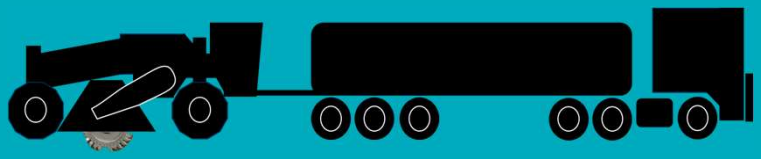
The use of 500mm Deep Lime Stabilisation as an Unsuitable Support Condition Treatment in Construction on TMR Stabilisation Projects



Department of Transport and Main Roads

Damian Volker A/Director and Meera Creagh Principal Engineer (Pavement Rehabilitation Unit)
Meera Creagh, Principal Engineer, Queensland Department of Transport and Main Roads

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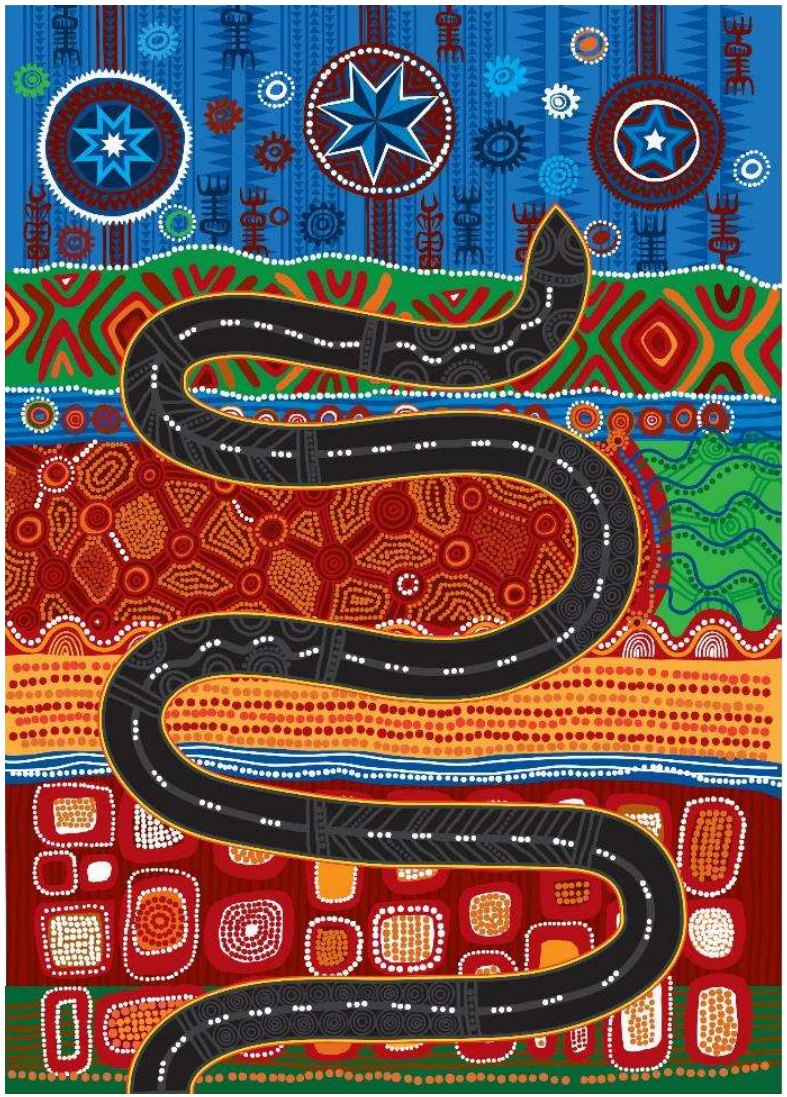
Acknowledgement of Traditional Owners and Elders

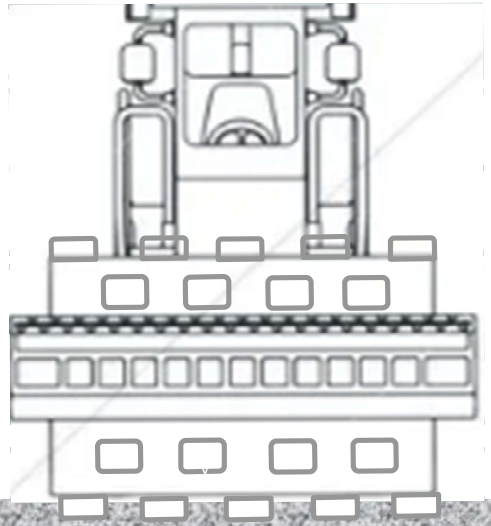
I’d like to begin by acknowledging the Traditional Owners of the land where we meet today. I would also like to pay my respects to the Elders both past and present.

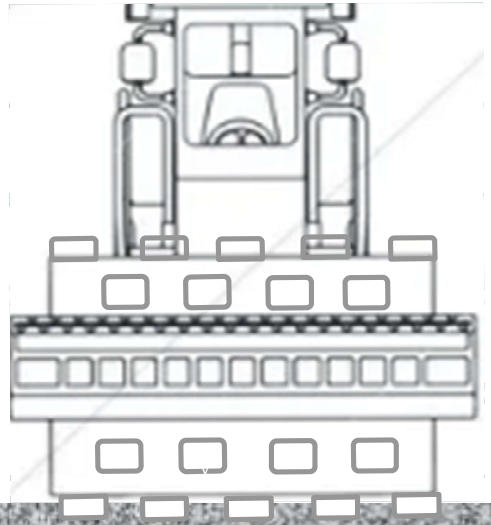
I also extend that respect to the Aboriginal and Torres Strait Islander people here today.



'Travelling' by Gilimbaa

Newton's Third Law and '*Anvil*' support condition concept





'For every action, there is an equal and opposite reaction'

DESIGN STABILISED SUBBASE or SUBGRADE LAYER

Which support condition will achieve compaction???

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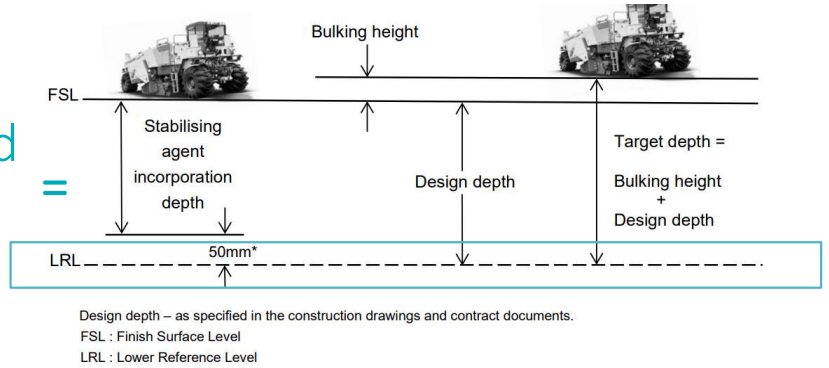
Some in-house terminologies:

The Subbase or Subgrade layer that is to be stabilised as per the design = DESIGN STABILISED LAYER

= The strength of the support condition directly under the layer to be stabilised

Lower Reference Level (LRL) is the bottom of the stabilised layer. It is also the top of the Anvil that we want to assess

=



Design depth – as specified in the construction drawings and contract documents.
FSL : Finish Surface Level
LRL : Lower Reference Level

= **Dynamic Cone Penetrometer (DCP).** Testing is measured from the LRL of the stabilised layer to assess the support condition (Anvil)

10+ things that can affect compaction

- Soil Tester – we always blame them first!
- Layer depths
- Compactive effort
  - (Roller type/size/speed/frequency/amplitude and number of passes)
- Moisture Content (Relative Moisture Ratio)
- Particles size and shape
- Anvil (the support underneath the stabilised layer) ???
- Working time / workability (setting up of the materials)
  - Temperature effects working time
- Over compaction / decompaction with too much rolling effort (vibration in reverse direction)
- Unfortunately - Fraudulent test results

In TMR, our Stabilised Subbase and Subgrade layers are most commonly 300mm and 350mm

Toowoomba-Cecil Plains Road 2014

Have you ever not been able to achieve proof roll (and compaction) in a stabilised layer?

300mm 8% Lime Stabilised layer failing proof roll 7 days after completion

Article number	T14/0871	Sampled by	Toowoomba Laboratory
Job number	265/324 Toowoomba - Cecil Plains Rd	Test site / Sender's number	Site No 5
Sampling method	Q114B - 2010	Material source	Insitu Material
Date sampled	26/06/2014	Test / Sample location	Ch 51.280 km 3.5m Left Side

Test method: Q114B - July 2010 Insitu California Bearing Ratio (Dynamic Cone Penetrometer)
* Q102A - 1993 Standard Moisture Content - Oven Drying

MATERIALS PROFILE					STRENGTH PROFILE		
Depth (mm)	Thickness (mm)	Description	Article number	* Moisture content (%)	Depth (mm)	Thickness (mm)	CBR
0	250	Profiled Existing Pavement	na	na			
250	160	Layer: Existing Pavement Gravel(proposed stabilized depth)	na	na			
410	140	Subgrade: Black Clay (proposed stabilized depth)	na	na			
550		Anvil	=		600	115	1.5
715	79						2
794	293						3
1087	199						3.5
1286	93						3.5
1379	829	Black Clay Subgrade (below proposed stabilized depth)	T14/0871	50.4			

300mm 8% Lime Stabilised Subgrade layer

1.5 – 3% Insitu CBR (DCP)

Moisture Content = 50.4%

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Toowoomba-Cecil Plains Road 2014 – early lessons

Due to the very weak anvil construction process had to change.

Grader unable to move the heavy clay, so lime added first to allow the design lime stabilised layer to be pushed out into a windrow/rill.

Anvil support layer lime stabilised at the same 8%.

Design stabilised layer material pushed back into box and stabilised as per the MRTS07A specification and design.

Costs doubled (double the square meterage rate for the project).

Learnings – It is extremely expensive to figure out the anvil is weak after the fact

TMR has found DCP's to be the best way to determine suitable anvil.

- Anvil weakness (low shear strength) is caused from high moisture contents.
- The DCP/insitu CBR is a snapshot of the bearing capacity based on the moisture content at the time the DCP is performed.
- The insitu CBR result will change with moisture content.
- Typically, problematic in CLAY subgrades (60% of Queensland).
- Therefore, when should the DCP testing be performed?

Dynamic Cone Penetrometer (DCP)

DCP's are a very useful tool for assessing the *Anvil.* They are an affordable test with very prompt results/outcomes.

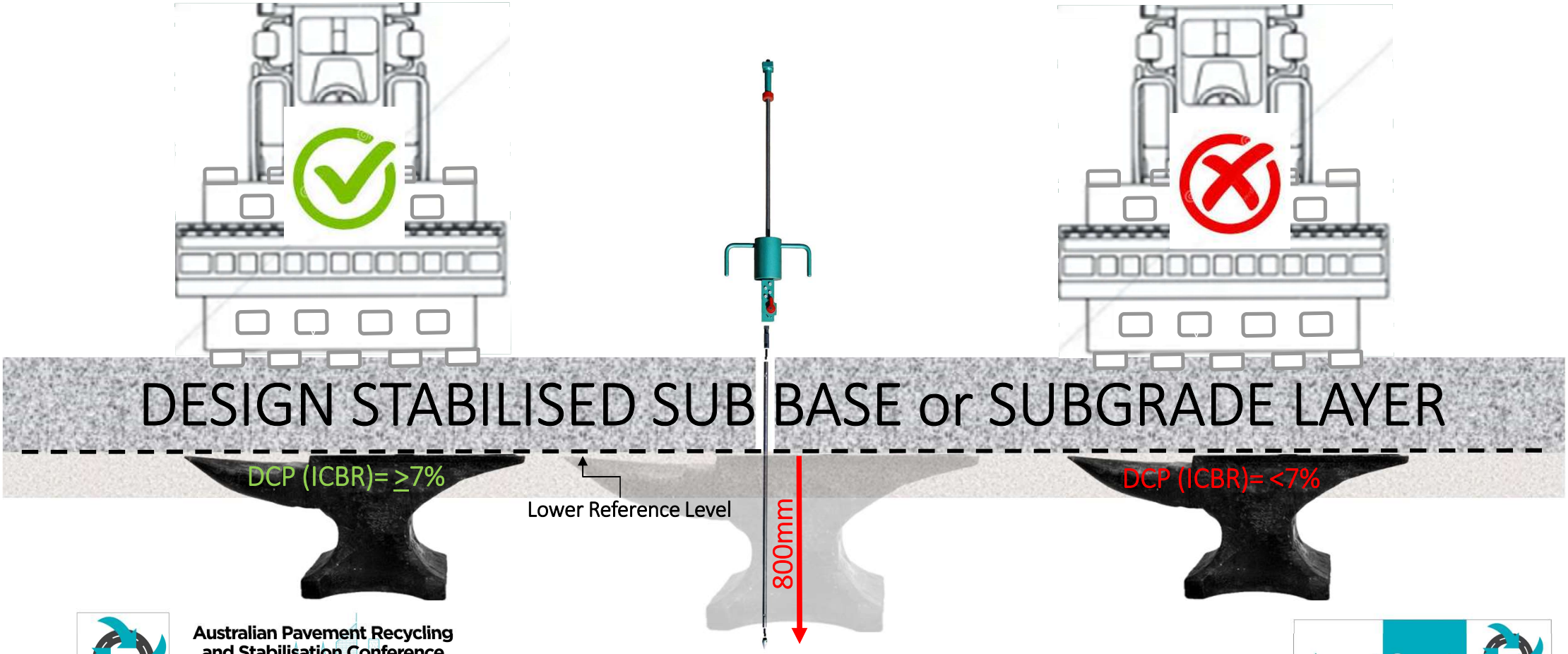
As part of pavement investigation

Prior to construction

During construction

Due to the sensitivity of the results, TMR use the DCP (depth per blow) 'Q' method and not the Australian Standard (blows per 100mm) Method

Dynamic Cone Penetrometer (DCP) to assess bearing capacity



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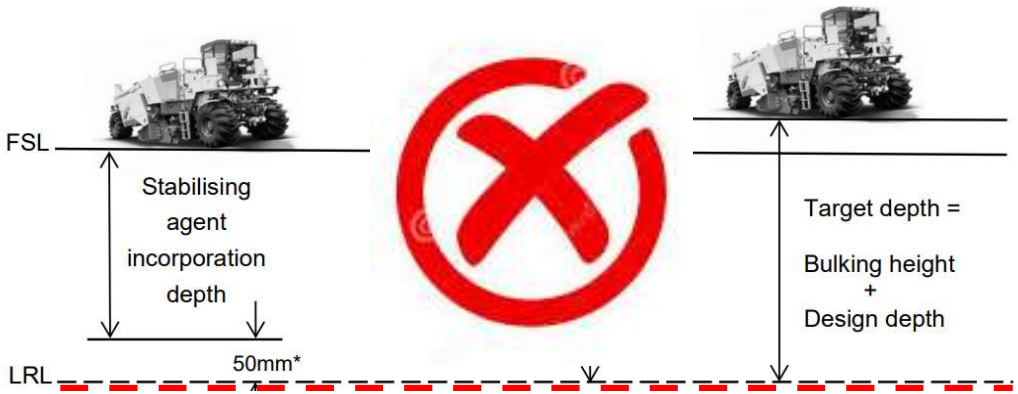
Design subgrade CBR vs Insitu CBR (DCP)

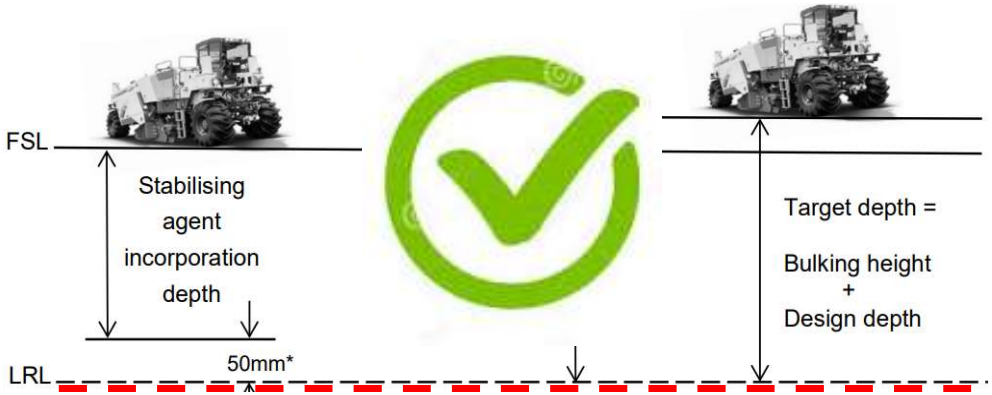
Question:

Design subgrade CBR under the design stabilised layer is 3%, a DCP tested from below the *Lower Reference Level* has an insitu CBR of 3%.

Can it be constructed successfully?



Design Subgrade CBR 3% vs DCP Insitu CBR 3%



Design Subgrade CBR 3% vs DCP Insitu CBR 7%

MRTS04 Type K or Special K
"Choose your own adventure"

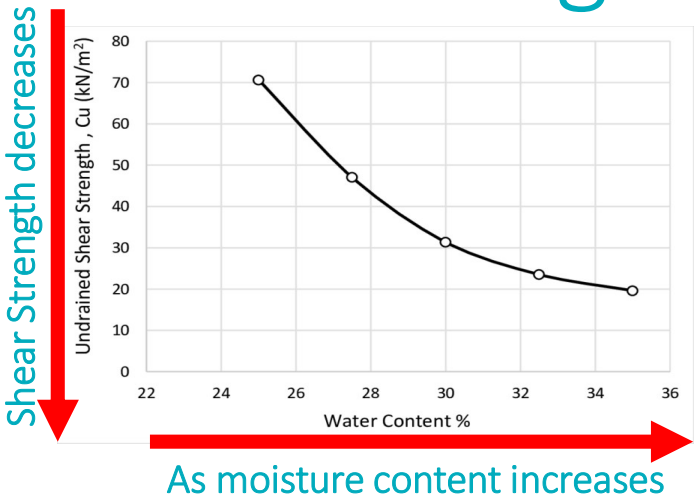
Table 18.3.3.2 – Summary of Subgrade treatments

Treatment type	Clause reference	Description	Drainage Layer required	Replacement material	Stabilisation method	Depth of treatment (mm)[1]
A	18.3.3.3	Compact existing	No	–	–	150
B	18.3.3.4	Replace with Earth Fill Material	No	Earth Fill Material	–	150
C	18.3.3.5	Replace with unbound granular material	No	Unbound granular material	–	150
D	18.3.3.6	Insitu stabilise existing	No	–	Insitu	150
E	18.3.3.7	Replace with plant-mixed stabilised material	No	Stabilised granular material	Plant-mixed	200
F1	18.3.3.8	Plant-mixed stabilised upper layer and unbound drainage lower layer	Yes	Stabilised granular material	Plant-mixed	150
				Unbound granular drainage material		100
F2	18.3.3.8	Plant-mixed stabilised upper layer and high-permeability drainage lower layer	Yes	Stabilised granular material	Plant-mixed	150
				High-permeability drainage material		300
G	18.3.3.9	Insitu stabilised Drainage Layer	Yes	Stabilised granular drainage material	Insitu	150
H	18.3.3.10	Plant-mixed stabilised Drainage Layer	Yes	Stabilised granular drainage material	Plant-mixed	150
I	18.3.3.11	High-permeability Drainage Layer	Yes	High-permeability drainage material	–	300
J	18.3.3.12	Bridging layer	No	Rock Fill	–	–
K	18.3.3.13	Special	[2]	[2]	[2]	[2]

[1] Unless otherwise specified on the drawings or Clause 12.3 of Annexure MRTS04.1 to this Technical Specification.

[2] As specified on the drawings.

Type K – Developed in 2017 Bruce Highway



= low DCP values

The objective on the Type K treatment is to reduce the Moisture Content in the lowest 150mm portion of the layer.
Achieved from:

- Mixing dryer material downwards (therefore wet material upwards).
- In some cases, gravels mixed down to give some ‘guts’ to the material matrix.
- Hydrated lime for moisture dry back.
- Anvil is to aid construction (will not achieve permanency)

Provisional item – MRTS04.1 Annexure

12.4 Subgrade treatment Type K (Clause 18.3.3.13)

Subgrade treatment Type K shall be in accordance with the following provisions.

Refer to drawing TCS_PZC_01 for Type K pavement treatment details.

1. Pulverise (mix) inner portion of existing pavement to a depth of 400mm on both sides of the Control Line.
2. Cutback and remove the outer portion of the formation to 400mm below 'Finished Surface Level' (FSL) for the Widening Platform.
3. Spread central pulverised material to a compacted level of 200mm below FSL across the widened platform.
4. Spread 10kg/m^2 of hydrated lime across the full width of stabilisation extents.
5. Mix 500mm depth with stabiliser from the compacted level of 200mm below FSL, to a depth of 700mm below FSL.
6. Using a grader, windrow top 100mm (nominal) of blended material to one side.
7. Undertake compaction of the stabilised area with a padfoot roller to achieve 95% standard compaction in the lower portion of the subgrade.
8. Using a grader, reinstate the windrowed blended material, shape and lightly compact.
9. Before proceeding (HOLD POINT) confirm lower 150mm of the Type K treatment has achieved DCP ≥ 7, by performing Q114B (DCP) to depth -900mm from FSL.

Type K 500mm stabilisation treatment (when at -200mm level from DFSL)

a. **DCP (Q114B) testing**

As determined necessary by the Administrator, *Insitu California Bearing Ratio - dynamic cone penetrometer* (DCP Q114B) testing on the exposed surface may be undertaken.

- DCPs shall be undertaken every 200m at four locations across the pavement at offsets of 2.0m and 3.5m both LHS and RHS of the control line.
- Subgrade level is defined as -550mm from DFSL.
- Each DCP shall penetrate at least 800mm (or until refusal) from the subgrade level (minus 550mm).
- DCPs shall be carried out in the presence of the Administrator's Representative **WITNESS POINT**.

b. DCP insitu CBR results analysis

Once the DCP testing has been completed, the insitu CBR results shall be reported to the Administrator. The reported insitu CBR results shall be analysed from -550 to -850mm from the FSL (that is, 300mm layer that will directly support the final lime stabilised subgrade layer).

- For areas where the insitu CBR≥7 ('sound' support), insitu lime stabilisation can proceed as per the MRTS07A 350mm Contract requirements.
- Where the insitu CBR<7 ('weak' support), undertake the 500mm deep type K subgrade treatment.

Additional DCP testing may be required to further define the limits of 'weak' support (CBR<7) and 'sound' support (CBR≥7).

The areas identified as having 'weak' support (CBR<7) shall be confirmed with the Administrator prior to commencing the subgrade treatment **HOLD POINT**.

c. **Deep treatment construction**

Spread 10kg/m2 of hydrated lime (or 7.5 kg/m2 quicklime) over the stabilisation extents (10.35m).

d. (Completely slake, if quicklime).

e. Mix with the stabiliser 500mm deep (that is, mix -200 to -700mm from the DFSL).

f. Using the grader, windrow 100-150mm of the blended material to one side.

g. Undertake compaction of remaining lime stabilised material with a Padfoot Compactor, to achieve 95% Standard Compaction in the lower portion of the layer.

i. Undertake testing to confirm compaction in the lower portion (lowest 150mm) of the deep treatment. Process standard can be adopted for the compaction testing of the Type K Deep lime stabilised subgrade treatment.

h. Using the grader, reinstate the windrowed material, shape, lightly compact and prepare for the hydrated lime (or quicklime) stabilised subgrade layer process as per the Contract (MRTS07A).

j. Q114B DCP testing should be used to indicate sufficient curing, a DCP≥7% in the lower 150mm portion (-550mm to -700mm) is considered adequate to facilitate compaction and continue with the 350mm lime stabilisation of subgrade process as per the contract.

500mm Deep **Type K** (with 10kg/m^2 of lime)

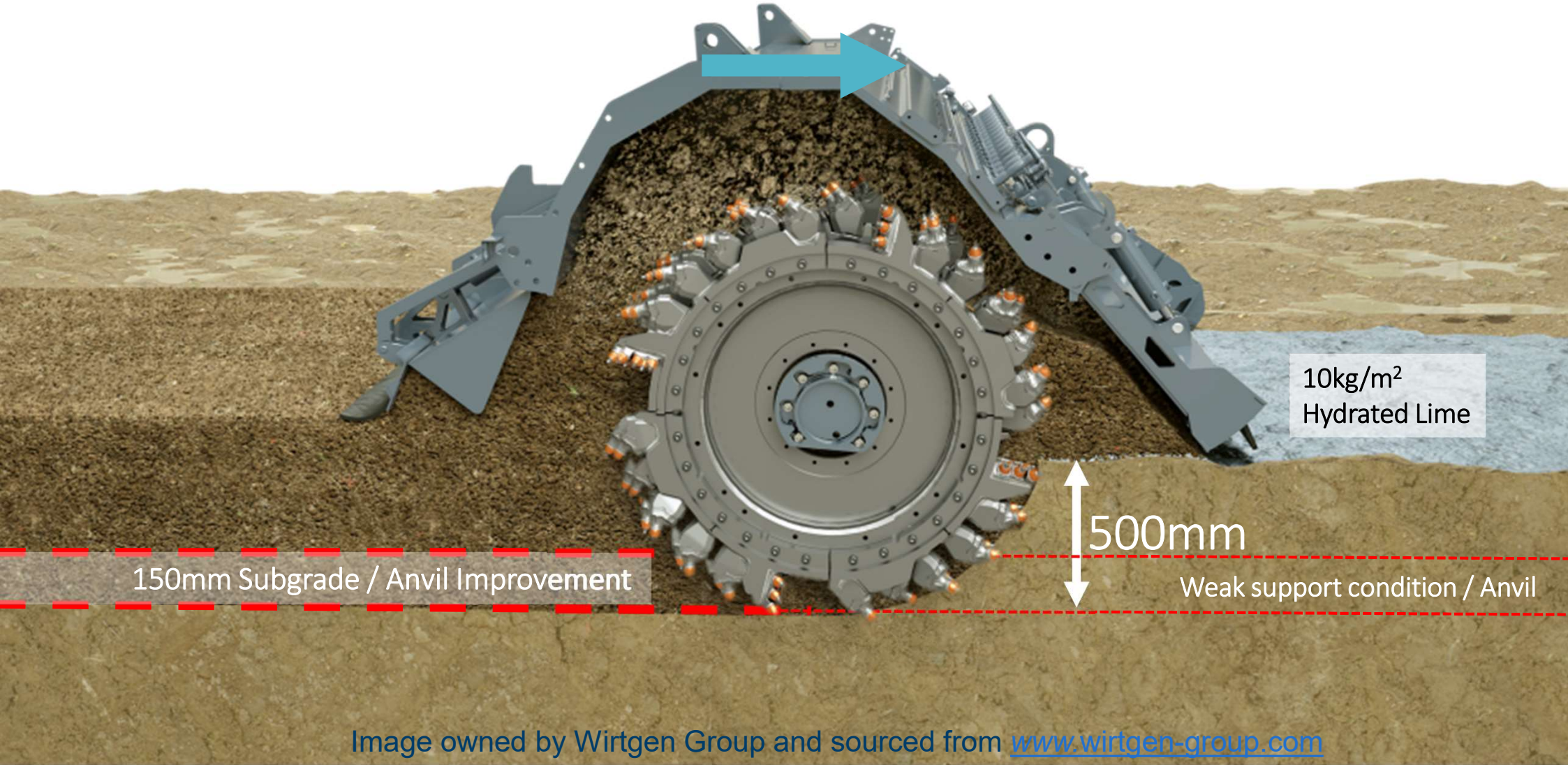


Image owned by Wirtgen Group and sourced from www.wirtgen-group.com

Compaction process

We can’t compact a 500mm deep layer, so we strip 150mm off and compact the lower 350mm portion of the layer.

Stabo mixing 500mm deep

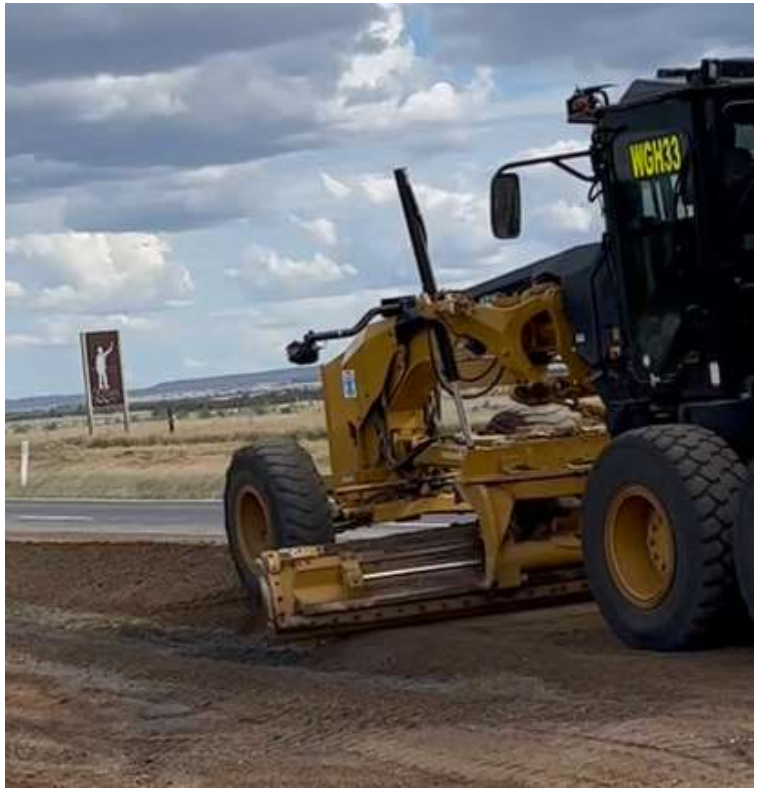
Strip top 150mm

Padfoot Compaction

Compaction testing lowest 150mm (process standard)

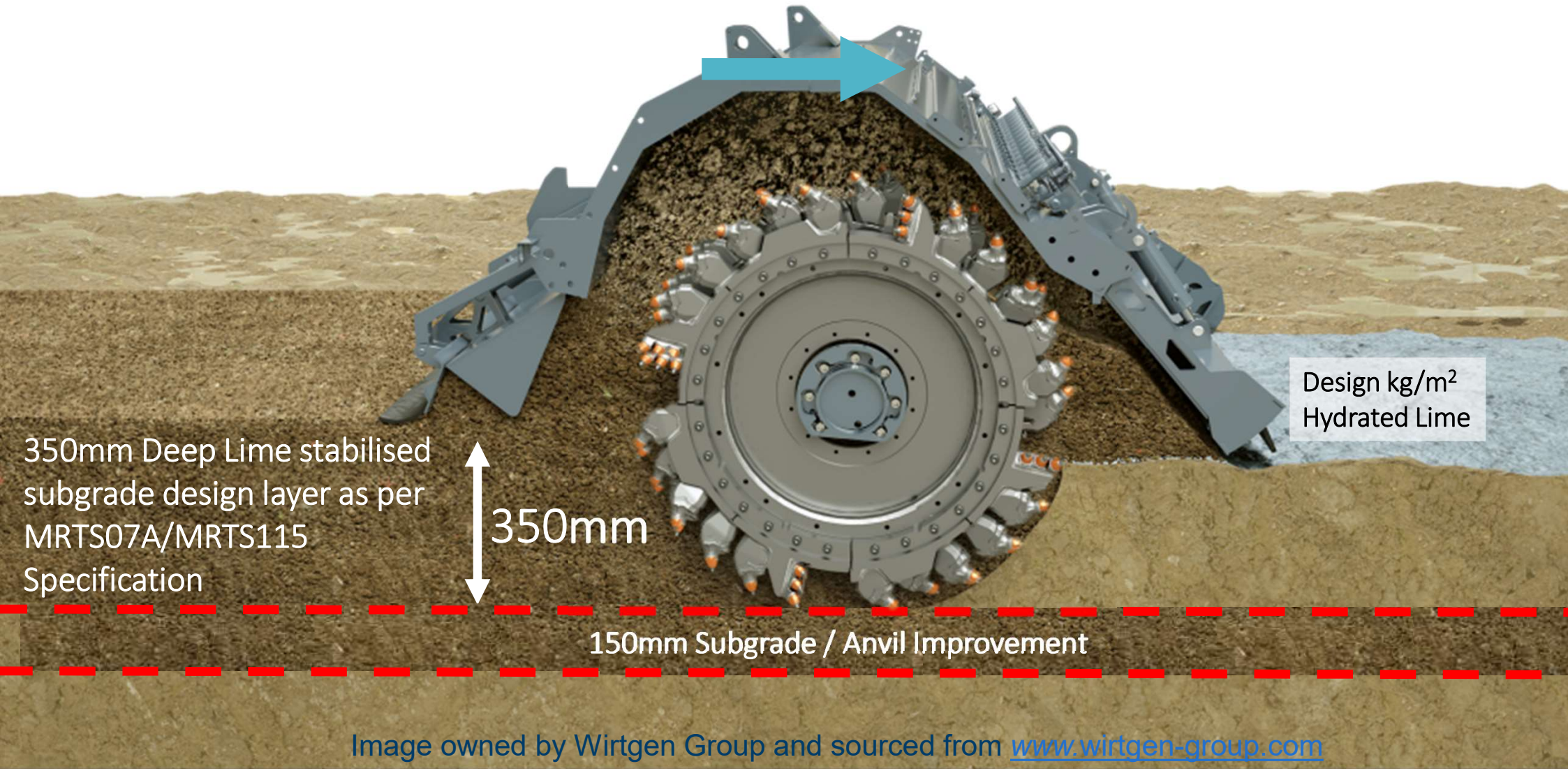
Test density in lowest 150mm

Targeting 95% in lowest 150mm



Reinstatement of the top 150mm

350mm Lime Stabilisation as per Design / Spec / Contract



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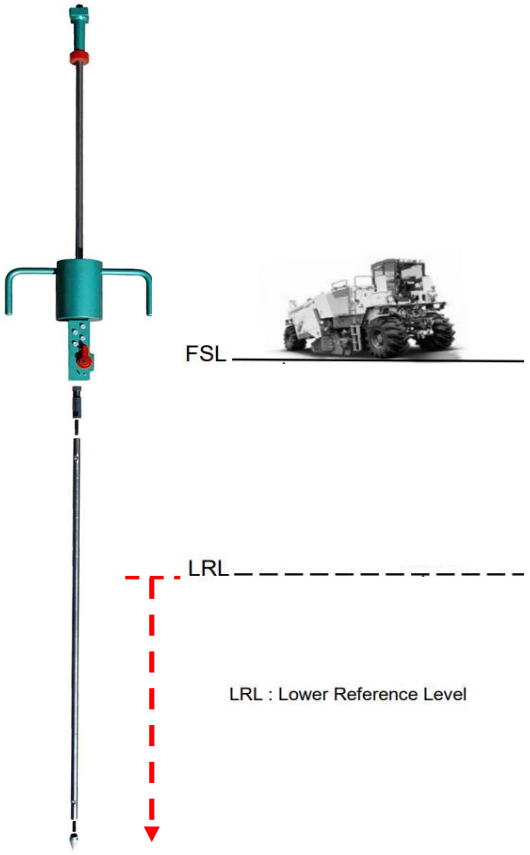
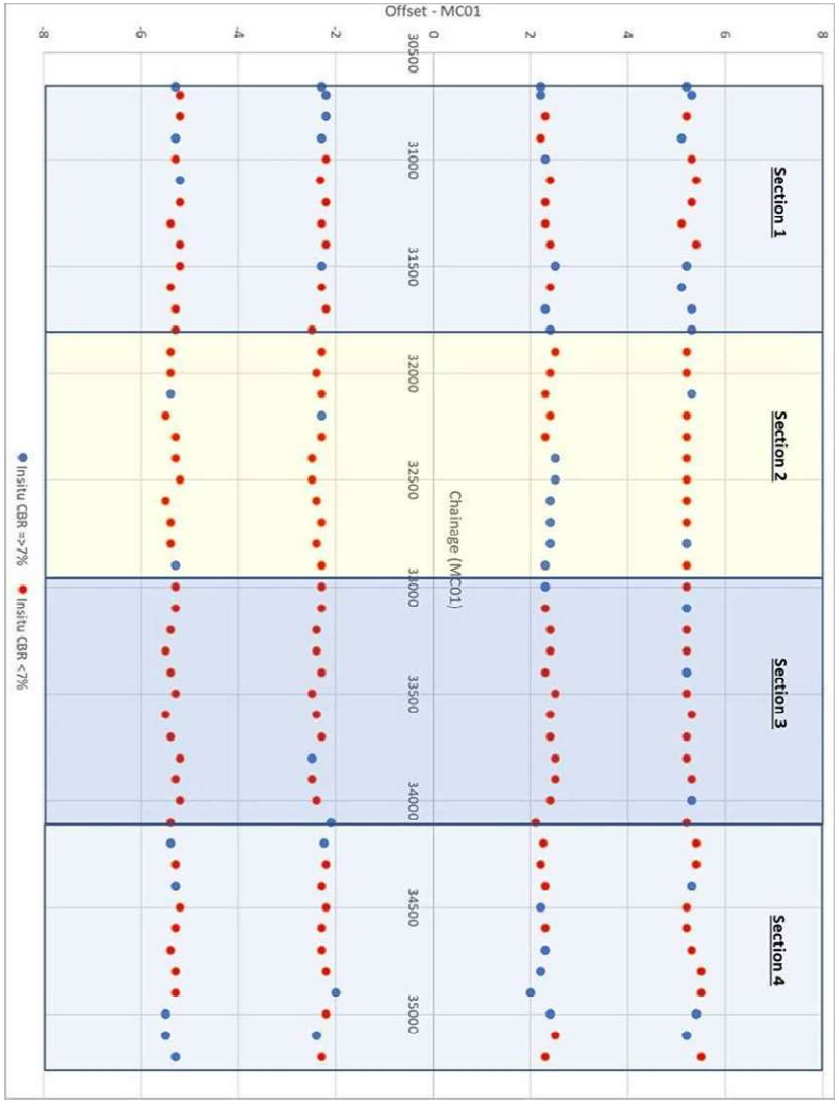
Collinsville Elphinstone Road





- Insitu CBR ≥7%
- Insitu CBR <7%

Tested from the Lower Reference Level prior to construction

The entire project needed to adopt the Type K process under the MRTS115 triple blend subbase

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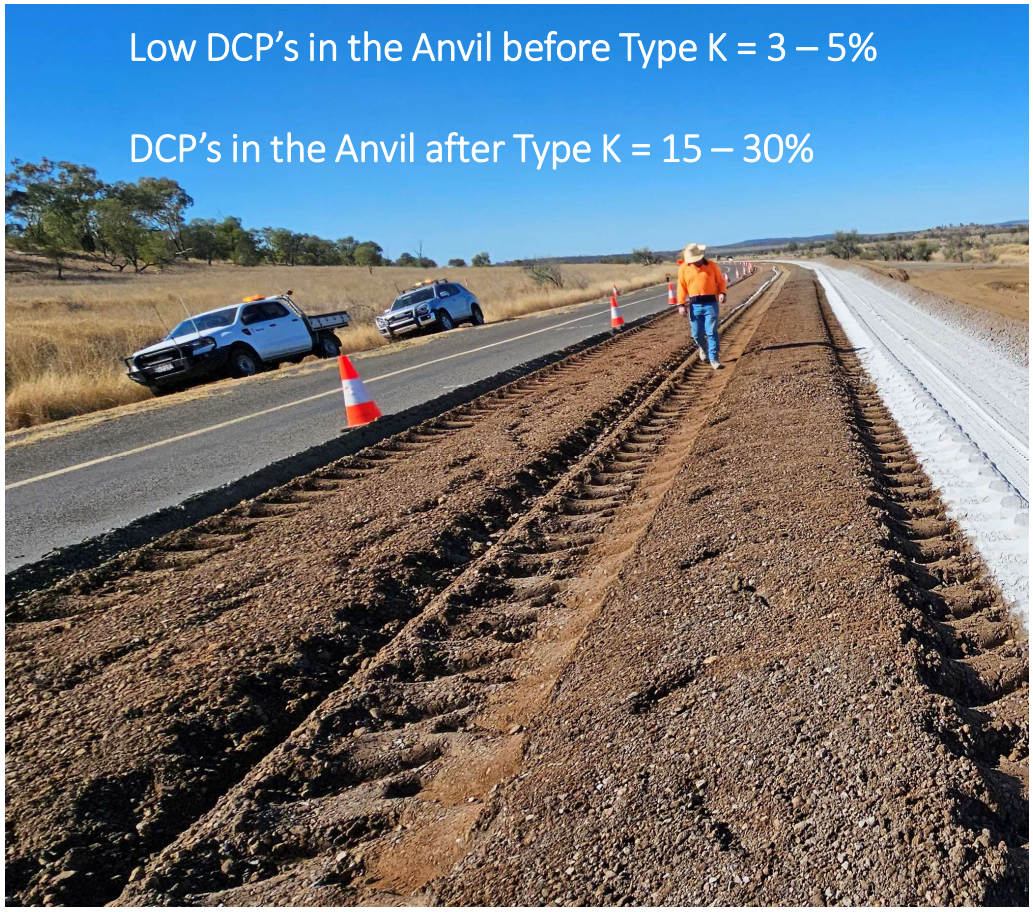
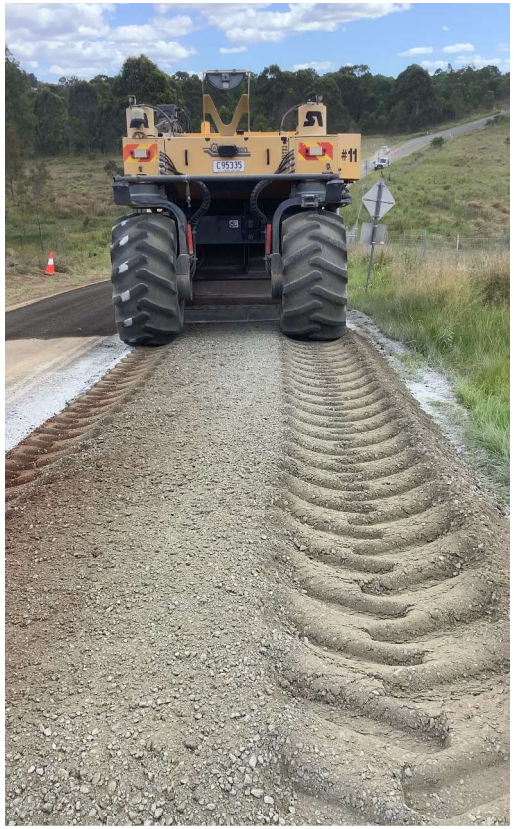
Warrego Highway – Amby (RoadTek)



Deep Dual stage patching with triple blend

September 2022



November 2022

May 2024

Deep Dual stage patching (RoadTek)

Date	13/03/2024												14/03/2024							
Test ID	08-S01	08-S02	08-S03	08-S04	08-S05	08-S06	08-S07	08-S08	08-S11	08-S12	08-S09	08-S10	08-S13	08-S14	08-S15	08-S16	08-S17	08-S18	08-S19	08-S20
Chainage	1.30		1.37		1.75		2.08		2.45		2.68		2.9		3.14		3.75		4.2	
O/S	3.2m Left	4.4m Left	3.2m Left	4.3m Left	3.3m Left	4.4m Left	3.3m Left	4.1m Left	3.2m Left	4.1m Left	3.2m Left	4.1m Left	3.2m Left	4.0m Left	3.2m Left	4.2m Left	3.25m Lef	4.55m Lef	3.1m Left	4.2m Left
Material	Brown sandy clay		Brown sandy clay		Brown clayey sand		Brown clayey sand		Brown Gravelly claye		Brown sandy clay		Brown clayey sand		Brown Cla	Gravelly c	Brown sandy clay		Brown sandy clay	
400-450	0	0	6	11	9	45	14	60	10	35	17	60	30	>60	0	20	16	30	10	4.5
450-500	8	30					20		13		6				4	11	12		3.5	
500-550						50				25								60		
550-600		40		5								45				4				
600-650							30		20		10								8	3
650-700		25			14					35									3	
700-750	10			4									40							
750-800			7														16			
800-850		14								45					2.5	7				
850-900		7		6											5		25			
950-1000			9		12															
1000-1050																				
1050-1100	14	11		12							12								6	3.5

Type K has now been adopted into a number of designs

Summary

- TMR pavement projects often incorporate stabilised subbases over clay subgrades; often as part of rehabilitation of existing roads
- Pavement design can be done for low CBR subgrades; but construction requires a suitable anvil
  - the layer below needs sufficient strength/stiffness to allow compaction
  - typically DCP≥7 required
- Type K deep stabilisation offers a cost-effective method of temporary stiffening of layers below the subbase to allow compaction
  - Limits removal and reinstatement of upper material
  - DCP provides fast, low cost assessment of moisture and support to trigger Type K
- Opportunities for extension into maintenance applications