Outcome of the National Asset Centre of Excellence (NACoE) Insitu Slaking of Quicklime Trials

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Australian Pavement Recycling and Stabilisation Conference

Sustainable Pavements for Future Generations Pullman Albert Park, Melbourne • 22nd August 2023



Recap (Since 2019 AustStab Annual General Meeting)

Intention of field trials to explore innovative methods of slaking quicklime



NACOE trial Mackay Ring Road 2018

Why do we need this?

- Quicklime is cheaper than hydrated lime:
 - 76% of quicklime is required compared to hydrated lime
 - hydrated lime is essentially carting 24% water to a project.





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Chemical Reactions

- Burning
 - CaCO₃ + heat (>1000°C) -> CaO + CO₂
- Slaking
 - CaO + H₂O -> Ca(OH)₂ + heat
- Pozzolanic reaction
 - Ca⁺⁺ + OH⁻ + soluble clay silica -> Calcium Silicate Hydrate (CSH)
 - CA⁺⁺ + OH⁻ + soluble clay alumina -> Calcium Aluminate Hydrate (CAH)



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Cunningham Highway Freestone Creek Lime Stabilised Core



Project Aim

To assess and evaluate the alternative method of slaking quicklime by insitu wet mixing, rather than the conventional method of quicklime surface slaking prior to incorporation.









Benefits





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Challenges finding insitu slaking trial location

- X Truck stop 1: Within 10 metres of Gas pipeline.
- X Truck stop 2: Endangered grass species.
- X Truck stop 3: No black soil.

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- Lot 1:Hydratod lime as per MRTS07A
- Lot 2:
 - Quicklime as per MRTS07A
- Lot 3 (option 3A or 3B):
 - Quicklime trial refer to trial brief.



AustStab AGM | 24 July 2019





Laboratory phase 2019 to 2022



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Linear relationship between change in temperature vs lime rate (%) (2019)





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Q = mc∆T

Q_{CaO}

• The energy released from the quicklime can be calculated.

ΔT=Q/mc

- Change in temperature can be determined from the mass of soil and water using specific heat capacity.
- Ratio of theoretical temperature vs actual temperature = % lime reacted.

$Q_{CaO} = Q_{\rm S} + Q_W$

 Ratio of energy released from the quicklime vs energy absorbed by the system = % lime reacted.



Comparison of three different lime source (2021)



Hand mixing % Quicklime reacted (20% OMC)



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Hand mixing:

- Results did not achieve the expected 86%.
- Results varied from 53% 83% reacted lime.
- Lime with a slower slaking rate (AS4489.3.1) calculated less than 45% of reacted lime in the sample.



Repeatability of the draft Q259A method



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Mechanical mixing

Using a lime with a fast slaking rate and 96.7% available Lime Index (ALI):

- results confirmed a linear relationship with each 2% addition of water
- results were repeatable between 93% 96% reacted lime for five samples.





Test Method field trial stage June 2022



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Cloncurry truck stop field trial 2022





Flinders Highway trial 2022



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Cloncurry truck stop field trial 2022



Flinders Highway trial 2022



Cloncurry truck stop field trial 2022



Flinders Highway trial 2022







Field trial June 2023

Flinders Highway trial 2023





Trial Sections

Control <i>MRTS07A</i> (50m)	AustStab (50m)	NACOE Trial (100m)
 Day 1 spread 7.5kg/m2 and surface slaked incorporation mix. Day 2 spread 7.5kg/m2 and surface slaked incorporation mix. final wet mix. 	 Day 1 spread 7.5kg/m2 and insitu slaking incorporation mix spread 7.5kg/m2 and insitu slaking incorporation mix final wet mix. 	 Day 1 spread 7.5kg/m2 and insitu slaking incorporation mix spread 7.5kg/m2 and insitu slaking incorporation mix. Day 2 final wet mix.
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Control Section Flinders Highway trial 2023





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AustStab Section





Flinders Highway trial 2023





NACoE Section



Flinders Highway trial 2023





Insitu lime slaking - Draft Q259A method







Initial temperature

Sample taken directly behind the stabiliser

Temperature rise is measured onsite





One day application vs Two day application



Sample 1 was sampled within the first 5-10m of lot.



99%

99%

5

- One day procedure 58% 79% reacted
 Two day procedure 76% 97% reacted (0-50m)
- Two day procedure 69% 99% reacted (50-100m)



Calculation Spreadsheets

Pre-Field testing result	5			
Maximum (1.69			
Available	92.2			
Insitu Mois	12.5			
Target Optin	16.0			
Lime spread rate / wat	er spread rate			
Lime ID				
	(kg/m3)	(%) and (time)		
Target Quicklime (kg/m ³)	15.0	3.55		
Drop 1 Quicklime (kg/m ³)	me (kg/m ³) 7.4			
Drop 2 Quicklime (kg/m ³)	op 2 Quicklime (kg/m ³) 7.4			
Total Quicklime (kg/m3)	14.8	3.50		

• Red text cells are automatically calculated

Data entry onsite includes:

- Pre-Field testing results
- Lime spread rate
- Sample identification details
- % Moisture added to site
- Depth of lot
- Mass of sub-sample
- Initial soil and water temperature
- Final slaked soil temperature



Bulk sample ID Bulk sample ID Bulk sample location Temperature probe X of target Quicklime added X water added to soil (Total) Moisture content of soil (Insitu + water added) Depth of sample portion Depth of sample portion Mass of test portion (soil and lime) Mass of test portion (soil and lime) Mass of test portion (soil and lime) Mass of soil calculated] Mass of water added on site in test portion (calculated) Mass of water added on site in test portion Total Moisture content of test portion Dry mass of soil (acludated) Initial soil temperature Initial soil temperature Time to mas heat rise Drames of soil of the set portion Dry mass of soil acludated Mass of soil calculated Mass of soil calculated Dry mass of soil and lime (calculated) Dry mass of soil calculated Dry mass o	X X M m M X ka ka ka ka ka ka ka ka	Sample 1 Insitu CB027.11 100% 3.0 15.5 0.250 0.200 4.379 EQUATIO 2.4 0.001 0.248 0.067 0.315 15.1% 1.984 1.984 1.984 2.005 2.400	Sample 2 Insitu DL1 100% 3.0 15.5 0.250 0.200 0.200 0.200 0.200 0.200 0.200 0.200 0.200 0.200 0.200 0.200 0.200 0.200 15.5 15.5 10.1 10.1 10.1 10.0 2.4 0.0 10.1 10.0 2.4 10.0 10.0 10.0 10.0 2.0 10.0 10.0 10.0	Sample 3 Insitu DL2 100% 3.0 15.5 0.250 0.200 4.379 .CULATED FO 2.4 0.101 0.248 0.067 0.315 15.1%	Sample 4 Insitu DL3 1002 3.0 15.5 0.250 0.200 4.379 PR MASS OF 0 2.4 0.101 0.248 0.067 0.315 15.12 1.984	Sample 5 Insitu CB27.10 100% 3.0 15.5 0.250 0.200 4.379 2UICKLIME AN 2.4 0.101 0.248 0.067 0.315 15.1%
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Initial soil temperature Initial water temperature Final soil temperature Time to max heat rise			2.400	2.400	2.400	2.400
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Final soil temperature Time to max heat rise	•C	21.7	21.7	21.7	21.7	21.7
Time to max heat rise	•C	16.8	16.8	16.8	16.8	16.8
Time to max neat rise	•C	47.0	52.8	48.5	49.1	49.7
	Minutes	16	15	17	12	13
Change in sample temperature nom staking	'C[25.43	31.23	26.93	27.53	28.13
Theoretical Heat Hise						
Energy released by Quicklime (theoretical)	kJ/mole	105.440	105.440	105.440	105.440	105.440
Energy absorbed by water	kJ/mole	33.464	41.096	35.438	36.227	37.017
Energy absorbed by soil	kJ/mole	42.306	51.953	44.801	45.799	46.797
		75 770	00.040	00.000	00.000	00.014
Energy absorbed total	kJ/mole	75.770	93.049	80.239	82.026	83.814
Quicklime (theoretical)	~	72%	88%	76%	78%	79%
Theoretical heat rise	'c	35.47	35.47	35.47	35.47	35.47
Change in temperature of soil / Change in temperature theoretical		72%	88%	76%	78%	79%
Residual Energy of Quicklime	kJ	29.67	12.39	25.20	23.41	21.63
Residual Quicklime	ka	0.026	0.011	0.022	0.021	0.019
Residual Quicklime	q	26.12	10.91	22.19	20.61	19.04
Residual Quicklime / Mass of Quicklime in test portion (calculated)	%	26%	11%	22%	20%	19%
Moles CaO in test portion	moles	1.6553	1.6553	1.6553	1.6553	1.6553
Energy released by Quicklime (theoretical)	kJ	105.440	105.440	105.440	105.440	105.440
Theoretical water required to complete reaction	kg	0.030	0.030	0.030	0.030	0.030
Results						
Slaking efficiency (Value fro	m row 83)	72%	88%	76%	78%	79%
Average Slaking efficiency	(reacted)				78.7%	
% Measured heat rise (value fro	m row 85)	72%	88%	76%	78%	79%
Minimum % measure	d heat rise				71.7%	



Summary Spreadsheet

				Q259:	Slaking of Quid	klime work	sheet (dr	aft V1.4)				
				W	orksheet for Re	sidual Quic	klime - S	ummary				
Sample details								-				
Test Method:	Q259:	Slaking of Q	uicklime	(draft)						Tested by	RD, SV	
Sample ID	Sectio	on - Q259 tria	I-2 days	s						Date tested:	22/06/202	3
Client sample ID	Clone	urry - Julia Cr	rry - Julia Creek oil						Target Quicklime (%)		3.00	
vlaterial type	Black	soil					ALI (%)	92.2				
Location		0-50mt - Chainage (50mt) 71.790						Energy relea	sed for Quicklime	ed for Quicklime Reacted (Av)		
				days	hours			Heat ri	se for Quicklime	Reacted (Min)	86%	
Time for curing before fina	al wet pas	s (slaking)		day/s	17.0 hour/s				Result for Quick	dime Reacted	SLAKED	
Average	Minim	um				CB027.11	DL1	DL2	DL3	CB027.10		
9	6%		86%		Total slaking efficiency	86%	104%	99%	99%	95%		
					Total heat rise %	86%	104%	99%	99%	95%		
					%	Quicklime rea	cted					
			120%									
		-	100%		104%	00	×	000/				
		CTED		9.53	104%	99	%	99%	95%			
		MERE	80%	86%								
		JUICKL	60%									
		%	40%			Total slaking efficiency	(
			20%		=	- Total hest rise % - Minimum						
			0%		-	Average						
				1	2	3 SAMP	LES	4	5			
						5411						

RD, SV, DV, KL
24/00/2022
21/06/2023
3.00
3.25
85%
72%
ADD MORE WATER



Considerations for test method Q259A

- Slow reacting lime does not reach the same heat rise as fast reacting:
 - slaking rate needs to be considered
 - more research required into a correlation factor.
- Agreed % for slaked lime yet to be determined:
 - currently set to more than 90% average and 80% minimum.
- Soil Temperature initial and final temperature is critical
 - 2°C missed temperature rise equals 6-7% slaking.



Flinders Highway trial 2023





Observations and recommendations

- Trapped heat appeared to cause cracking in both June 2022 and June 2023 trials.
- Final wet mix on separate day releases heat.



Seeking trial in high lime percentage stabilisation project.





Acknowledgements

- NACoE Project P107: Undertaken by ARRB and TMR through the National Asset Centre of Excellence (NACoE) Program.
- TMR Bulwer Island Laboratory and Cloncurry Laboratory undertook the testing. (Robyn Devitt and her team, Brian Lowe, Liying Shao).
- North West District, TMR (Chris Pyne and Upali Adikaram).
- Koppens Stabilising / Koppens Contracting.
- Cement Australia (Paul Ribinsky).
- ARRB (Justin Nicols and Satheeban Vaikunthanathan).
- Jothi Ramanujam and Peter Evans.



