B/09 & Beyond
A Stabilised Platform for Performance Pavements

Allen Browne

Hiway Stabilizers

NZ Transport Agency & NZIHT
20 ANNUAL CONFERENCE


You can't build a great
building on a weak foundation.
Gordon B. Hinckley
quotefancy
or ROAD

Stabilisation of Subgrade & Soils Conditioning

Why Stabilise Soils?..............

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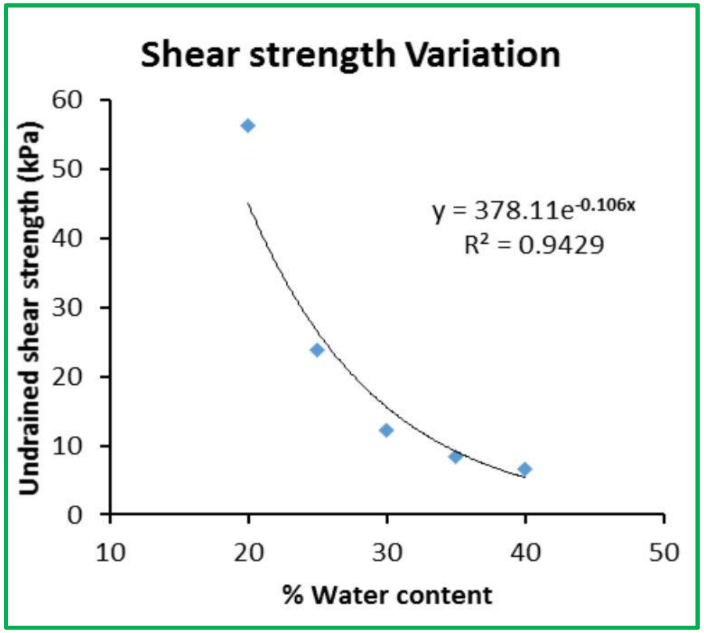
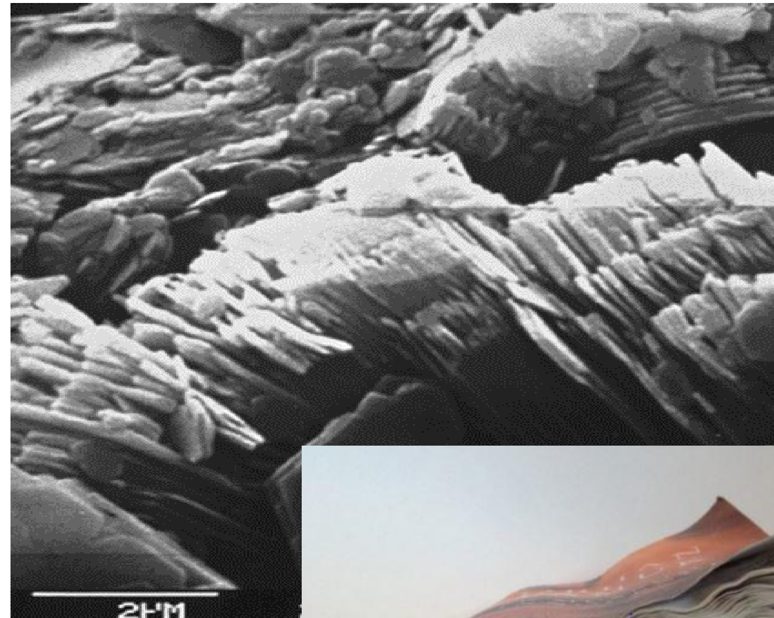
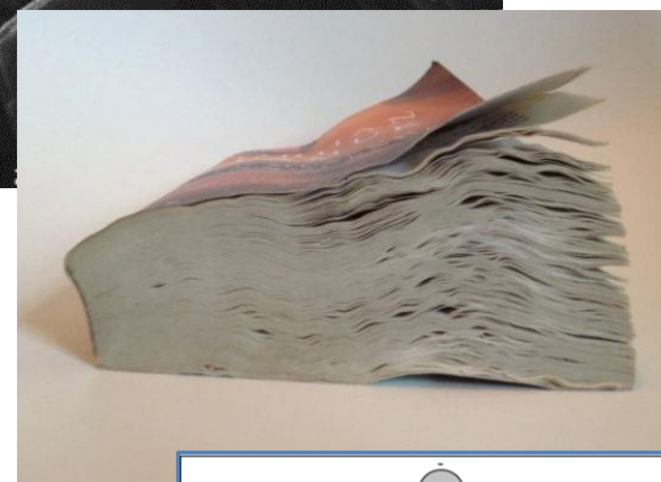
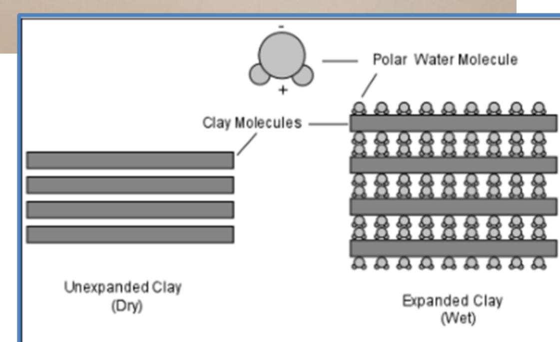
Strength – lets have some more

Why Stabilise Soils?..............





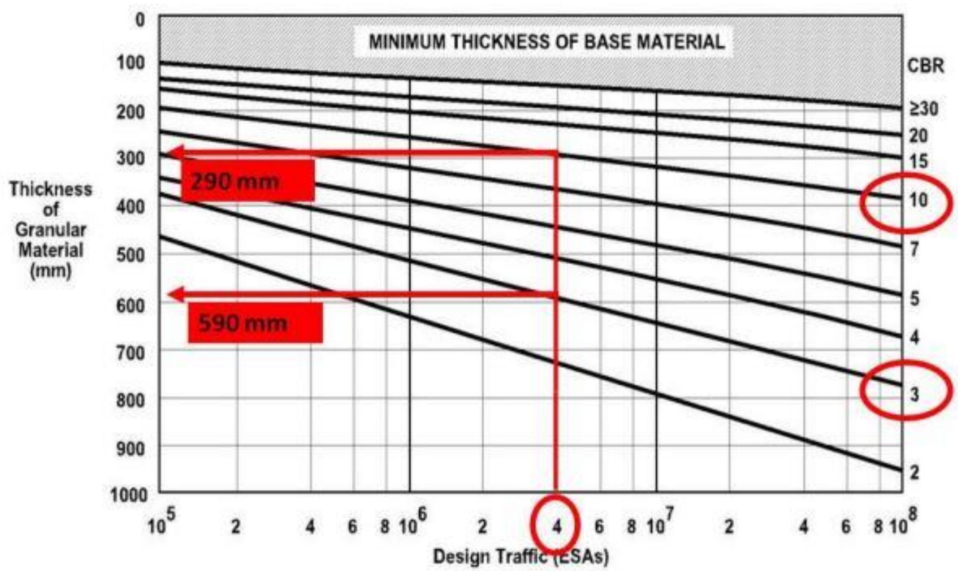


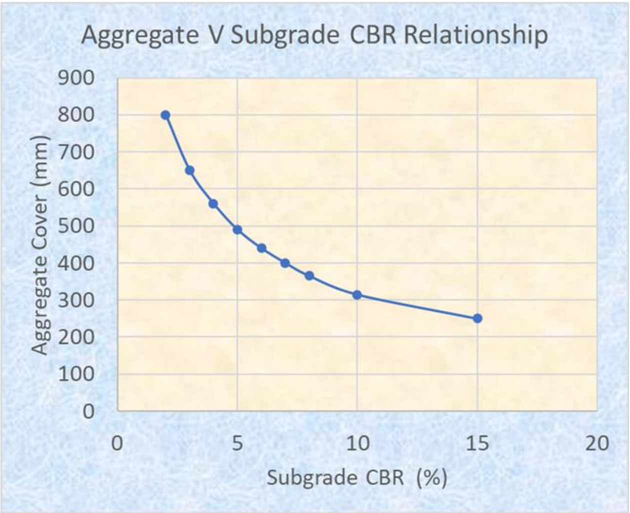


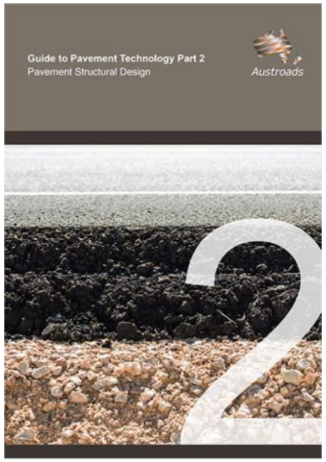
Moisture Sensitivity

- Soil loses strength upon ‘wetting’
- Clay huge surface area - holds more water than sands
- Wetting/winter = substantial strength reduction

Why Stabilise Soils?..............







Pavement Structure Benefits

- Weaker Subgrade = More aggregate for same capacity
- Stronger subgrade = better construction anvil

  = lower pavement deflection/ curvature

Plant Evolution, but Specifications?

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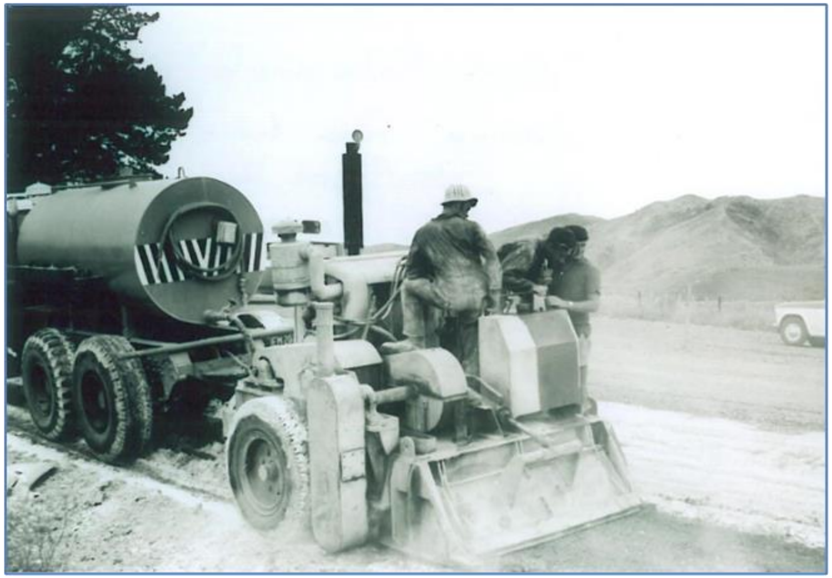


WAKA KOTAHI
NZ TRANSPORT AGENCY

PILOT NZTA B/09P:2020

PILOT SPECIFICATION FOR IN- SITU SUBGRADE STABILISATION

1. SCOPE

This specification shall apply to the in-situ stabilisation of subgrade layers comprising either natural in situ soils, imported fill materials or a combination of both using cement, lime or a combination of these.

The subgrade layer(s) shall be constructed in accordance with the levels, grades and cross-sections shown in the drawings of the Project Specifications.

Before using the in-situ stabilisation specifications, the user needs to be aware of the aim of the stabilisation activity to understand what the stabilisation activity is intended to achieve. This specification covers subgrade stabilisation, aiming at reducing moisture content, reducing water susceptibility; provide a homogeneous substrate for overlying pavement layers and to increase the shear strength of the material being treated.

2. DEFINITIONS

Definitions of terms that are used in these specifications are described in the Notes to these Specifications.

NZTA B/09 Pilot Specification for In-Situ Subgrade Stabilisation - 2020

Waka Kotahi note re Subgrade Stabilisation:

- Effective techniques to reducing resource use.
- No standard procedure an impediment to widespread use.
- Already a viable design option in pavement design via AGPT
- PM's should ask Designers what consideration given to Insitu SG Stab in developing designs

Pilot NZTA B/09: 2020

Direction regarding:

- Stabilising Agents
- Water
- Plant for Spread/Water/Mixing
- Construction Temp/Time
- Production plan
- Spreading/Slaking/Mixing/Compaction
- Acceptance Criteria
- Basis for Payment

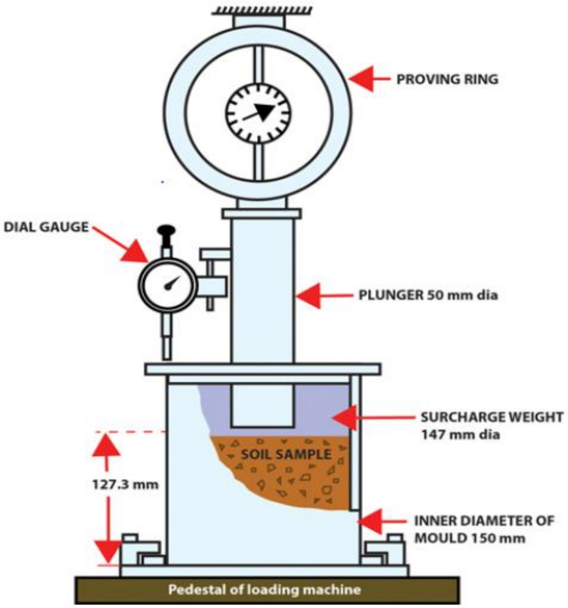
Method based – not performance, due to soils variability

Minimum standards & acceptance criteria

Pilot NZTA B/09: 2020 – Missing?

7.1.3 Design Strength

It is assumed that sufficient testing has been undertaken to confirm that the permanent strength and durability of the stabilised material will achieve (or better) the required design parameters. Of particular importance is to determine the range of water content within which the subgrade soil(s) can be stabilised with the selected stabilising agent dosage to achieve the required design strength / durability properties.



B/09 doesn't outline how to determine binder content

- Need to sample representative materials and test extremes
- Lime demand
- Knowing design target strength helps optimise binders
- Lab to field (remoulded soaked – relationship to optimum moisture, mixing, anvil, consistency of spread/materials)

Pilot NZTA B/09: 2020 – missing?

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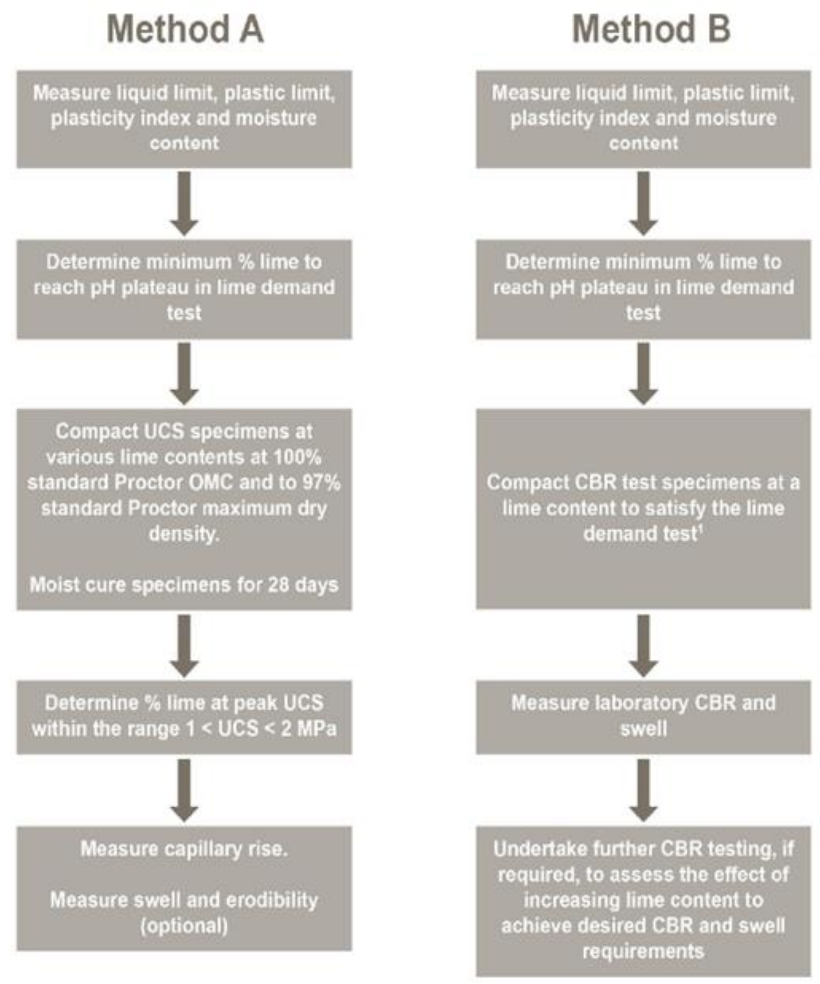
Table 2.4: Preliminary selection of binder/additive type

Particle size	More than 25% passing 75 µm sieve			Less than 25% passing 75 µm sieve		
Plasticity index (PI)	PI ≤ 10	10 < PI < 20	PI ≥ 20	PI ≤ 6 & PI x %passing 75 µm ≤ 60	PI ≤ 10	PI > 10
Binder type						
Cement and cementitious blends[1,3]	Usually suitable	Doubtful	Usually not suitable	Usually suitable	Usually suitable	Usually suitable
Lime	Doubtful	Usually suitable	Usually suitable	Usually not suitable	Doubtful	Usually suitable
Bitumen	Doubtful	Doubtful	Usually not suitable	Usually suitable	Usually suitable	Usually not suitable
Bitumen/ lime blends	Usually suitable	Doubtful	Usually not suitable	Usually suitable	Usually suitable	Doubtful
Granular	Usually suitable	Usually not suitable	Usually not suitable	Usually suitable	Usually suitable	Doubtful
Dry powder polymers	Usually suitable	Usually suitable	Usually unsuitable	Usually suitable	Usually suitable	Usually not suitable
Other proprietary chemical products[2]	Usually not suitable	Usually suitable	Usually suitable	Usually not suitable	Doubtful	Usually suitable

1. *The use of some chemical binders as a supplementary addition can extend the effectiveness of cementitious binders in finer soils and soils with higher plasticity.*
2. *Should be taken as a broad guideline only. Refer to trade literature for further information.*
3. *TMR uses triple blend and have a method based on % passing 0.425 mm sieve and linear shrinkage (Volker & Hill 2016).*

Stabilised Subgrade Mix Design - Australia

AGPT04D-19 Section 4.8 Lime Content Mix Design Process



1. *CBR test procedures vary between road agencies in relation to moisture content and density of CBR specimens and soaking prior to testing.*

Method A – UCS Approach:

- Lime content UCS 1 < UCS ≤ 2 (28 day cure)
- Favoured by TMR Queensland
- TMR Note 151 Testing Materials Lime Stab(2018d)

Method B – CBR Approach:

- Measure CBR / Swell% for use in design
- This method favoured by RMS, VicRoads & NZ
- COP RC 500.23 Lime Stabilised Earthworks Materials – Available Lime, Assigned CBR & Swell (Vicroads 2016)

Stab SG - Design Guides / Specifications

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Many documents - both stand alone or supplementary to Austroads

AGPT04D-19 Guide to Pavement Technology Part 4D Stabilised Materials

Other Australasian documents:

- AustStab – Pavement Recycling and Stabilisation Guide (2nd Ed 2015)
- AustStab - Specification for the Insitu Stabilisation of Subgrade Using Lime for Main Roads
- AustStab - Specification for the Insitu Stabilisation of SG & Pave Mat Using Lime for Local Govt Roads
- Qld - MRTS07A Insitu Stabilised Subgrades using Quicklime or Hydrated Lime. July 2019
- Qld - MRTS07B Insitu Stabilised Pavements using Cement or Cementitious Blends
- VicRoads RC 301.04 – Lime Stabilised Earthworks Materials - Available Lime, CBR and Swell
- NSW – Roads Maritime Services - QA Specification R50 Stabilisation of Earthworks
- WA – MRWA Specification 501 - Pavements
- SA – Dept Planning Transport & Infrast. Supplement to Austroads GPT Part 2: Pavement Struct Design
- NZ - Pilot Stabilisation Specification NZTA Webpage B/9

Stabilised Layer – Affected by Support

Mix Design / Binder Content established - Now Dep Layer Properties

Sets maximum top sub-layer modulus / sub-layering.

Ensures design represents field conditions.

*Stabilised top sub-layer Modulus is **least** of:*

~~1) Maximum 15%~~, 2) ~~Presumptive Values / Empirical Experience~~ **or**

3) Function of support via Eqn's 39 & 40 as follows:

Max Permissible $\text{CBR}_{\text{STAB LAYER}} = \text{CBR}_{\text{underlying material}} \times 2^{(\text{STAB LAYER THICKNESS} / 150)}$ (39)

$$R = \left[\frac{E_{V \text{ material top sublayer}}}{E_{V \text{ underlying material}}}\right]^{\frac{1}{5}} \quad (40)$$

I.E.: Stabilised CBR = 10 @ 250mm thick over CBR 2 = $2 \times 2^{(250/150)}$ = CBR 6.4

No matter how strong stabilised strength. Top sublayer for 250mm limited to CBR 6.4

The optimum thickness of stabilised subgrade layer for **EQ39** is 300mm (for CBR = 8)

Subgrade Impact on Pavement Properties

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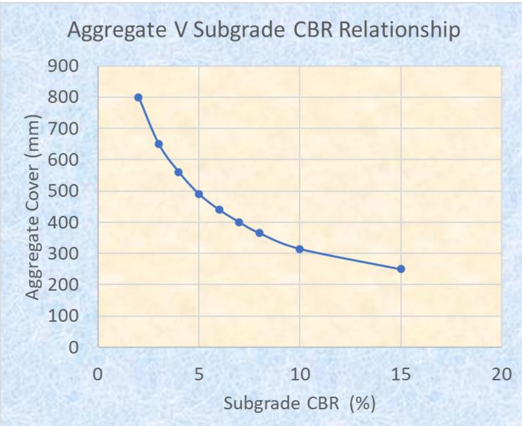
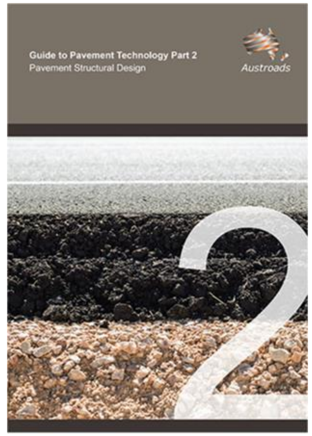




$$E_{V\ \text{top granular sublayer}} = E_{V\ \text{underlying material}} \times 2^{(\text{total granular thickness}/125)} \qquad 41$$

$$R = \left[\frac{E_{V\ \text{top granular sublayer}}}{E_{V\ \text{underlying material}}}\right]^{\frac{1}{5}} \qquad 42$$

- Modular Ratio / Sublayering:
- Weak Subgrade – cannot realise or develop aggregate properties
- Subbase properties 250MPa – but constrained to <40% of that value at top of layer!!

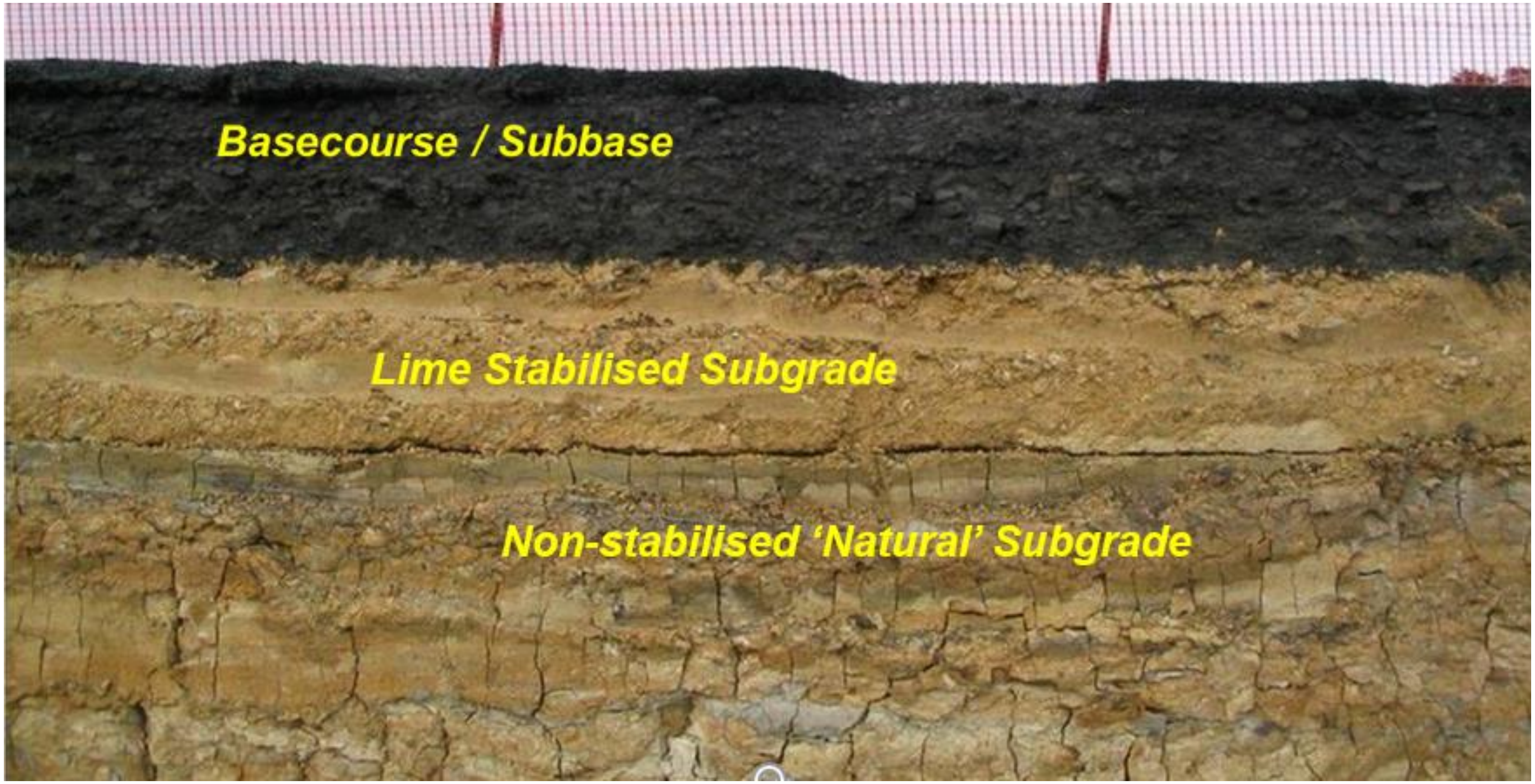
Unstabilised CBR = 3 Subgrade

Layer	Sublayering		Resilient Modulus (E)	Thickness (mm)
Subbase	Sublayers	1	90.00	40
		2	78.80	40
		3	66.60	40
		4	54.40	40
		5	42.20	40
Subgrade	Semi Infinite	SG	30.00	Semi infinite

Stabilised CBR = 10 Subgrade

Layer	Sublayering		Resilient Modulus (E)	Thickness (mm)
Subbase	Sublayers	1	303.10	40
		2	262.50	40
		3	221.90	40
		4	181.30	40
		5	140.60	40
Subgrade	Semi Infinite	SG	100.00	Semi infinite

Subgrade Stabilisation Intention



Aims to ***Permanently***:

- Reduce moisture susceptibility
- Provide homogeneous substrate
- Increase shear strength

Stabilised Subgrade Contribution

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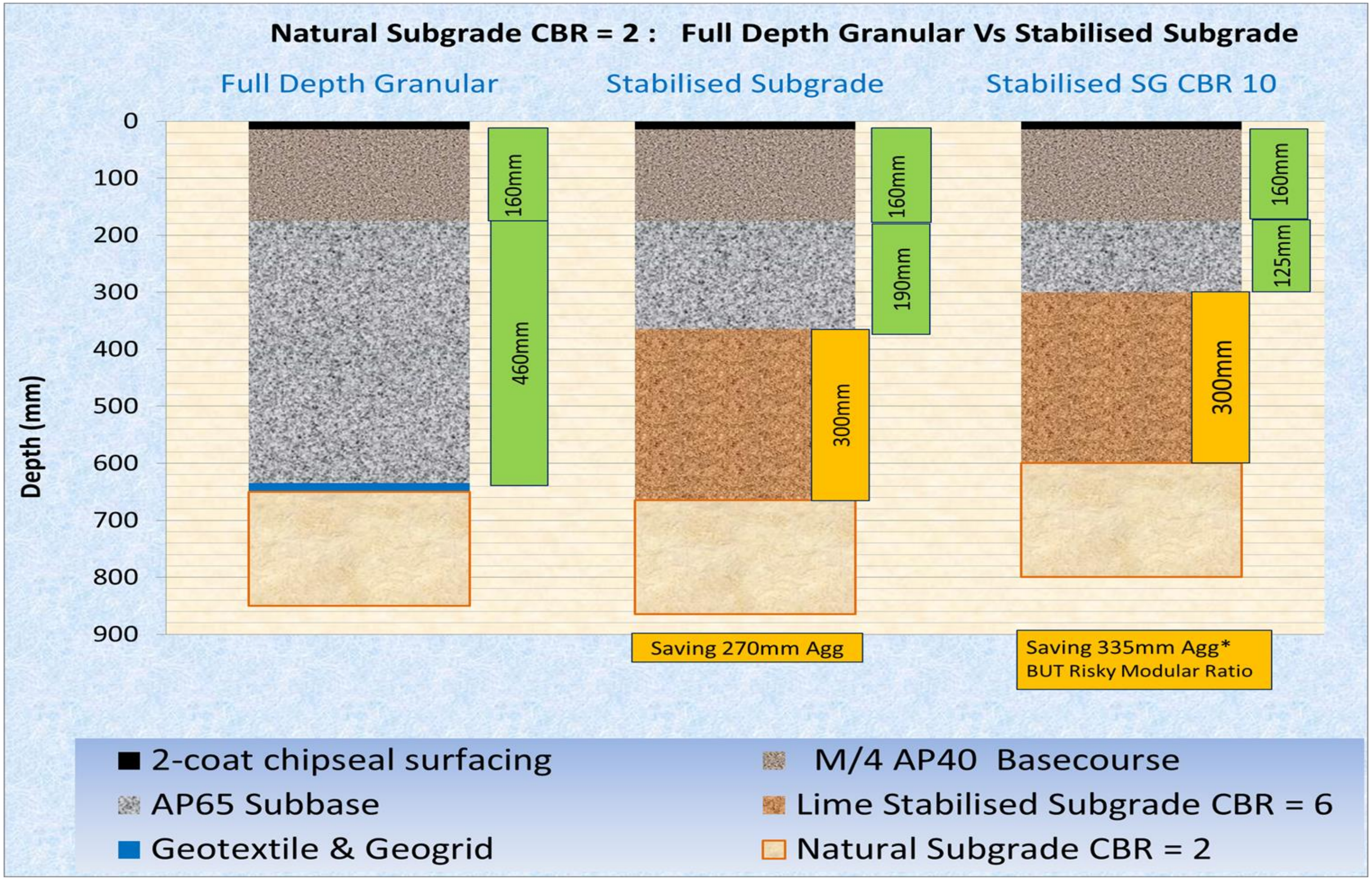

Sub-layered as per Austroads Select Fill

Fill Drying / Soils Conditioning

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Winter & wet/cold weather = delays

Rain & reduced sun/drying/evaporation)

Wet soils are difficult to work

Compromise air voids & shear / CBR strength

Drying is impeded by cooler temperatures and rain

Conventional drying = discing and/or sun & wind

- restricted by cold temps/rain

Drying via chemical binder far quicker

Most effective and successful is Quicklime (Calcium Oxide)

$Ca0 + H_20$ $\qquad$ $Ca\,(OH)_2$ + **HEAT**

What is Fill / Soils Conditioning

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Quicklime   3mm topsize particles

No slaking - draws moisture from wet soil

Fine grading easily spread & large surface area/weight

Process Benefits Threefold:
Hydration/slaking CaO = dries soil

Hydration heats soil - temp 50degC = additional drying

Then typical stabilisation benefits:

Plasticity reduction

Moisture reduction

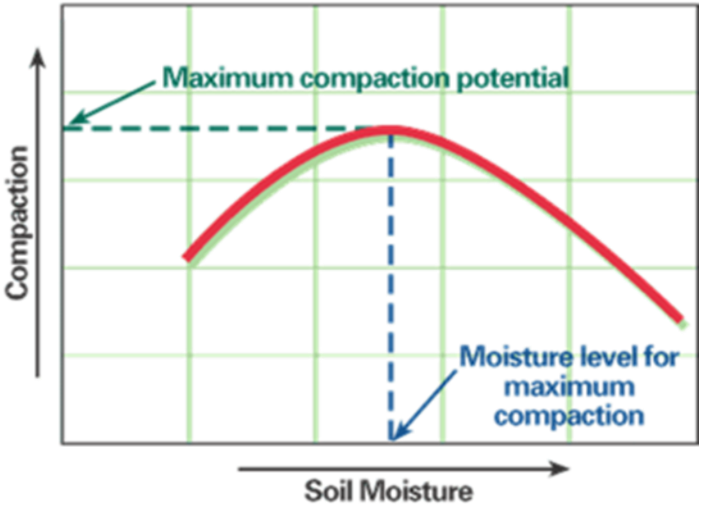
Capacity to absorb water & swell reduced

Improved workability – more friable

Improved shear strength & stability

Solid working platform from existing soils

(reduce need for cloth/grid/imported aggregate).



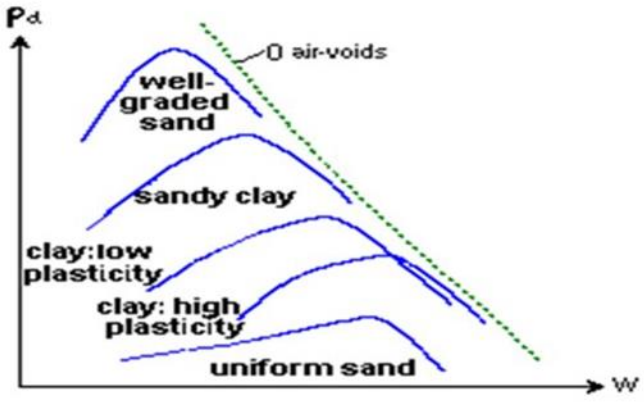
SOIL CONDITIONING – DESIGN & TESTING

Design process approached pragmatically

Lab testing to confirm soils strength at field water content vs achievable when dried back

If highly variable soil / moisture contents, not practical to test the full range.

Rather test materials / moisture extremes to evaluate guide of outcome(s)



SOIL CONDITIONING – DESIGN & TESTING

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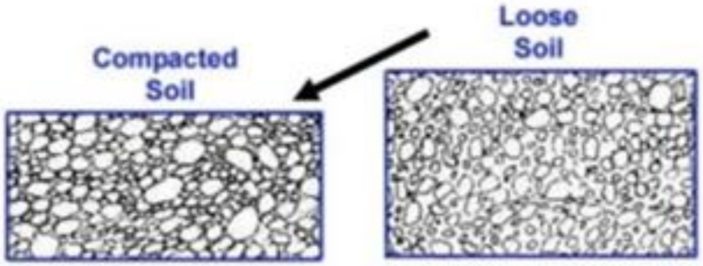
Design usually 1% - 3% lime to condition

Varies for different materials/moisture

Extreme is 5 - 6% binder

4 Control Factors:

- Compaction Effort – Influence with Plant
- Soil Type / Grading
- Moisture Content – Influence with Drying
- Dry Unit Weight



Management of Fill Drying / Soil Conditioning

QA testing ensures design expectations are surpassed - spread rate, depth, moisture, compaction testing

Shear strength / CBR validation, Cu / DCP / Bulk samples compacted (i.e. std comp dry/soaked CBR)

Site conditions monitored (soil type, moisture etc), determine if modifications necessary (squeeze tests too)

Application Soil Conditioning – major projects

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Suited to:

- Variable wet of optimum "Difficult" soils
- Sensitive silts / saturated clays
- Restricted access and limited drying areas.
- Large cuts / fill volumes.
- 250 to 300mm compacted layer thickness
- Binder recipes tailored for dependable outcome
- Most materials very reactive to Quicklime
- Work can progress through winter months
- Major projects often optimistic re weather impact on programme
- ***Significant programme advantages in early use of Soil Conditioning / Fill Drying & Stabilised clay/silt subgrades***

  Esp where construction footprint is haul route
- ***Our experience = minimum 25% reduction in earthworks programme***

Application Soil Conditioning – major projects

Earthworks always carry programme risk. These risks include:

Construction Issue	How Fill Drying Reduces Risk
-Naturally wet/sensitive materials not able to placed to meet stringent strength testing requirements in their natural state.	Fill Drying addresses these conditions and strengths are generally achieved within 6 hours of mixing
-Poor weather conditions/regular rainfall preventing earthworks from proceeding as the material becomes wet and cannot be placed to meet stringent strength testing requirements.	Fill Drying allows earthworks to continue in marginal weather and immediately after rain
-Limited drying areas/geographical constraints reducing ability to naturally dry back wet materials.	Fill Drying allows earthworks to proceed in very constrained areas
-Naturally drying back wet materials can be very ineffective if rain events take place half way thru the drying process.	Fill Drying eliminates this requirement
-In some cases it is not economical to conventionally dry/condition the natural materials and it is carted to waste and replaced with imported materials	Fill Drying greatly reduces this requirement
-Inadequate on site resource to carry out high productivity earthworks when the weather is favourable(not economic to have large fleet on site idle when earthworks can only be carried out 60% of the year)	Fill drying allows earthworks to continue nearly all year and contractors can gear up for consistent on site productivities.
-Potential long term earthworks failures	Fill drying greatly reduces this risk as the chemical strength gain and moisture insensitivity is indefinite

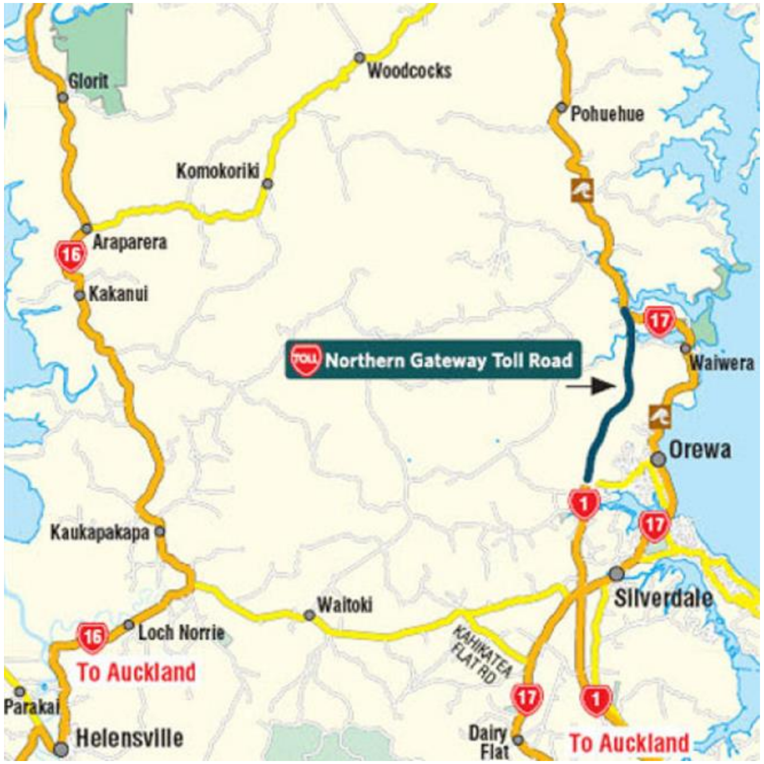
Case Study – Northern Gateway

Treatment: **>500,000m² Fill Drying; >250,000m2 Stabilised Subgrade**

Client: NZTA / Fulton Hogan / Leightons

Date: 2011 – 2014

- Reduced Cut to Waste = Huge savings
- Able to continue in marginal/poor weather
- Stab Subgrade >> Design CBR ***7***
- Adjusted design SG to CBR ***15***
  - reducing subbase
  - 200mm GAP65 to 100mm GAP40
- **6500m3 less Subbase** required + Acceleration
- 25% Subbase budget cost saving
- Very low deflection (BBeam & FWD) achieved



Wrapping up

Common practice for more than 50 years in NZ

Many methodologies and innovations available – Now B/09 Pilot

Need to understand sustained response to binders

Construction cost savings can be substantial.

Homogenous strong / durable substrate gets the best out of overlying pavement

NZTA want you to employ subgrade stabilisation in your designs / scheme assessments

Thanks to NZIHT/NZTA for providing platform

Remember – with stabilised foundations you can build great roads