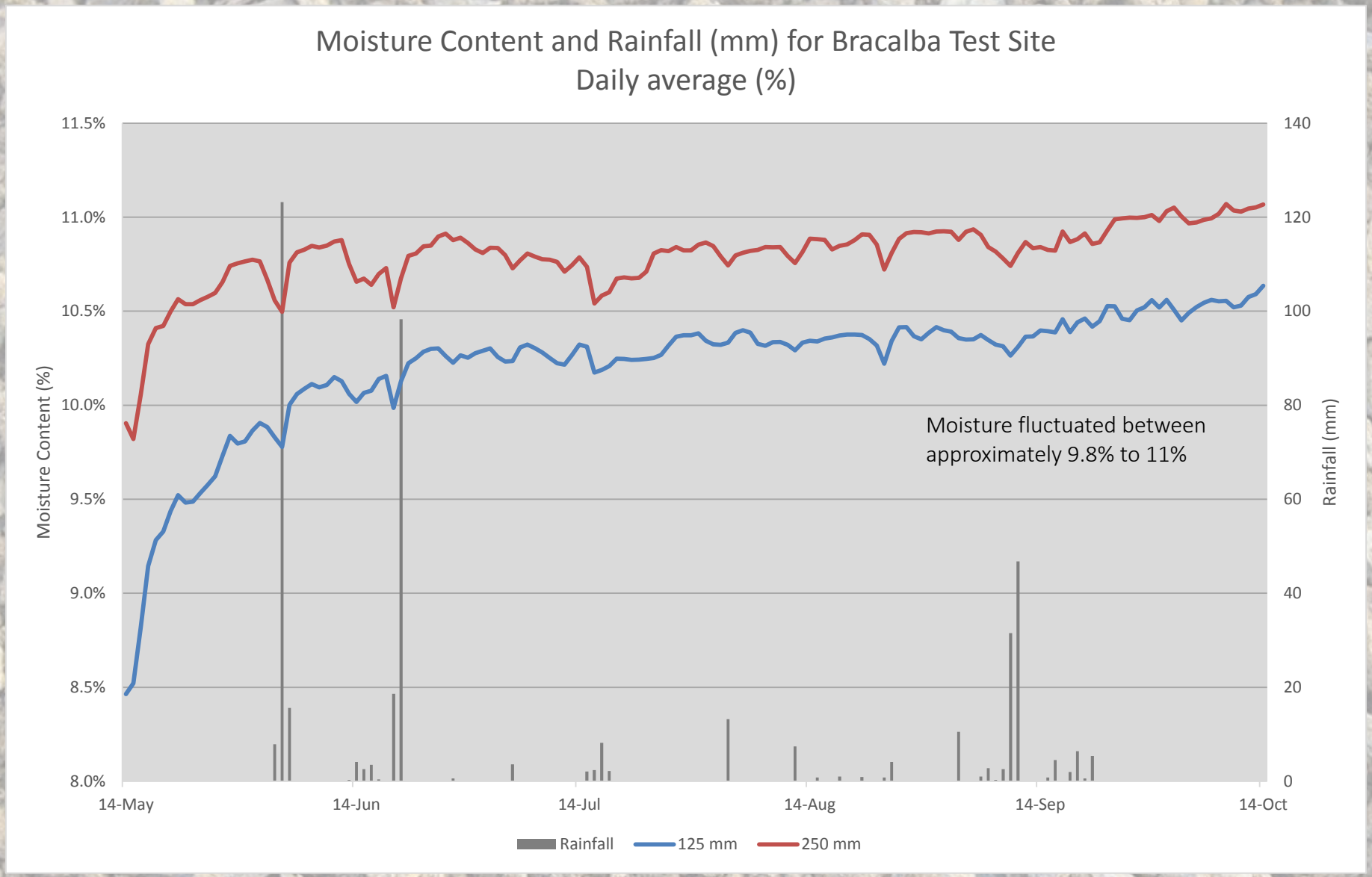
Quality Control

- Moisture Content
  - Continuously observed throughout the treatment and construction process
  - Achieved by a portable moisture sensor
  - Moisture had to range between optimum or slightly above
- Compaction
  - Over compaction was observed which resulted in surface cracking
  - Corrected by wetting the surface and re-compacted
- Consolid system
  - C444 was measured out prior to application by Austrablend and contained in known quantities in drums
  - Powder was also measured out by the trial site size prior to application

Soil Monitoring

- Moisture Gauges
  - The 1st was fitted in the middle of the layer at (125 mm)
  - The 2nd was fitted at the bottom of the section (250 mm)
  - An auger was used to provide a means of installation
  - Sensors provide dielectic, temperature and electric conductivity readings of the soil

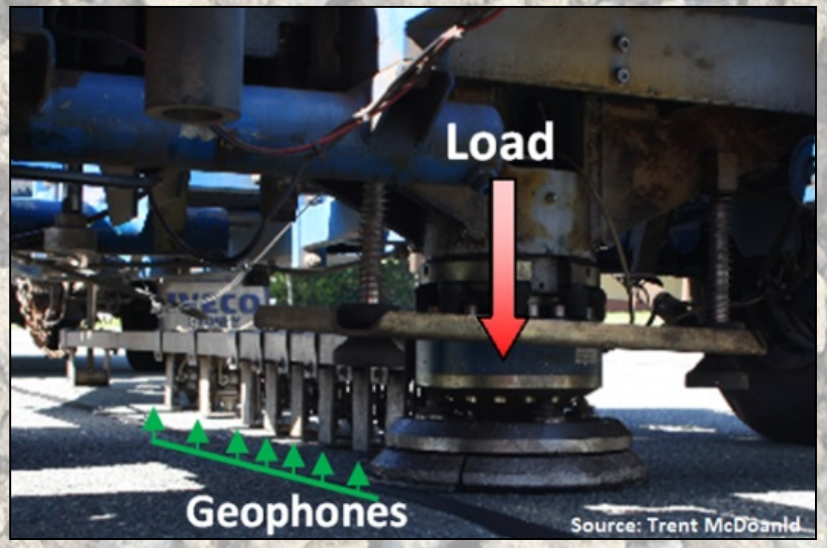




$$VWC\left(\frac{m^3}{m^3}\right) = 5.89\,x\,10^{-6}E^3 - 7.62\,x\,10^{-4}E^2 + 3.67\,x\,10^{-2}E - 7.53\,x\,10^{-2}$$

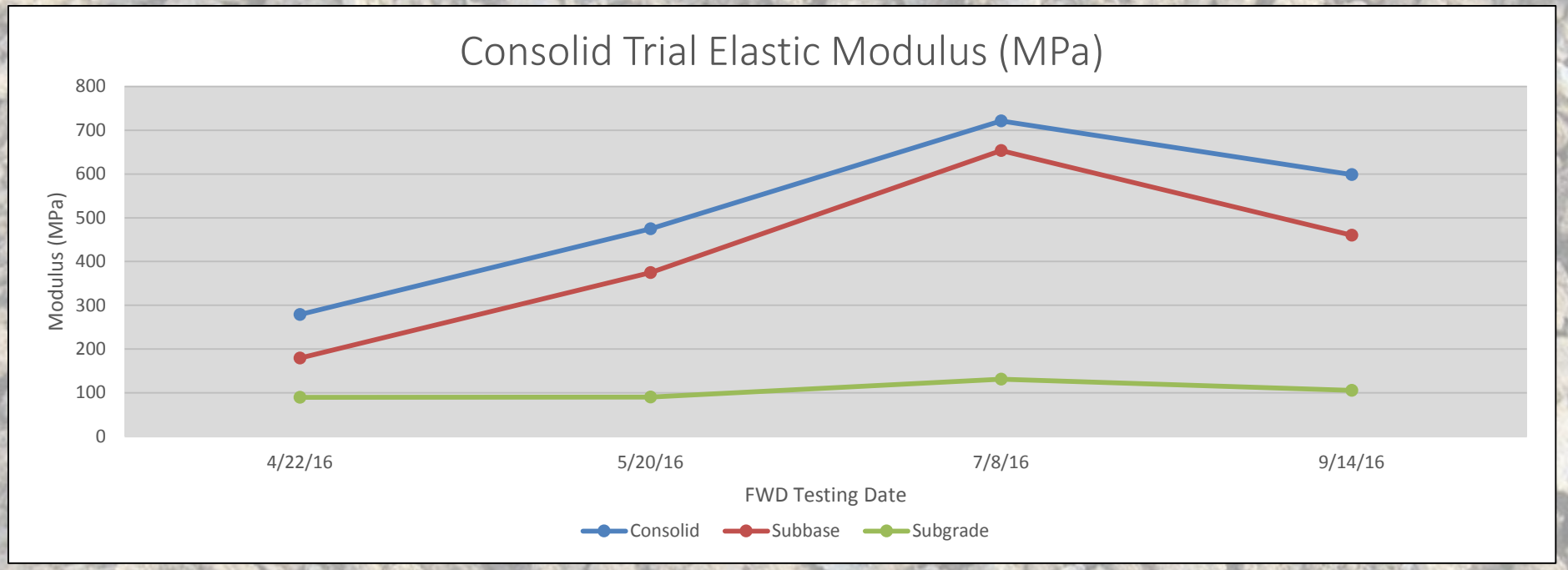
Pavement Testing

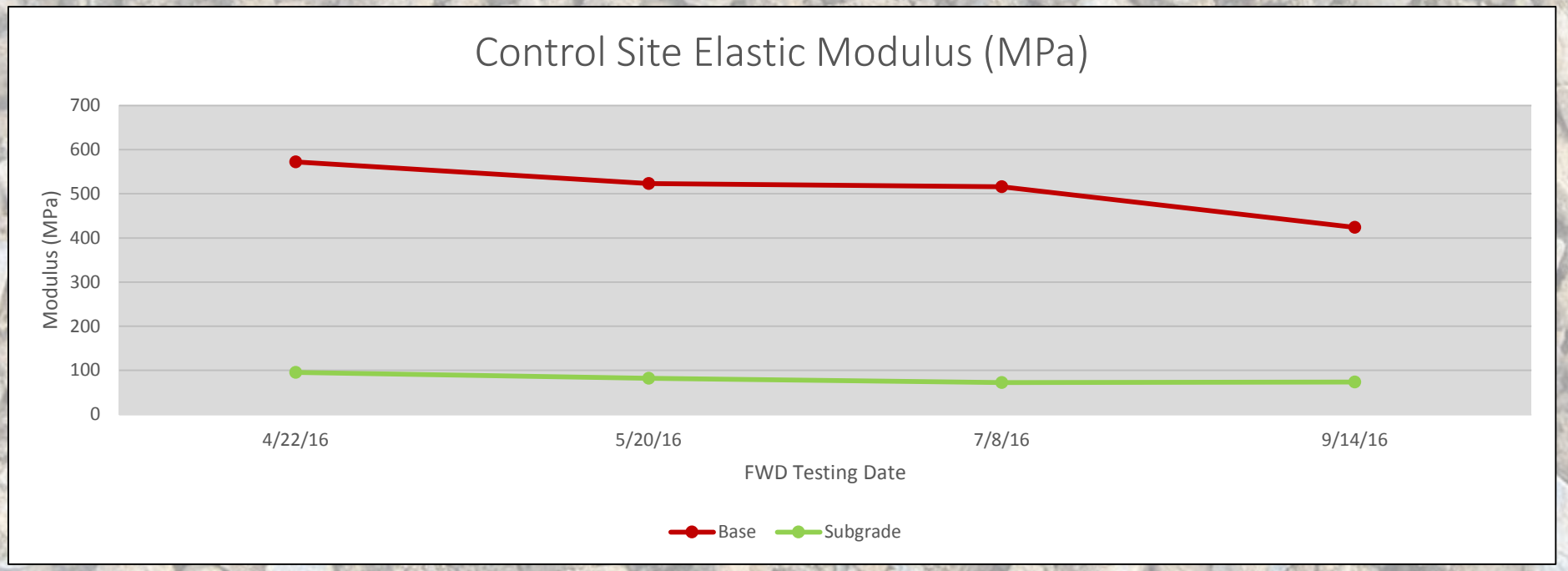
- Falling Weight Deflectometer
  - Measures Pavement Response to Loading.
  - Deflections Measured at 9 locations from the Load.
  - The surface of the pavement performs a deflection bowl under the load
  - Deflection depends on the stiffness of the modulus of the subgrade reaction
  - Used ELMOD6 for Back-calculation analysis of Pavement Layer Modulus.
  - Moduli of pavement layers is calculated from the deflections measured by the FWD testing
  - Evaluation of pavements by means of non-destructive testing



Pavement Testing

- Falling Weight Deflectometer
  - The tests were conducted at the Bracalba Quarry site four separate occasions by Pavement Management Services:
  - The dates these occurred:
    - 22nd April
    - 20th May
    - 8th July
    - 14th September
  - Testing occurred on the **Trial site** and a **Control site**
  - Control site established a quality control of the testing equipment


Consolid Trial Elastic Modulus (MPa)
800
700
600
500
400
300
200
100
0
Modulus (MPa)
4/22/16
5/20/16
7/8/16
9/14/16
FWD Testing Date
Consolid
Subbase
Subgrade

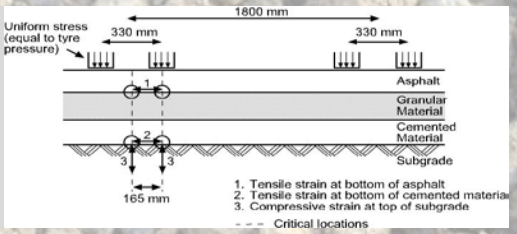

Control Site Elastic Modulus (MPa)
700
600
500
400
300
200
100
0
Modulus (MPa)
4/22/16
5/20/16
7/8/16
9/14/16
FWD Testing Date
Base
Subgrade

Standard Axle Repetitions (SAR's)

Permanent Deformation of Subgrade

$$N = \left(\frac{9{,}300}{\mu\varepsilon} \right)^{7}$$

Where:
N = Number of Cycles Till Failure
με = Compressive Microstrains



Control Site Test	1	2	3	4
Base - Modulus (Mpa)	572	523	516	424
Subgrade - Modulus (Mpa)	95	82	73	73
SAR's	4.31E+09	1.90E+09	1.20E+09	5.98E+08

Treated Site Test	1	2	3	4
Base - Modulus (Mpa)	279	475	721	599
Subbase - Modulus (Mpa)	180	374	654	460
Subgrade - Modulus (Mpa)	89	90	131	106
SAR's	1.80E+08	1.19E+09	2.45E+10	4.53E+09

Discussion

- Previous Laboratory test results
- Water truck spray rate approximately 2 Litres/m^2
- Increase Optimum Water Content
- Austroads Type 2.5 unbound material
- Increase in Modulus over testing
- Approximately 350 Heavy Truck movements daily
- Minimal deformation or erosion

	Un-stabilised M_R (MPa)	Stabilised M_R (MPa)	Difference (%)
Image Flat 2.5	646	538	-16.70%
Obi Obi Overburden	471	637	35.23%
Moy Pocket 2.3	494	316	-35.99%

Conclusion

- Field results support the previous Laboratory results
- The modulus increased over the period of monitoring and testing
- Field results show that a low quality granular material can achieve a high modulus
- The Control site showed consistent results
- Moisture content is not greatly affected rainfall or other water effects

Recommendations

- Establish a control site with the same material
- Conduct dynamic modulus testing on the Type 2.5 Granular material
- Continued site inspections to monitor performance
- Continue Falling weight deflectometer testing at the trial and current control site
- Boreholes to determine accurate pavement profiling
- Monitor moisture sensors
- Further studies should continue up to two years on the site to determine its performance

I would like to thank all those involved with supporting me through my studies and particularly those have have assisted with my final year honors research project.

Any Questions?

References

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