Revision of the Flexible Pavement Design Method

Road Pavements Forum Feedback

Construction of the experimental sections on R104

6 November 2013

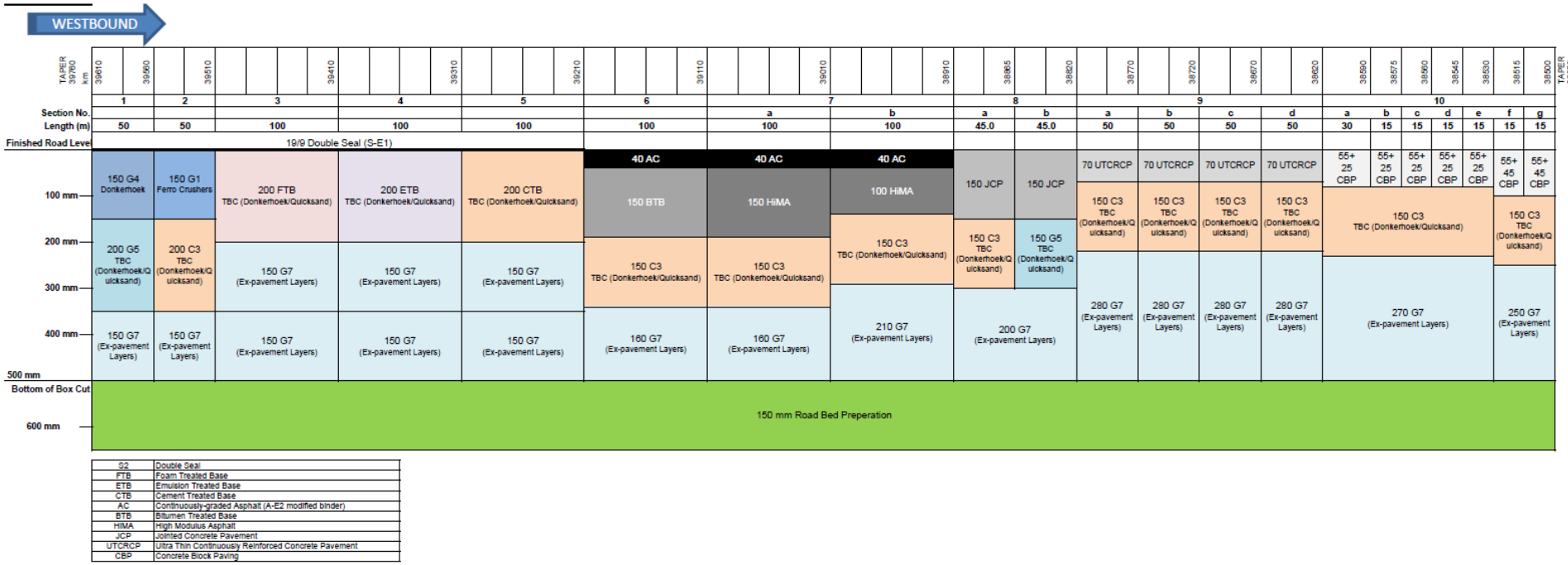
H L Theyse

Construction of the experimental sections on R104

Site location and layout

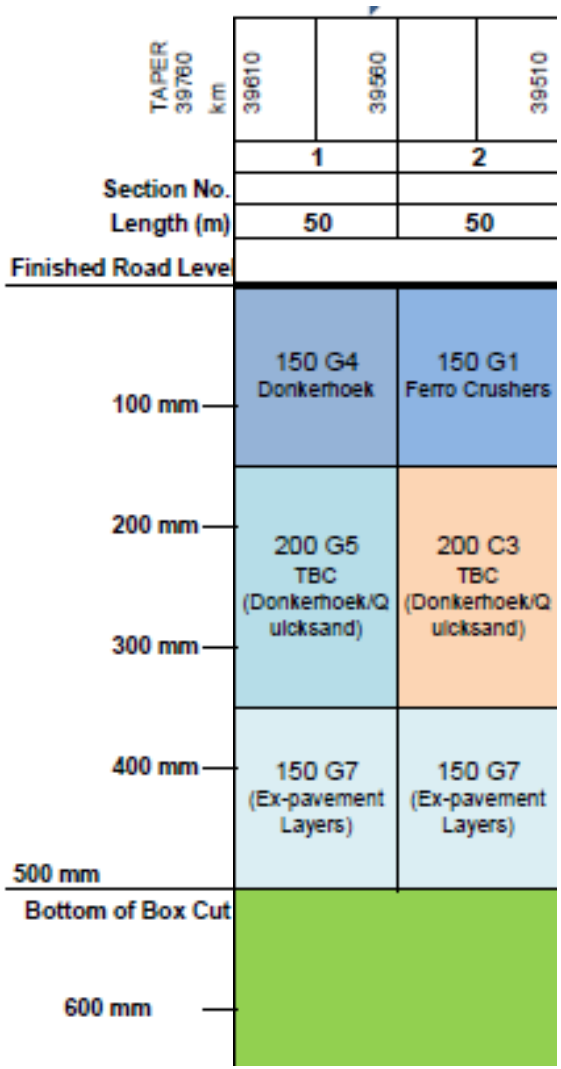
Site location

Site layout – all sections



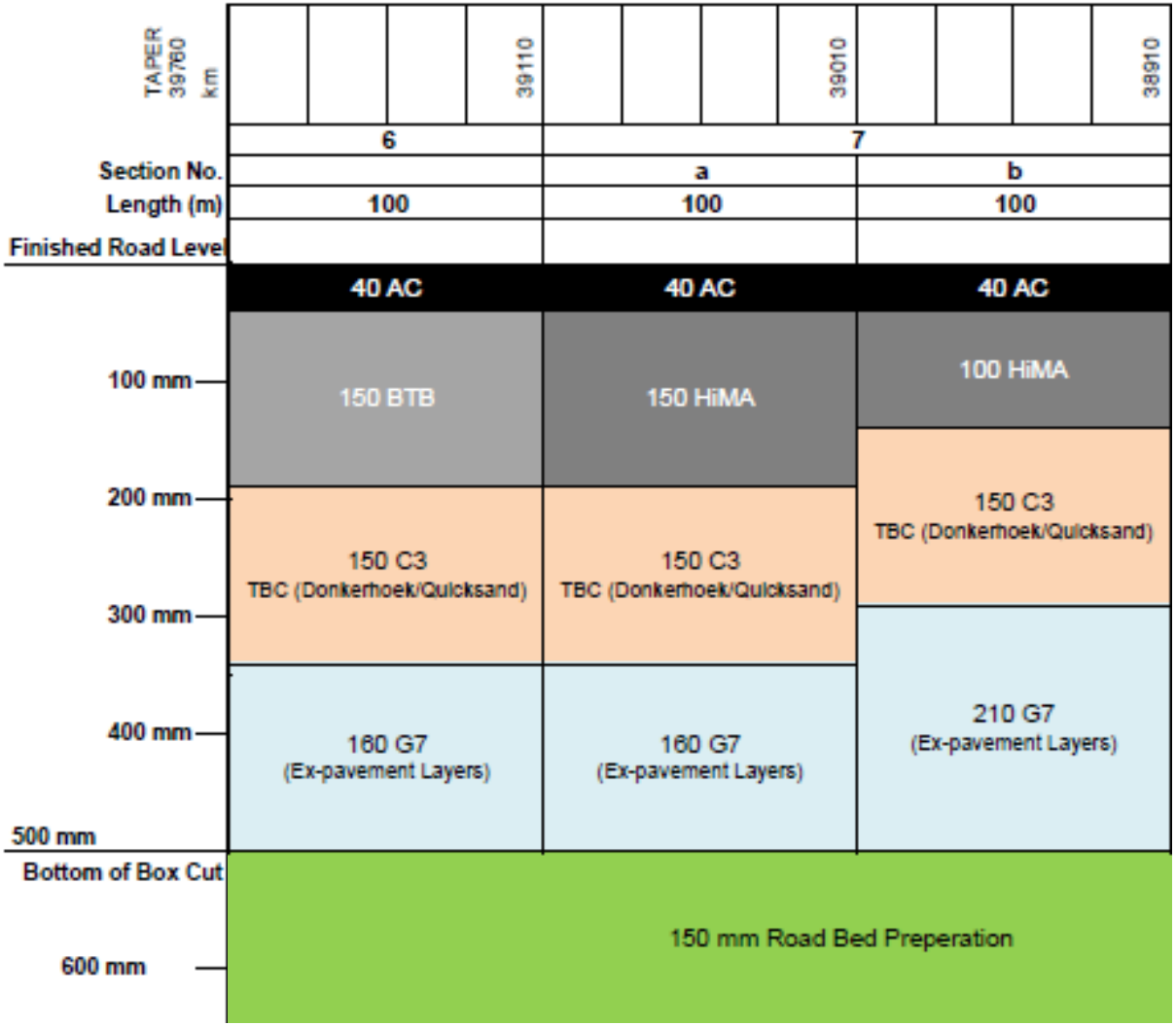
S2	Double Seal
FTB	Foam Treated Base
ETB	Emulsion Treated Base
CTB	Cement Treated Base
AC	Continuously-graded Asphalt (A-E2 modified binder)
BTB	Bitumen Treated Base
HiMA	High Modulus Asphalt
JCP	Jointed Concrete Pavement
UTCRCP	Ultra Thin Continuously Reinforced Concrete Pavement
CBP	Concrete Block Paving

Site layout – granular base sections



Site layout – stabilized base sections

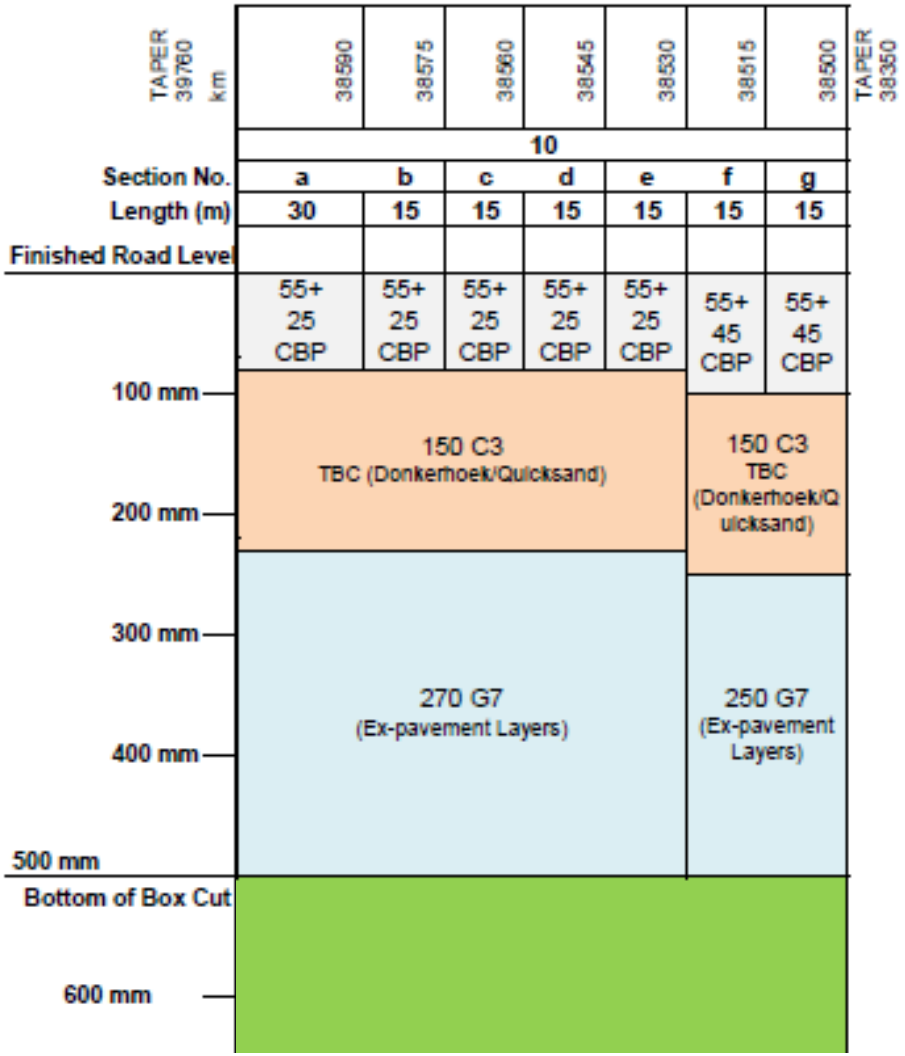
Site layout – hot-mix asphalt sections



Site layout – concrete sections

TAPER 39760 km		38865		38820		38770		38720		38670		38620
	8				9							
Section No.	a		b		a		b		c		d	
Length (m)	45.0		45.0		50		50		50		50	
Finished Road Leve												
	150 JCP		150 JCP		70 UTCRCP		70 UTCRCP		70 UTCRCP		70 UTCRCP	
100 mm					150 C3 TBC (Donkerhoek/Quicksand)		150 C3 TBC (Donkerhoek/Quicksand)		150 C3 TBC (Donkerhoek/Quicksand)		150 C3 TBC (Donkerhoek/Quicksand)	
200 mm	150 C3 TBC (Donkerhoek/Quicksand)		150 G5 TBC (Donkerhoek/Quicksand)									
300 mm					280 G7 (Ex-pavement Layers)		280 G7 (Ex-pavement Layers)		280 G7 (Ex-pavement Layers)		280 G7 (Ex-pavement Layers)	
400 mm	200 G7 (Ex-pavement Layers)											
500 mm												
Bottom of Box Cut												
600 mm												

Site layout – concrete block paver sections



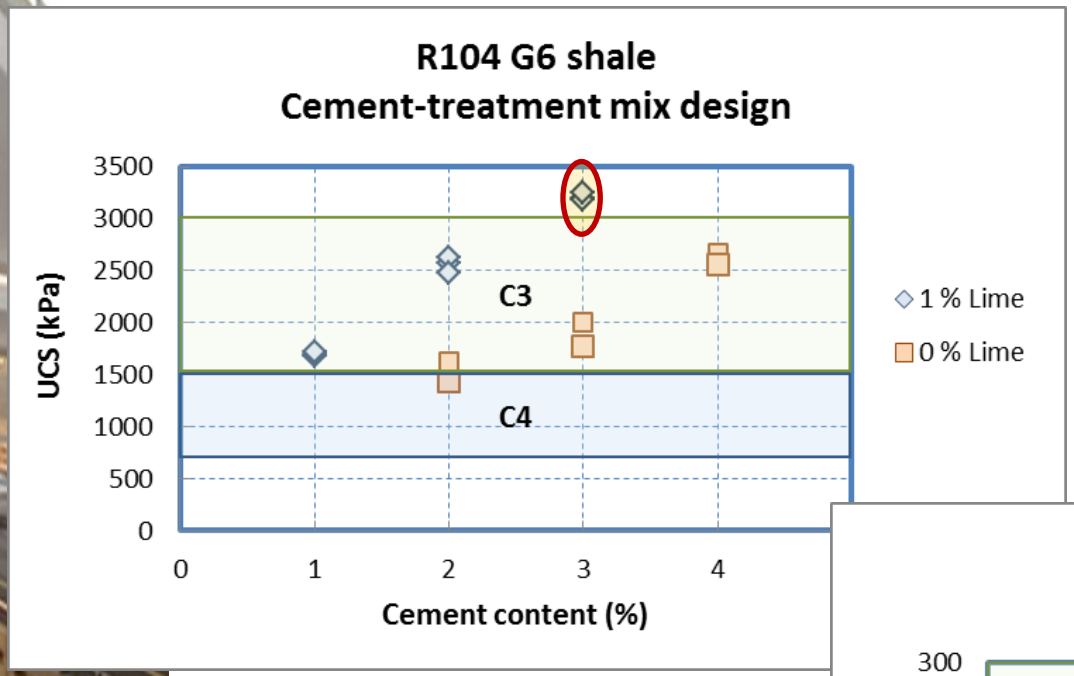
Construction of the experimental sections on R104

Subbase construction

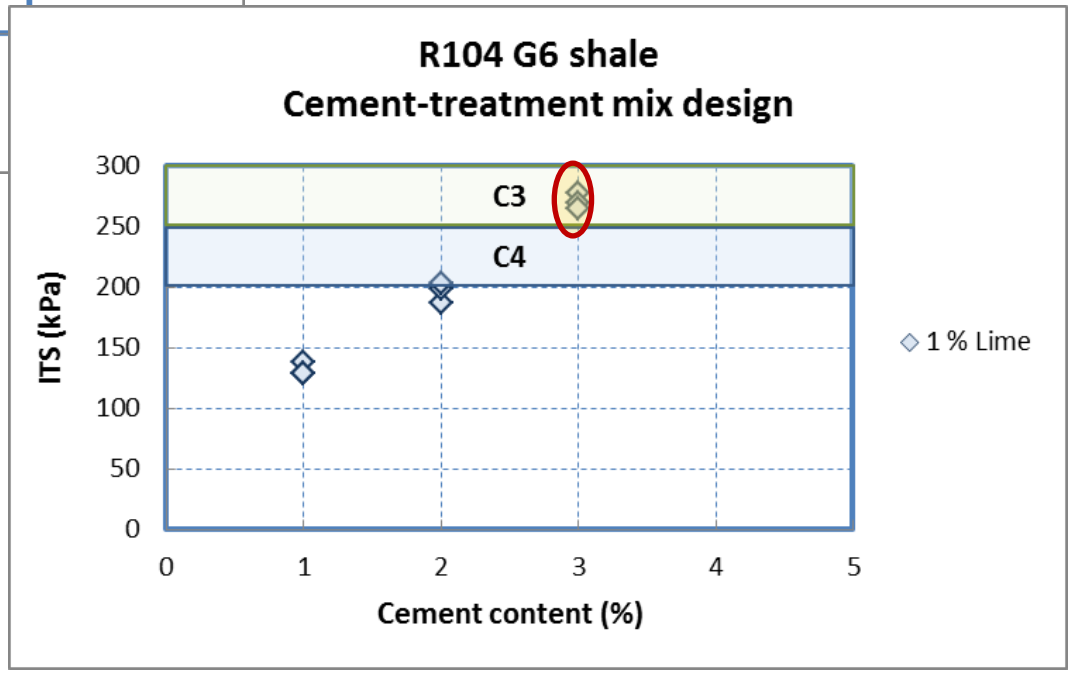
Subbase types

- Granular
  - Section 1 – G5 subbase
  - Sections 3 to 5 – reworked old layers
- **Cement stabilized (C3)**
  - **Section 2 – G1 base**
  - **Sections 6 to 7b – HMA base**
  - **Section 8a – JCP**
  - **Section 9 – UTCRCP**
  - **Section 10 - CBP**

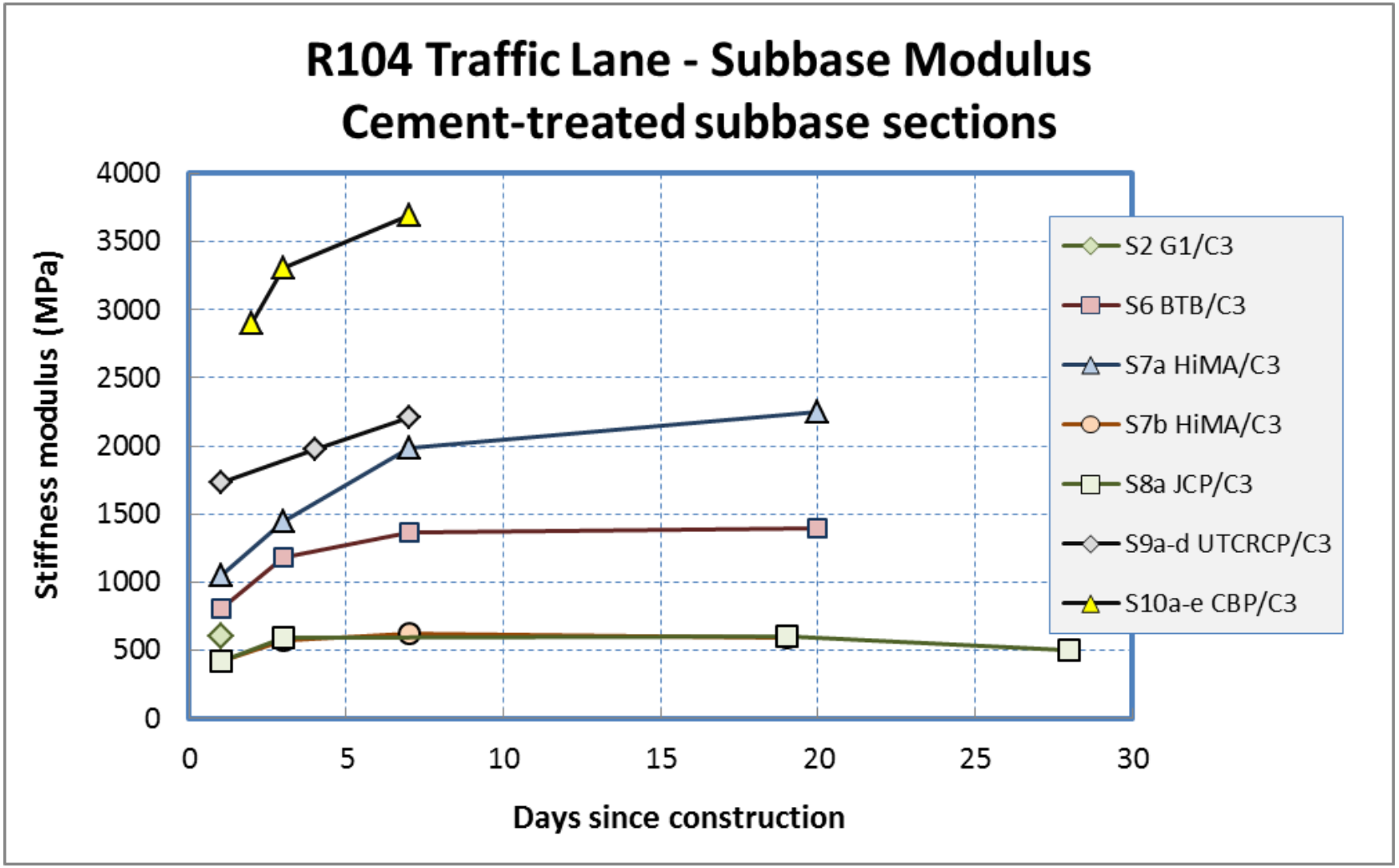
Subbase mix design



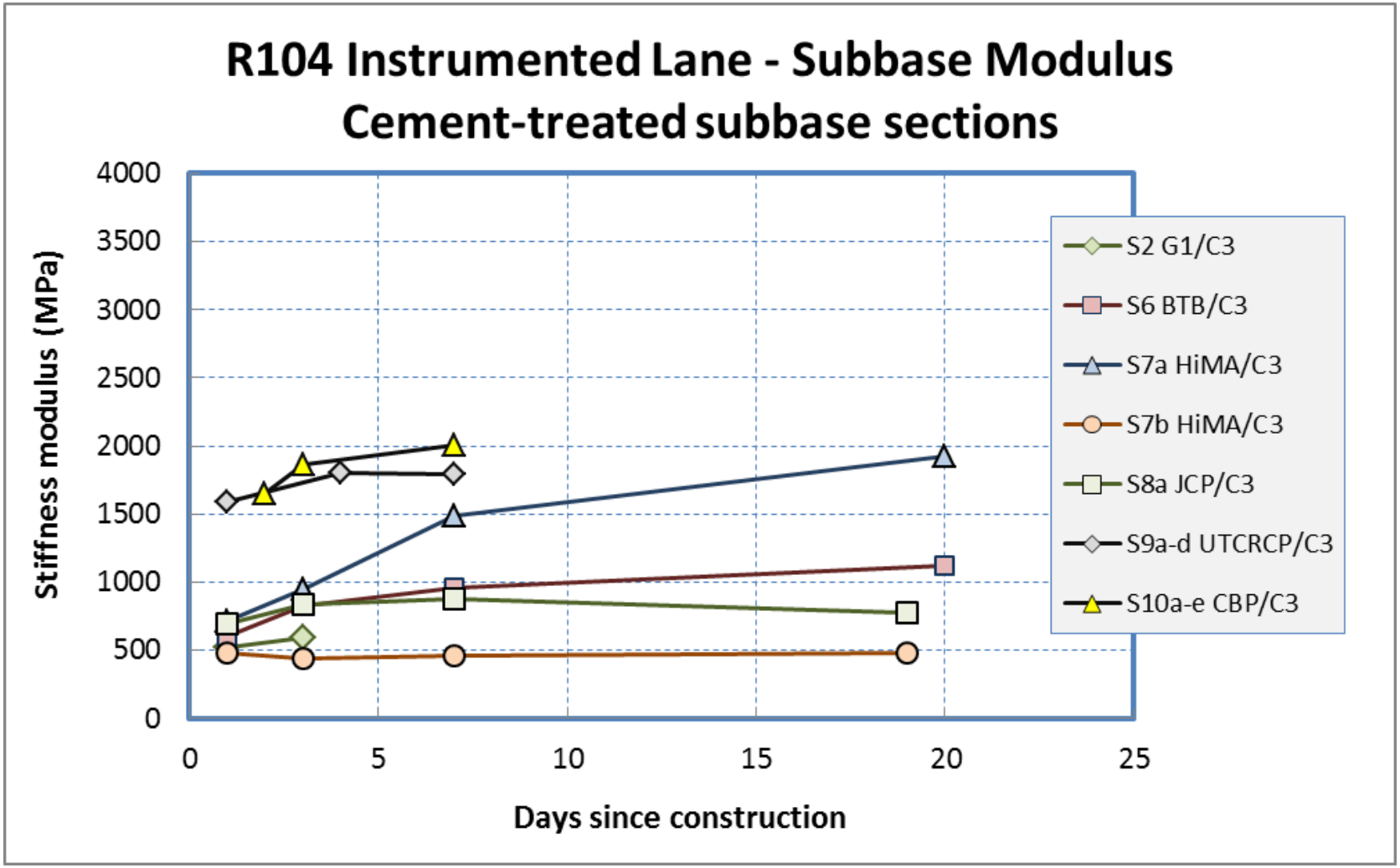
- C3 material
  - G6 burnt shale
  - 1 % lime
  - 3 % cement



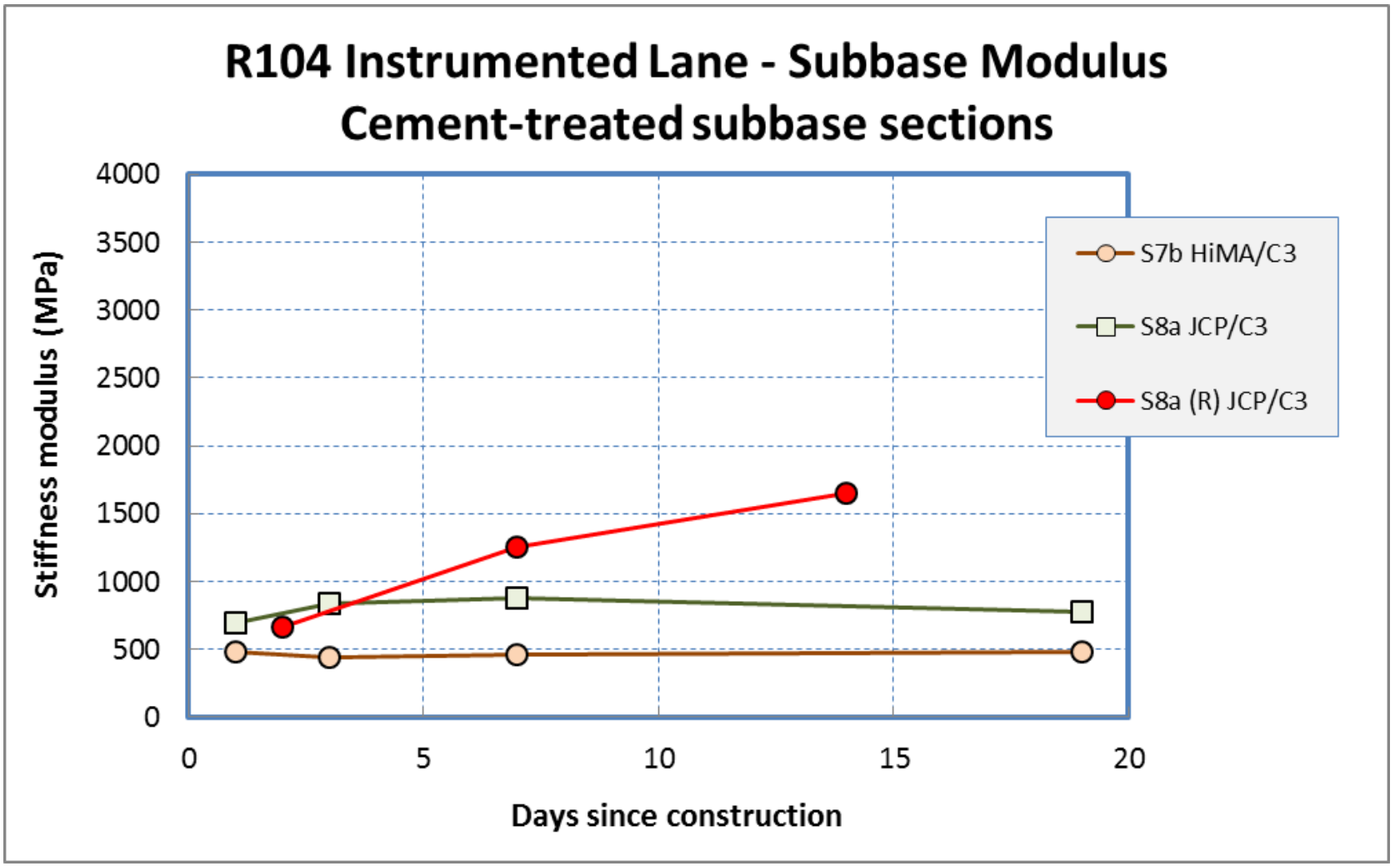
Stabilized subbase – Traffic lane



Stabilized subbase – Instrumented lane



Stabilized subbase – Instrumented lane



Subbase condition summary

- Granular subbase
  - 500 – 600 MPa stiffness directly under FWD
  - Acceptable quality for granular subbase

Subbase condition summary

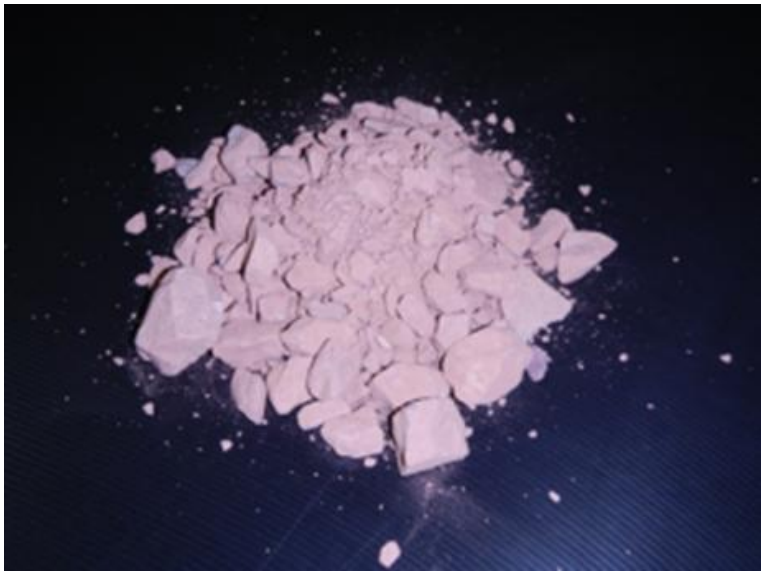
- Cement stabilized (C3)
  - G1 section
    - CS tipped too early to test subbase
  - Sections 6 and 7a – 150 mm BTB and HiMA
    - 1000 to 2500 MPa
  - Section 7b – 100 mm HiMA base
    - **Probably 500 to 1000 MPa**
  - Section 8a – JCP
    - Reworked – probably higher than 2000 MPa
  - Section 9 and 10
    - Very stiff – probably higher than 2500 MPa

Construction of the experimental sections on R104

G1 Base construction

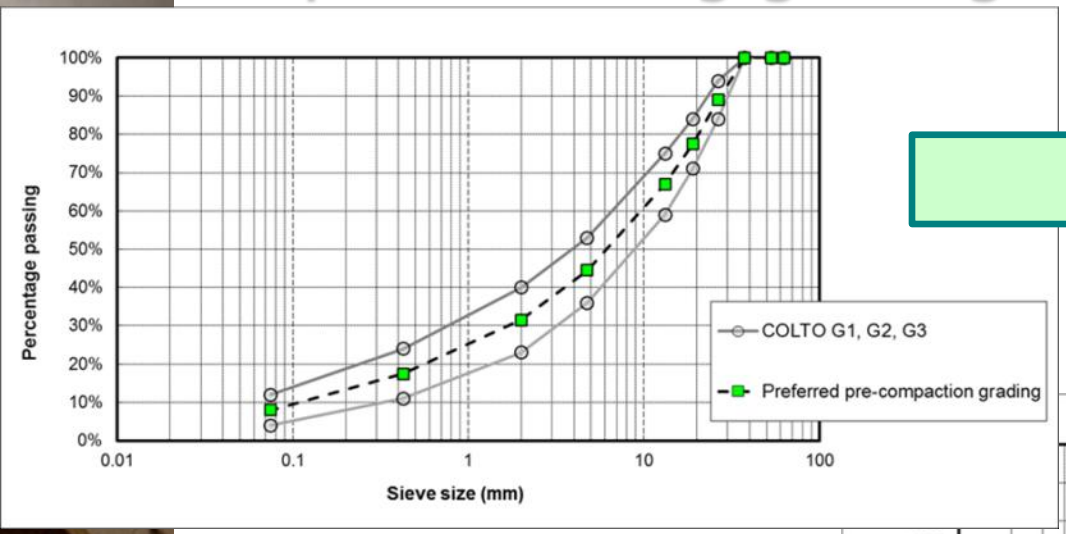
H Theyse & E Kleyn

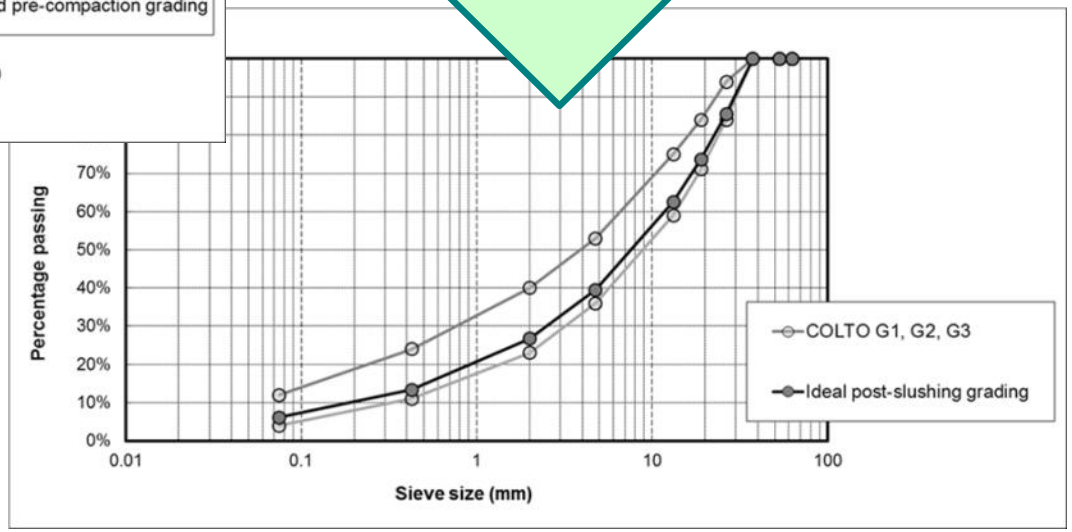
R104 G-nothing construction



Background

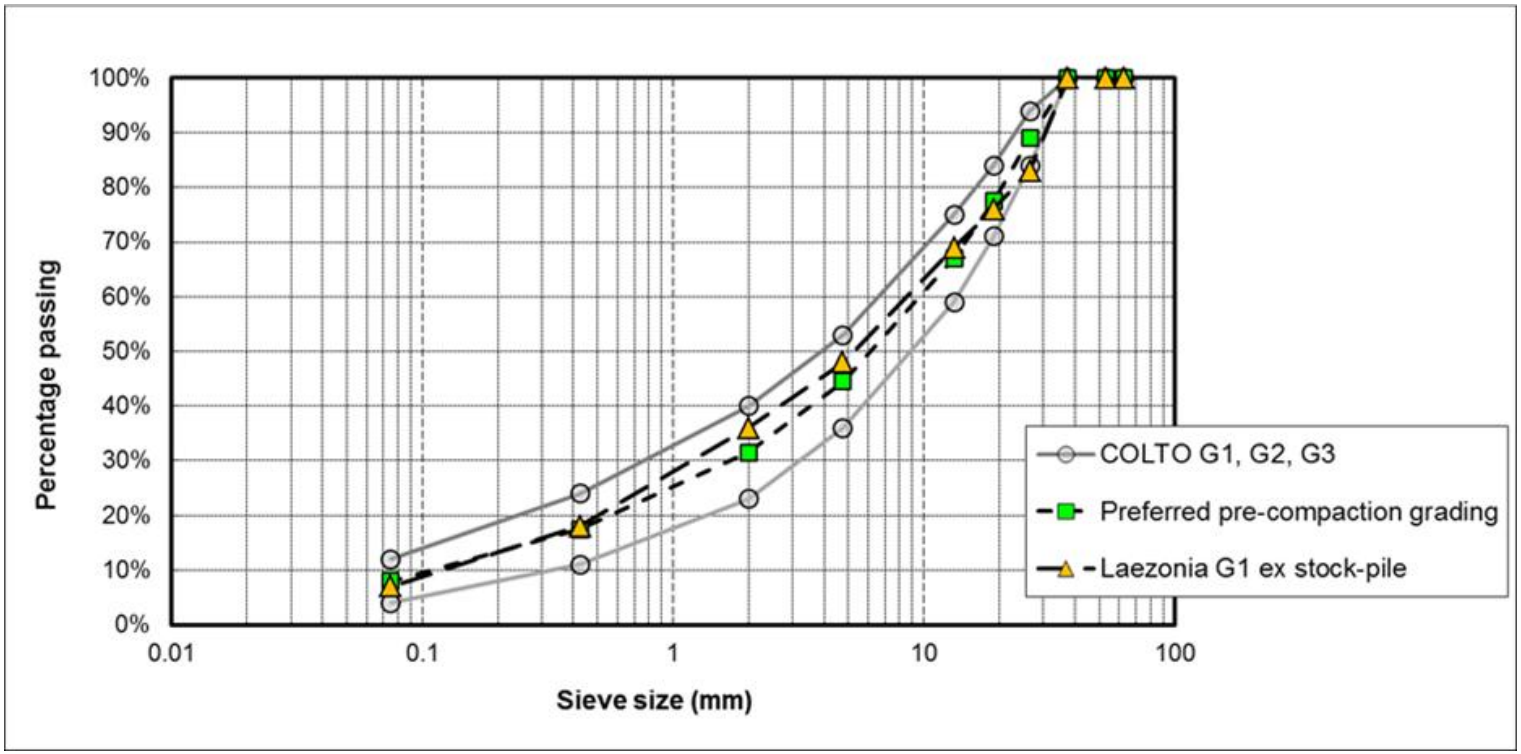
- The purpose of slushing is to get from the preferred pre-compaction grading to the ideal post-slushing grading





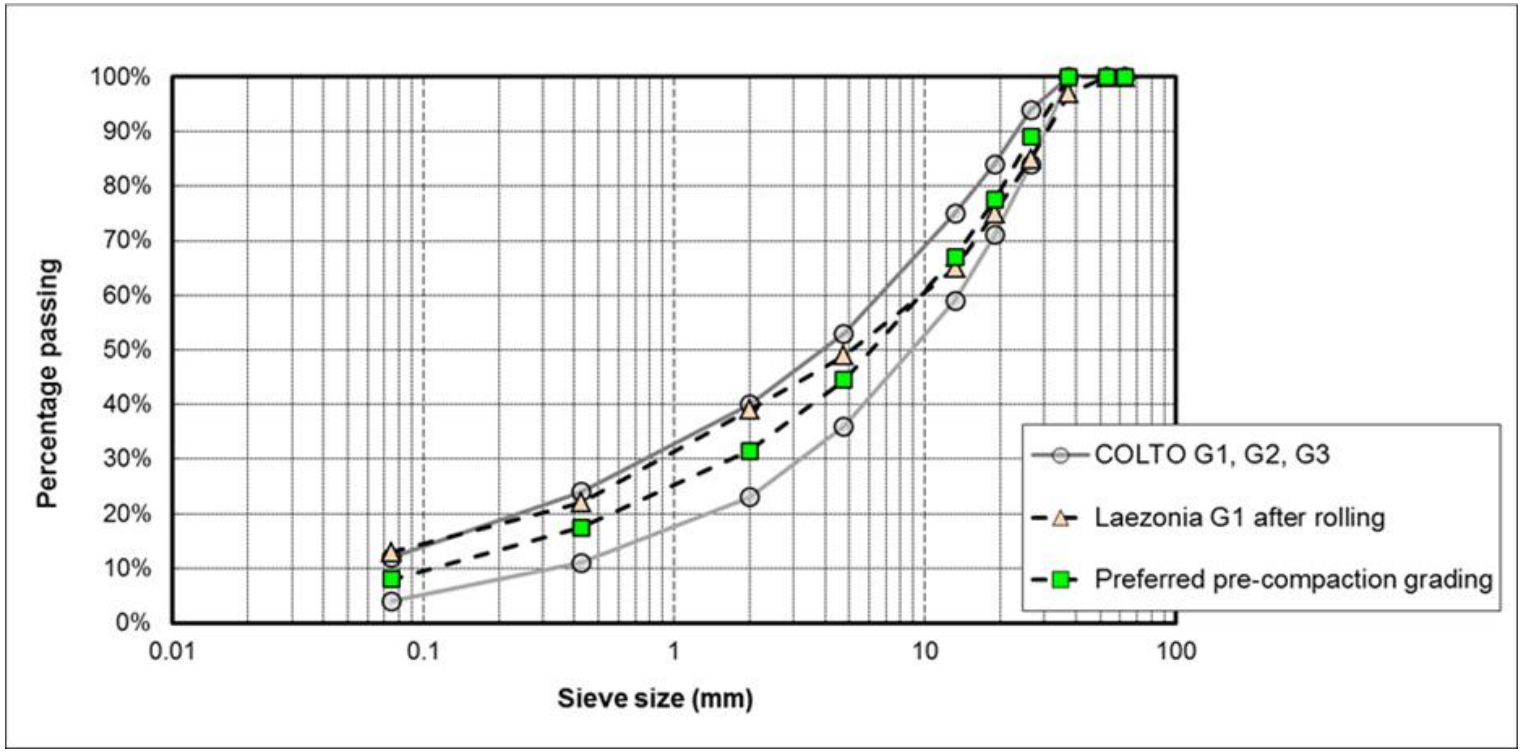
Material test results – R104

- Stockpile grading



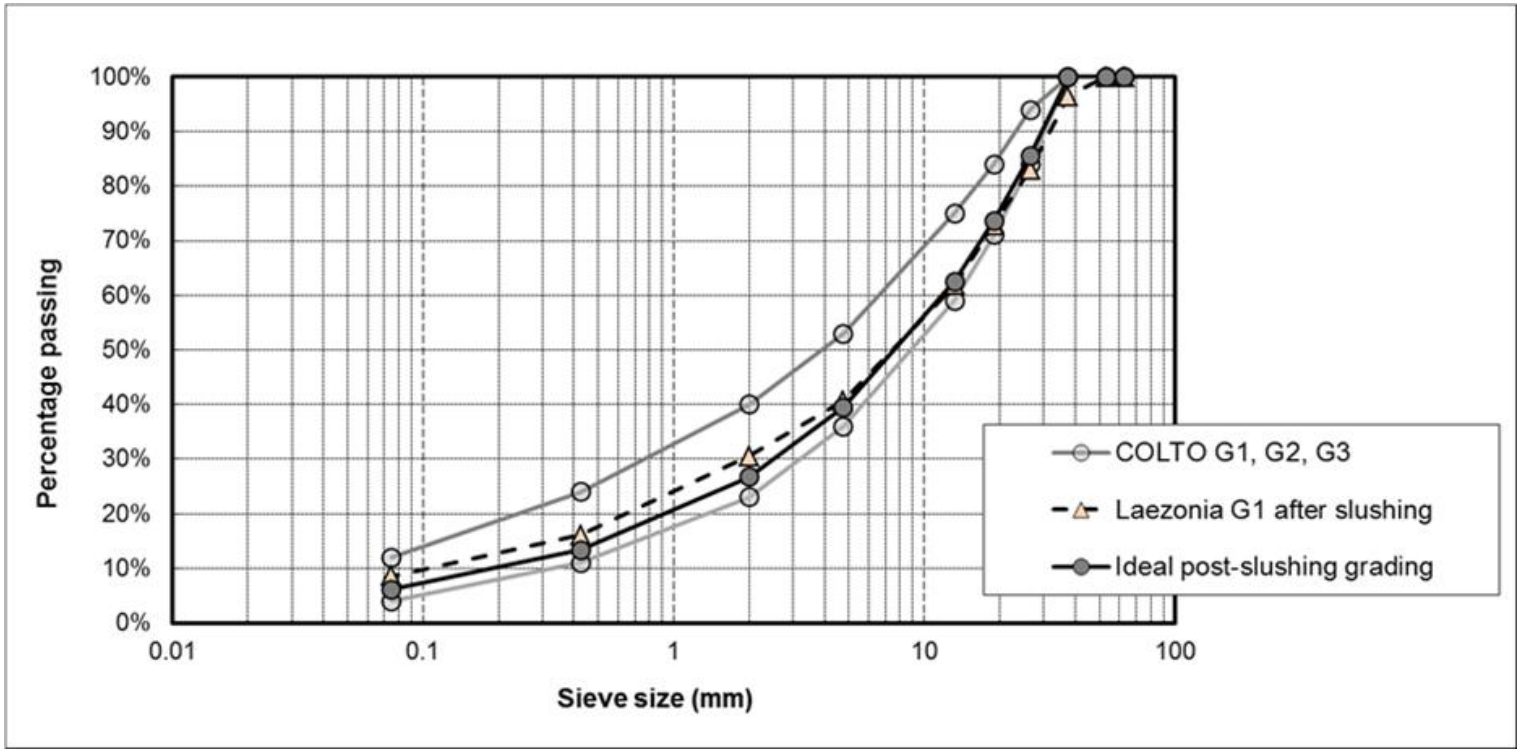
Material test results – R104

- Field grading after excessive rolling



Material test results – R104

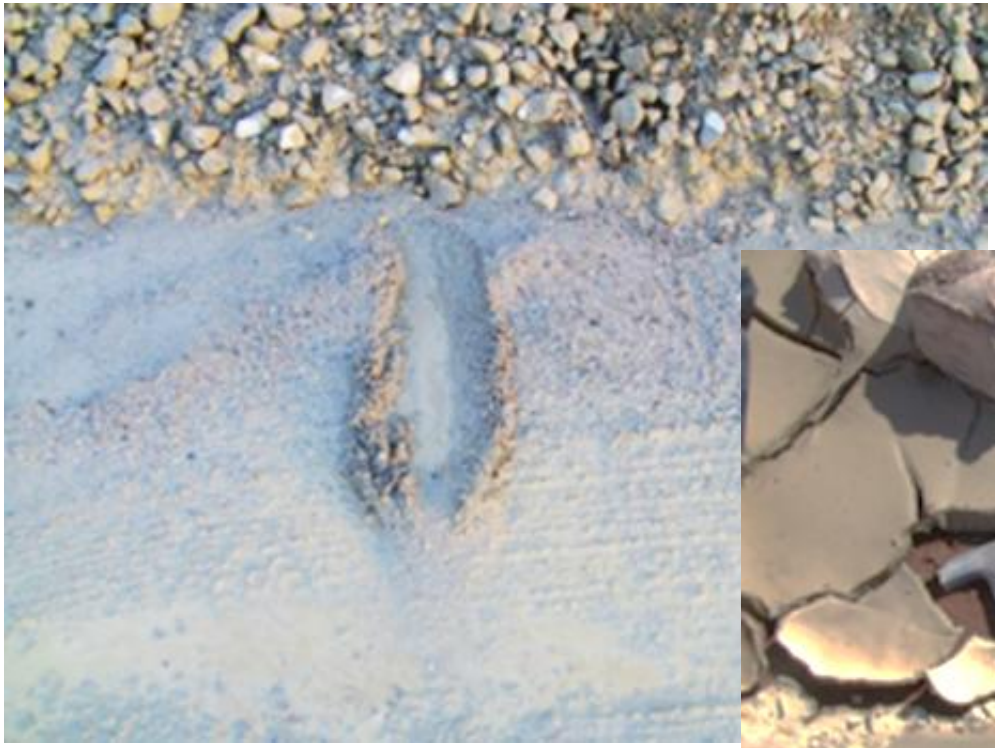
- Field grading after slushing



R104 – G1 construction

Material test results – R104

- Record volumes of material removed by slushing

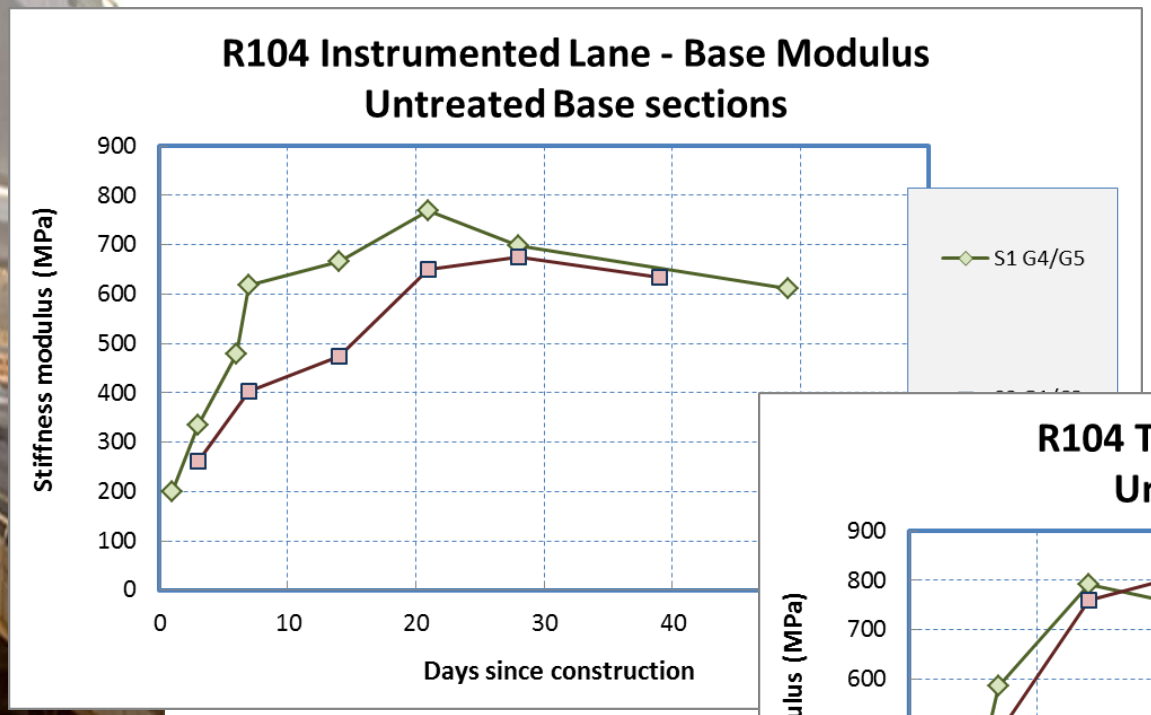


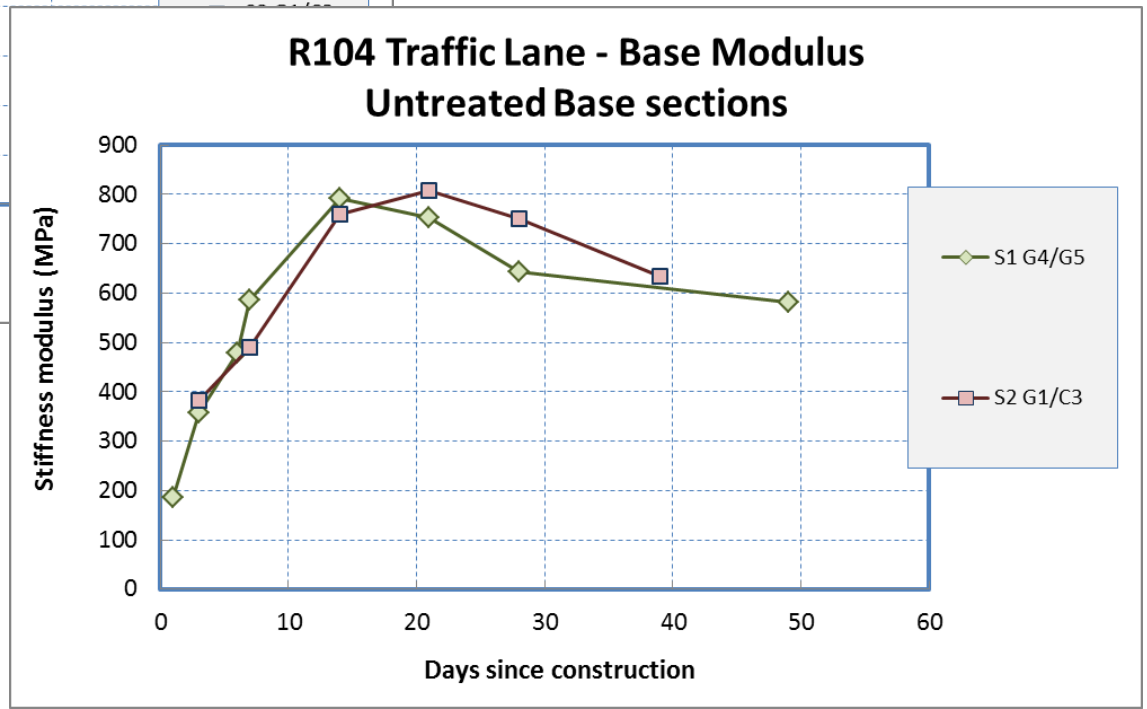
Material test results – R104 G1 density

Chainage	C-L offset (m)	Apparent density (kg/m³)	Field dry density (kg/m³)	Field moisture content (%)	Relative density (%)
39+510	8.0	2727	2463	2.9	90.3
39+520	5.5	2842	2510	3.1	88.3
39+530	3.0	2707	2450	2.9	90.5
39+540	5.1	2710	2461	3.3	90.8
39+550	8.0	2715	2422	3.1	89.2
39+550	2.8	2729	2431	3.3	89.1

R104 unbound granular bases

- FWD base moduli after construction





R104 G1 – Conclusions

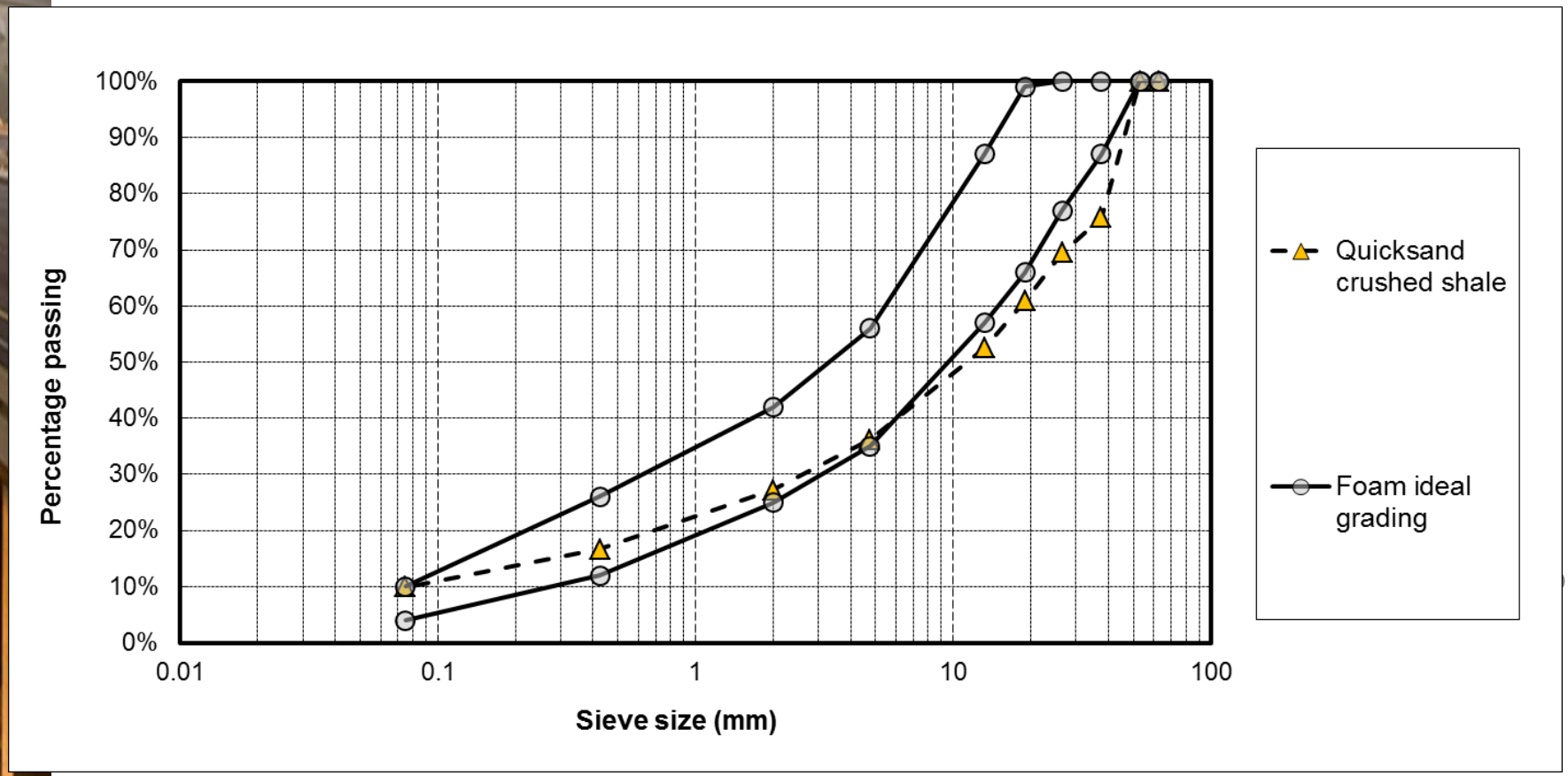
- G1 base layer construction successful under the guidance of E Kleyn
- Contrary to popular believe the construction process is
  - Neither complicated
  - Nor time-consuming
- Recommendations made to amend COLTO grading specifications
  - Preferred pre-compaction grading
  - Ideal target grading after slushing

Construction of the experimental sections on R104

Stabilized base construction

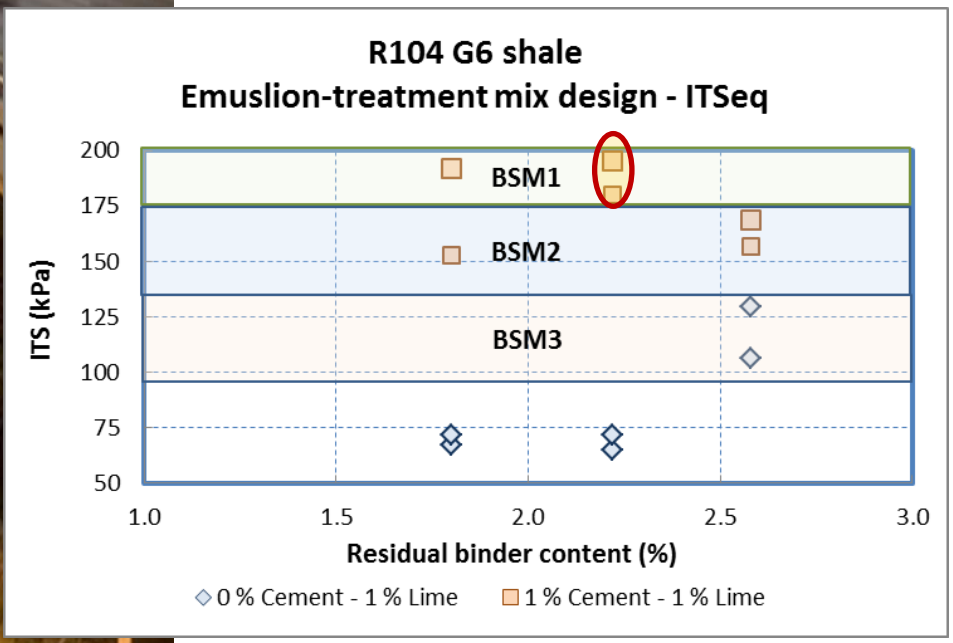
BSM mix design - aggregate

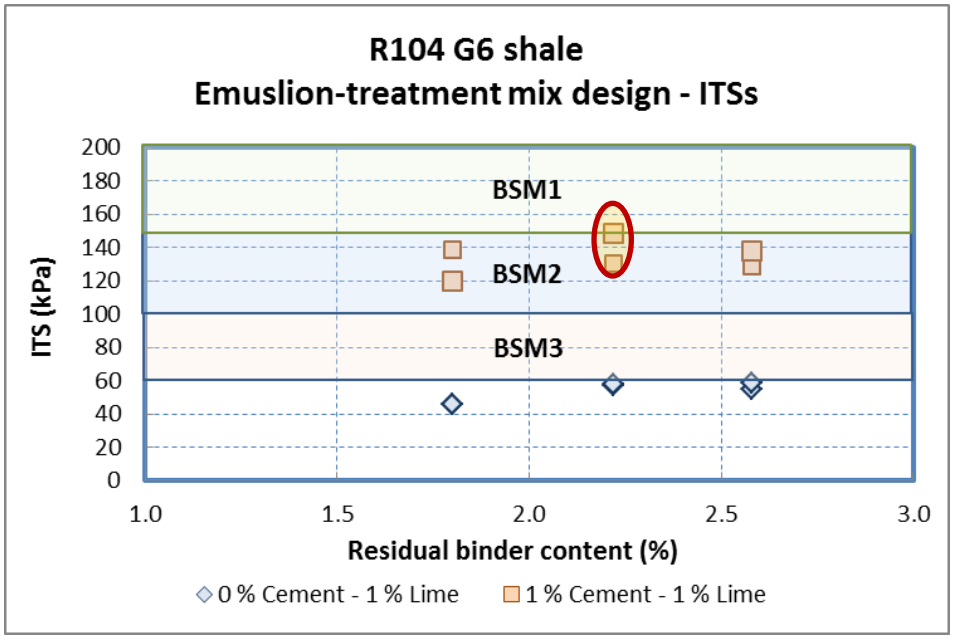
- G6 burnt shale
- GM = 2,46
- PI = 9
- MDD = 2202 kg/m^3
- OCMC = 6,6 %



BSM emulsion mix design

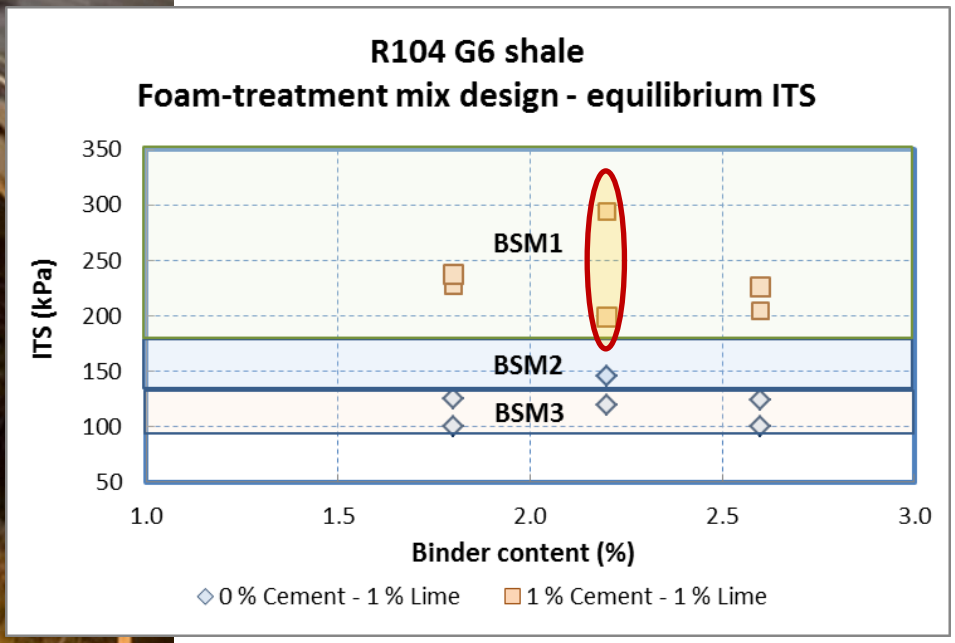
- Tested
  - 0 % lime - 1 % cement
  - 0 % lime - 2 % cement
  - 1 % lime - 0 % cement
  - 1 % lime - 1 % cement
- Selected
  - 1 % lime
  - 1 % cement
  - 3,7 % emulsion
  - 2,2 % residual binder

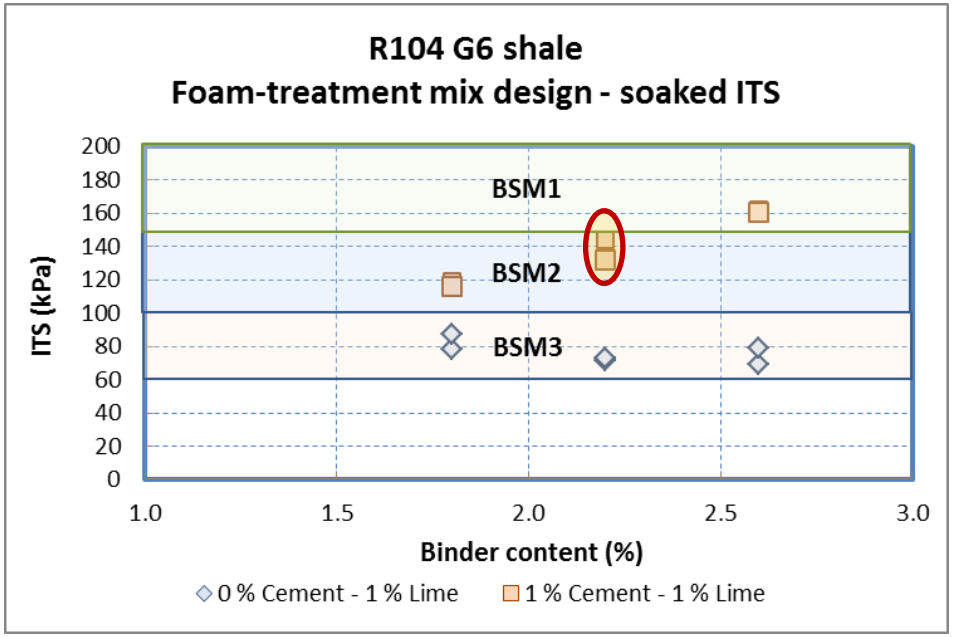




BSM foam mix design

- Tested
  - 0 % lime - 1 % cement
  - 0 % lime - 2 % cement
  - 1 % lime - 0 % cement
  - 1 % lime - 1 % cement
- Selected
  - 1 % lime
  - 1 % cement
  - 2,2 % binder

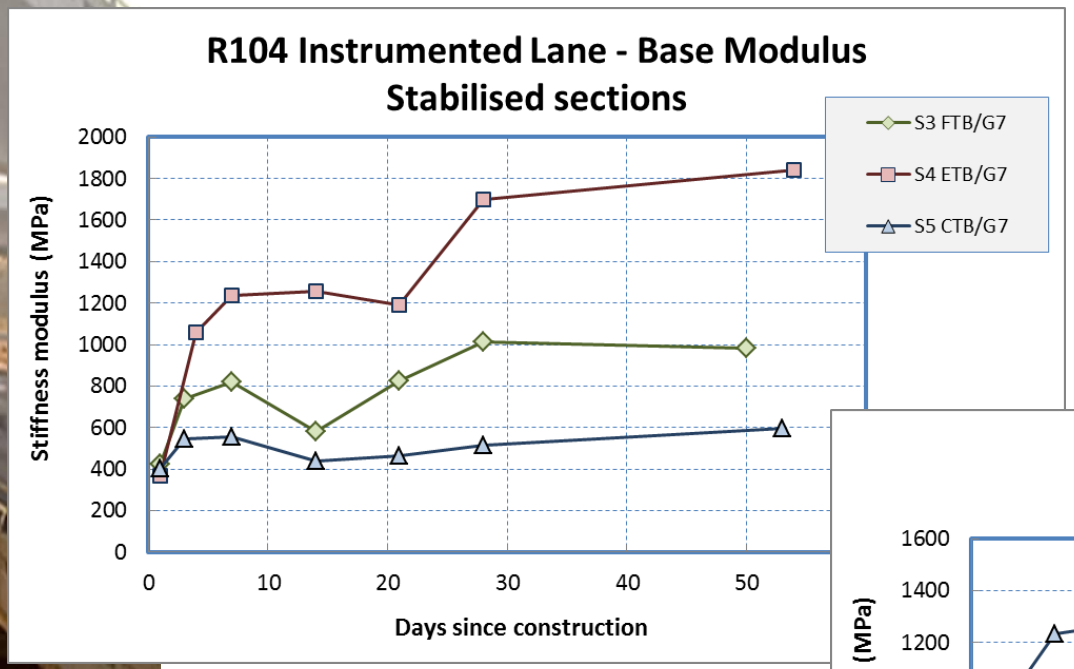


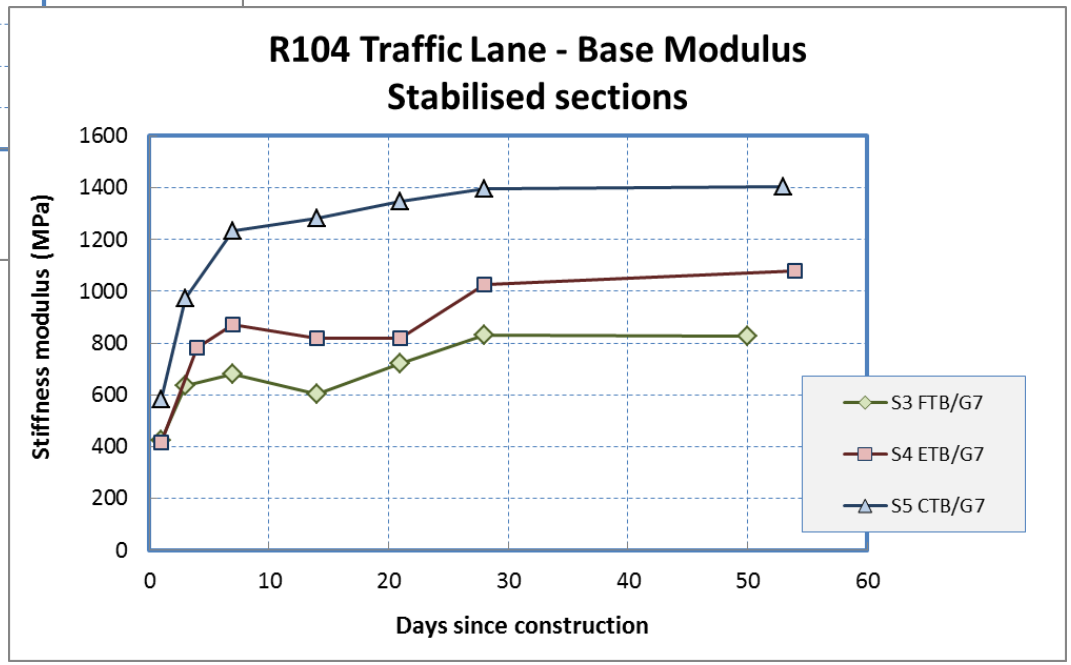


R104 construction of stabilized bases

R104 stabilized bases

- FWD base moduli after construction





R104 construction of stabilized bases

- Why the low stiffness on instrumented lane CTB?

R104 construction of stabilized bases

- Why the low stiffness on instrumented lane CTB?

R104 stabilized bases – Conclusions

- Section 3 – Cement-treated base
  - Weak strips at longitudinal joint between two DISR cuts
    - Segregation observed
    - Low stiffness identified from FWD on instrumented lane
    - 500 MPa after 28 days
  - Much stiffer material on central portion of DISR cut
    - Confirmed with FWD and acoustic sensing
    - 1400 MPa after 28 days

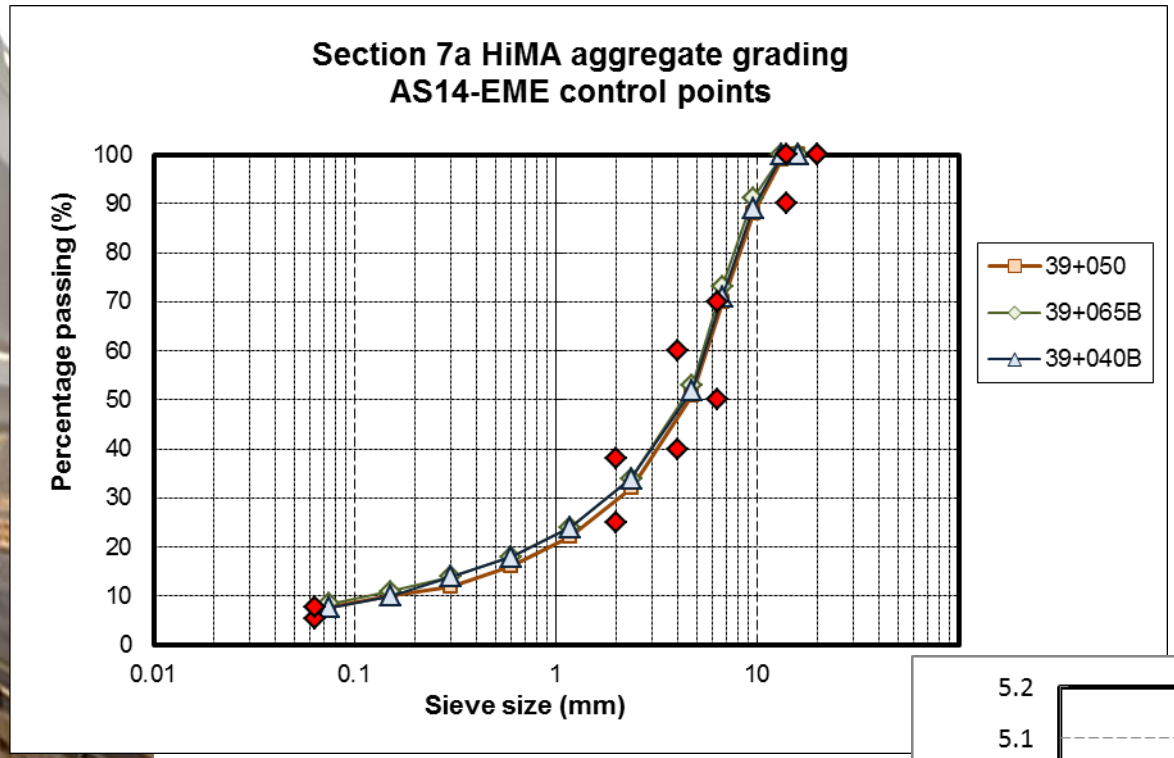
R104 stabilized bases – Conclusions

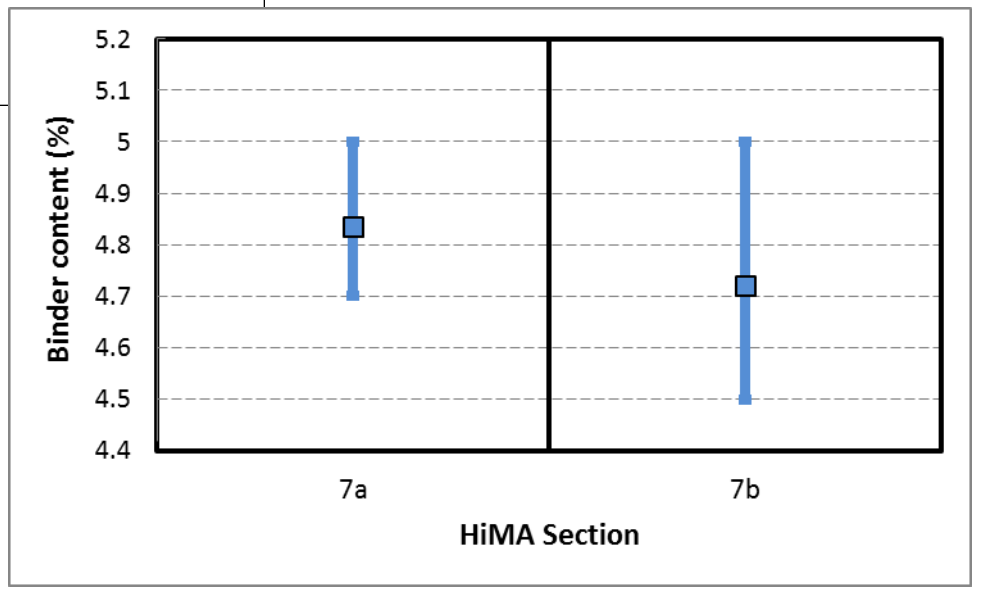
- Sections 4 and 5 – BSM bases
  - BSM emulsion
    - Traffic lane – 1000 MPa stiffness after 28 days
    - Instrumented lane – 1700 MPa stiffness after 28 days
  - BSM foam
    - Traffic lane – 800 MPa stiffness after 28 days
    - Instrumented lane – 1000 MPa stiffness after 28 days

Construction of the experimental sections on R104

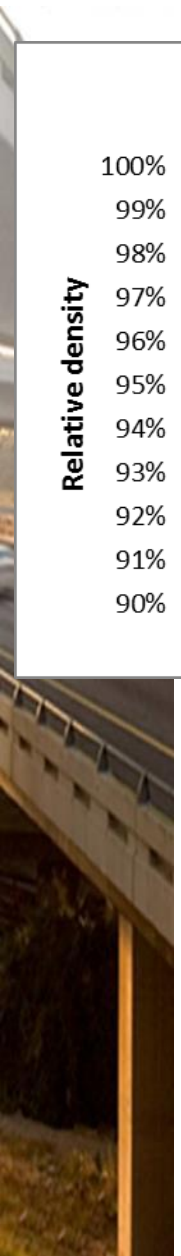
Construction of hot-mix asphalt bases

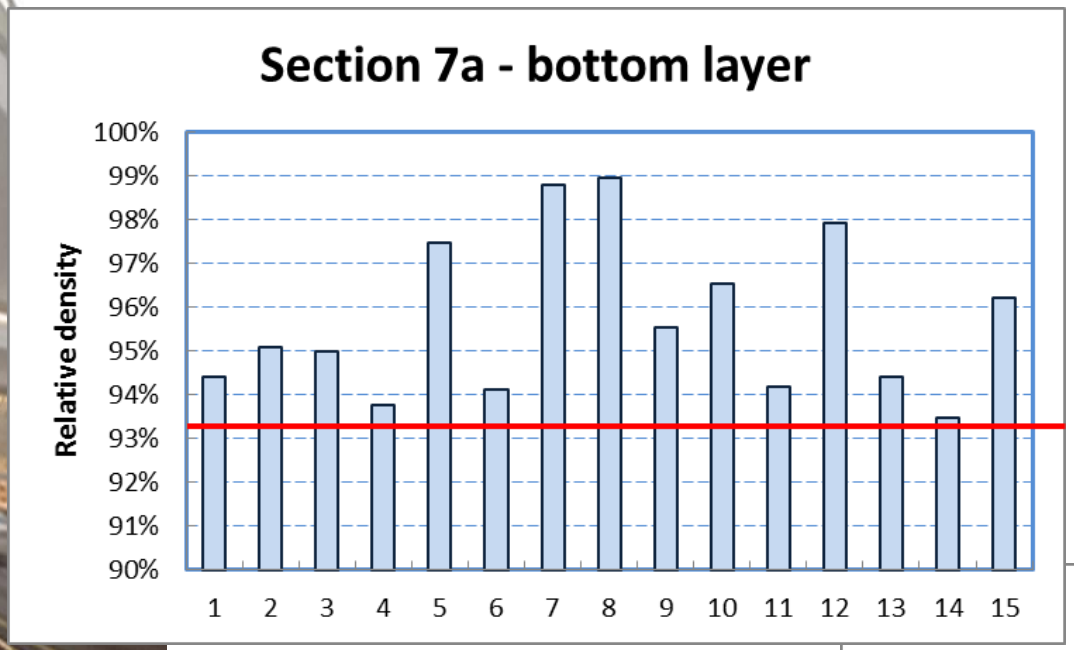
HiMA Mix

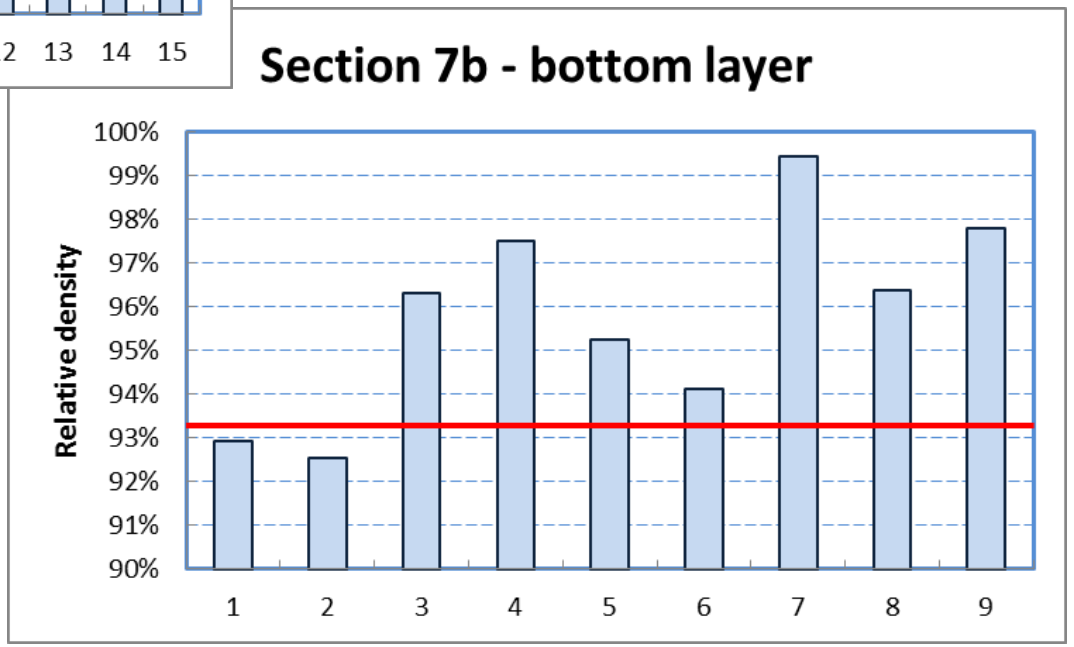

Section 7a HiMA aggregate grading
AS14-EME control points
Percentage passing (%)
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
Sieve size (mm)
39+050
39+065B
39+040B


Binder content (%)
5.2
5.1
5
4.9
4.8
4.7
4.6
4.5
4.4
7a
7b
HiMA Section

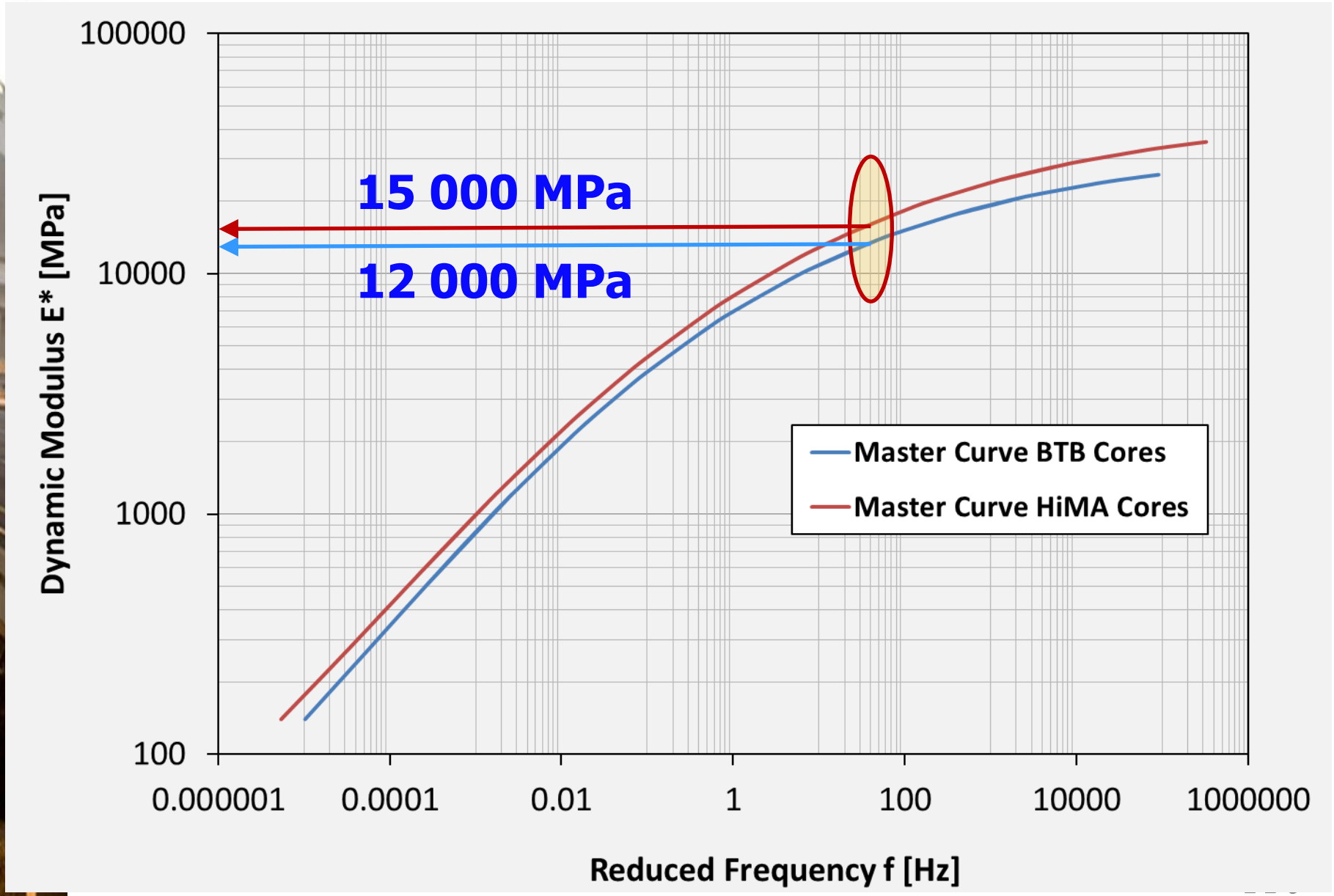
HiMA Mix




Section 7a - bottom layer
Relative density
100%
99%
98%
97%
96%
95%
94%
93%
92%
91%
90%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

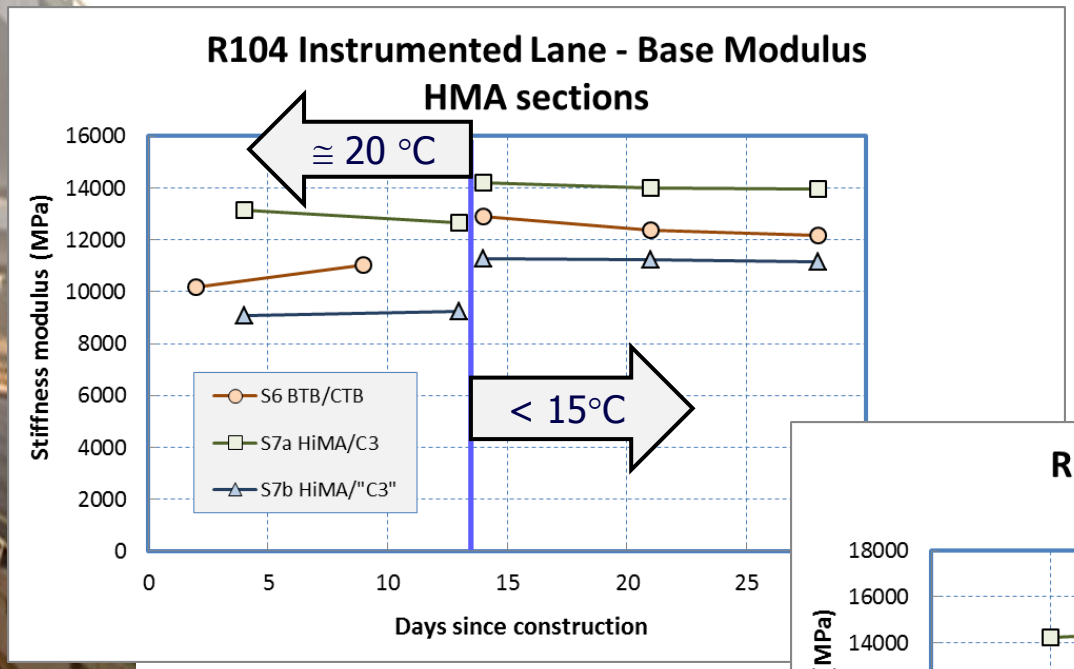

Section 7b - bottom layer
Relative density
100%
99%
98%
97%
96%
95%
94%
93%
92%
91%
90%
1 2 3 4 5 6 7 8 9

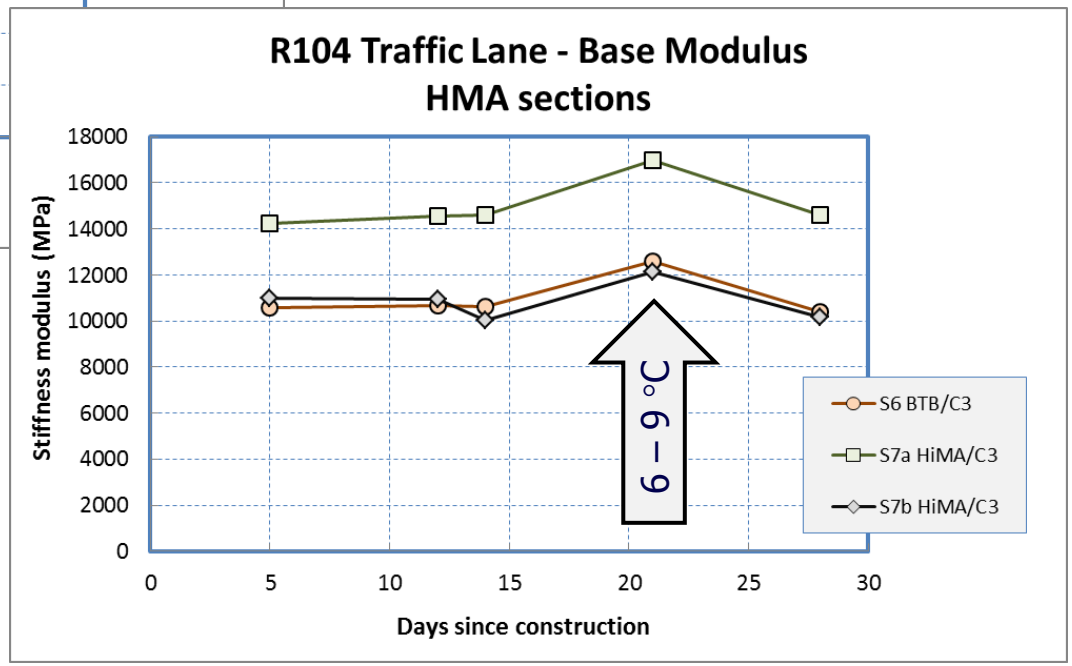
Laboratory results on cores



R104 hot-mix asphalt bases

- FWD base moduli after construction





R104 hot-mix asphalt bases – Conclusions

- Section 6 – 150 mm BTB base
  - Good subbase support
    - 1 000 to 1 500 MPa stiffness
  - High FWD stiffness on both lanes
    - 10 000 to 12 000 MPa with higher stiffness occurring at lower temperatures

R104 hot-mix asphalt bases – Conclusions

- Section 7a – 150 mm HiMA base
  - Excellent subbase support
    - 2 000 to 2 500 MPa stiffness
  - Very high FWD stiffness on both lanes
    - 13 000 to 17 000 MPa with higher stiffness occurring at lower temperatures
- Section 7b – 100 mm HiMA base
  - Weak subbase support
    - 500 to 600 MPa stiffness
  - Reasonable FWD stiffness
    - Traffic lane - 10 000 to 12 000 MPa very similar to BTB
    - Instrumented lane - 9 000 to 11 000 MPa
- Good agreement between FWD and lab
  - Repeat FWD tests in summer at higher temperature

R104 construction – Closing statement

- Similar to other experimental sections, the variability of stabilized layers is surprisingly high
  - Even under "controlled" experimental conditions
- Proper G1 available for testing
- Unfortunately the support of 100 mm HiMA is different from other HMA sections
- Concrete and block paving sections
  - Blocks ripped-out under traffic
  - Replaced with thicker blocks on instrumented lane