Revision of the South African Pavement Design Method Phase 3

Road Pavements Forum

13 May 2015

Project SAPDM/D-3: Stabilised Material

H Theyse

R35 Bethal - Objectives

- Assess properties of BSM foam, BSM emulsion and cement treated sections
  - Initial properties
  - Medium-term changes in properties
- Compare the performance of BSM foam, BSM emulsified and cement stabilised sections under similar traffic and environmental conditions
- Compare the performance of thin asphalt (AC) and Cape seal (S4) on the above base types
- Assess the accuracy of the design models available (2012) for stabilised material

R35 Bethal - Status in November 2012

- Planning document completed
- Pavement and mix design completed
- Construction
  - Southbound base construction
    - Started on **11 April 2012**
    - Completed on **7 May 2012**
  - Northbound base construction
    - Started on **1 August 2012**
    - Completed on - **6 September 2012**

R35 Bethal - Status in November 2012

- Section identification

Material type	Material symbol	Lime [%]	Cement [%]	Residual binder [%]
Cement stabilised	C3	1 %	2 %	NA
BSM emulsion	ETB1	NA	1 %	2.4 %
	ETB2	NA	2 %	2.4 %
	ETB3	NA	1 %	0.9 %
BSM foam	FTB1	NA	1 %	2.4 %
	FTB2	NA	2 %	2.4 %

Pavement structures

Southbound

Cement content:	2%	2%	1%	1%	2%	2%	1%	1%	2%	2%	
Lime content:	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	
Bitumen content:	0%	0%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
425	**575**	**350**	**350**	**350**	**350**	**350**	**350**	**350**	**350**	**350**	**350**
G1(1)	G1(2)										
200 C3 Sub(1)	200 C3 Sub(2)	200 C3(1)	200 C3(2)	175 ETB1	200 ETB1	175 ETB2	200 ETB2	175 FTB1	200 FTB1	175 FTB2	200 FTB2
425	425	150	700	700		700		700		700	
SANRAL											
km 6,925	km 6,350	km 6,500	km 6,850	km 7,200	km 7,550	km 7,900	km 8,250	km 8,600	km 8,950	km 9,300	km 9,650	km 10,000

Northbound

Cement content:	2%	1%	1%	1%	2%	2%	1%	1%	2%	2%	
Lime content:	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Bitumen content:	0%	0.9%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
333	**333**	**334**	**350**	**350**	**350**	**350**	**350**	**350**	**350**	**350**	**350**	**350**
G1(1)	G1(2)	G1(3)										
200 C3 Sub(1)	200 C3 Sub(2)	200 C3 Sub(3)	200 C3(1)	200 ETB3	175 ETB1	200 ETB1	175 ETB2	200 ETB2	175 FTB1	200 FTB1	175 FTB2	200 FTB2
333	333	334	350	350	350	350	350	350	350	350	350	350
SANRAL												
km 5,833	km 6,166	km 6,500	km 6,850	km 7,200	km 7,550	km 7,900	km 8,250	km 8,600	km 8,950	km 9,300	km 9,650	km 10,000

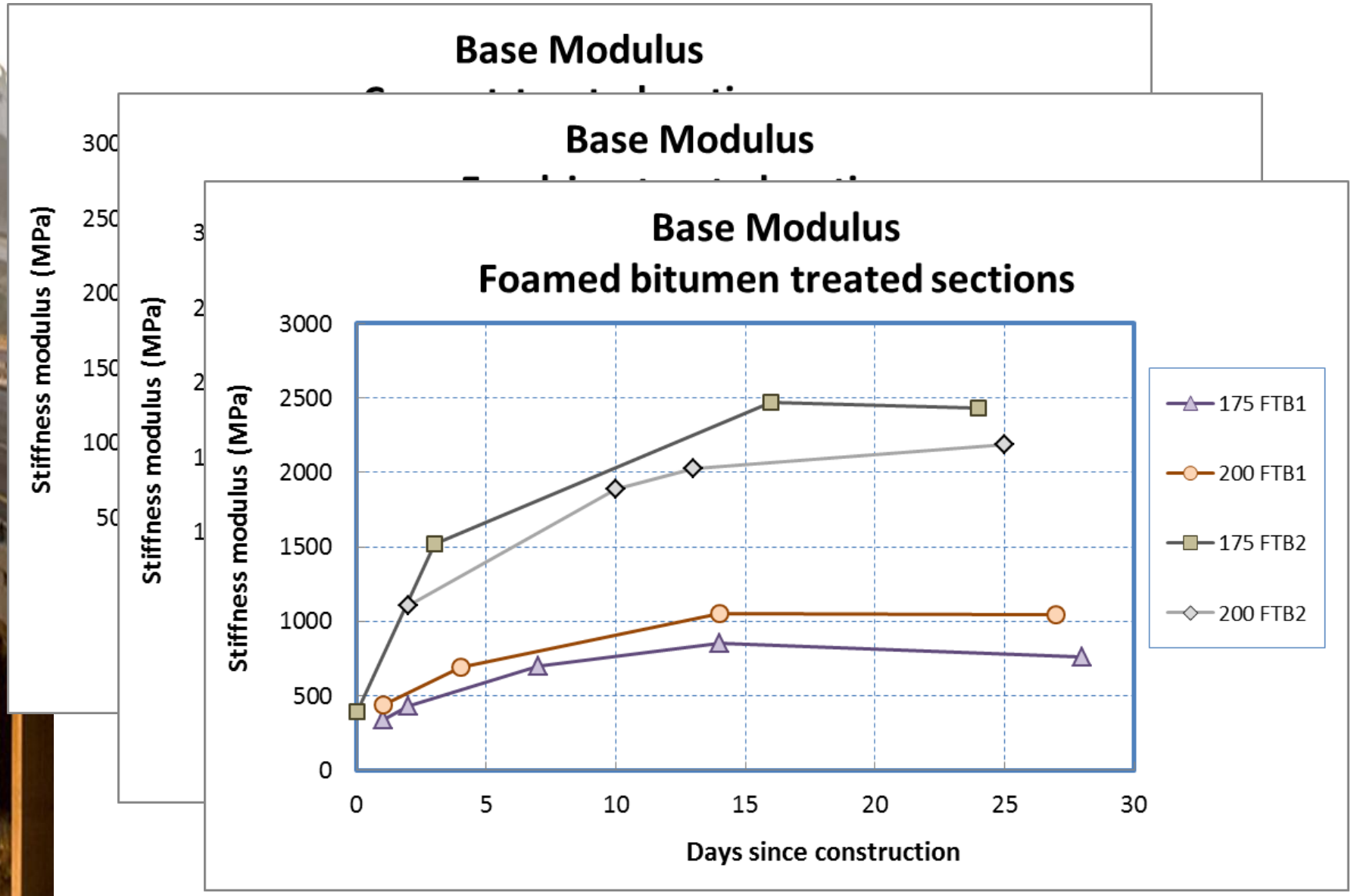
Curing of stabilised sections

Short-term properties of stabilised material

Monitoring of curing period

Days since construction	Tests	Responsibility
1 day	1) Visual condition 2) FWD 3) LWD 4) 3 x cores for UCS, ITS and moisture content	Site supervision SRT CSIR/SSI Site supervision
7 days	1) FWD 2) LWD 3) 3 x cores for UCS, ITS and moisture content	SRT CSIR/SSI Site supervision
14 days	1) FWD 2) LWD 3) 3 x cores for UCS, ITS and moisture content	SRT CSIR/SSI Site supervision
28 days	1) FWD 2) LWD 3) DCP 4) 3 x 150 mm Ø cores for UCS and MC 5) 3 x 150 mm Ø cores for ITS and MC 6) 10 x 150 mm Ø cores for tri-axial tests and MC 7) 1 x 500 mm x 500 mm slab for flexural beam tests	SRT SSI PMC Site supervision

Monitoring of curing period: FWD temporal variation on SB



2-Year Performance Assessment

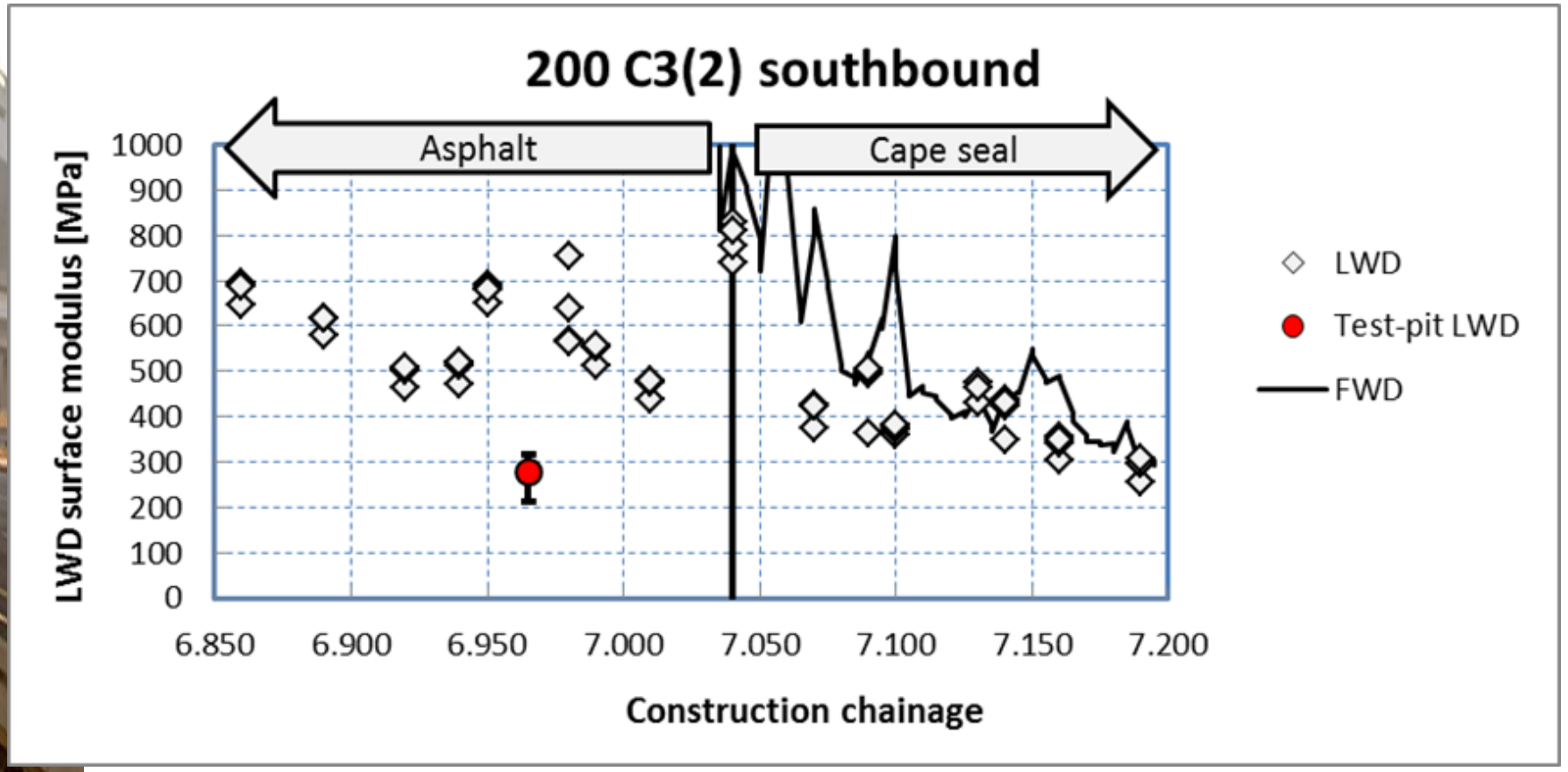
Medium-term properties of stabilised material

Medium-term monitoring

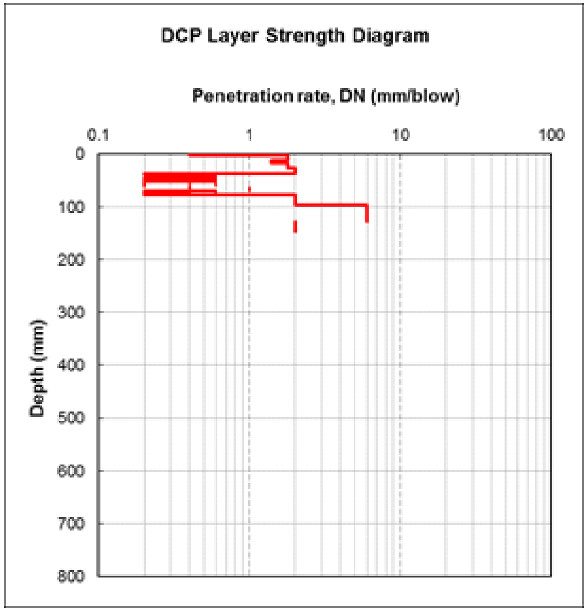
- FWD deflection recorded on all sections up to Aug 2014
- Detail investigation during April 2014
  - Not full 2 year service – assess condition after relatively wet summer
  - Sections revisited
    1) 200 C3(2) SB
    2) 200 ETB2 SB
    3) 200 FTB2 SB
    4) 200 FTB1 km 22
    5) 200 FTB1 km 30

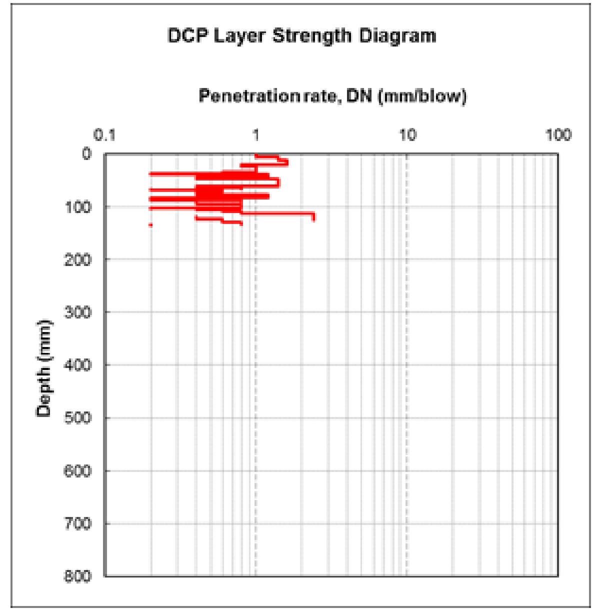
200 C3(2) SB – Visual Condition

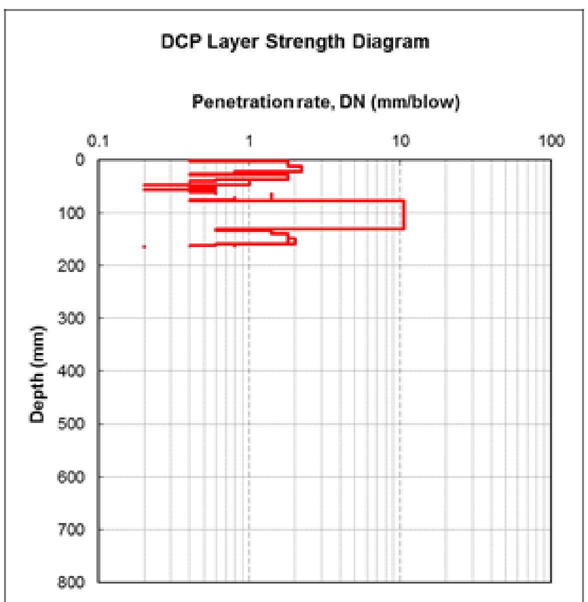
200 C3(2) SB – Deflection

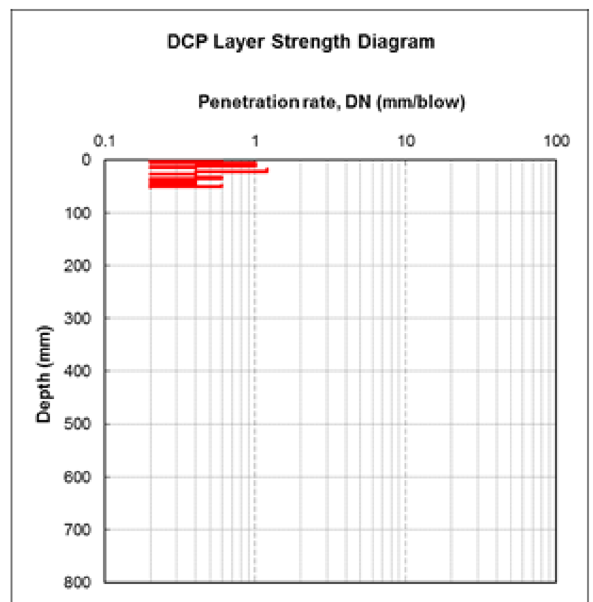


200 C3(2) SB – DCP

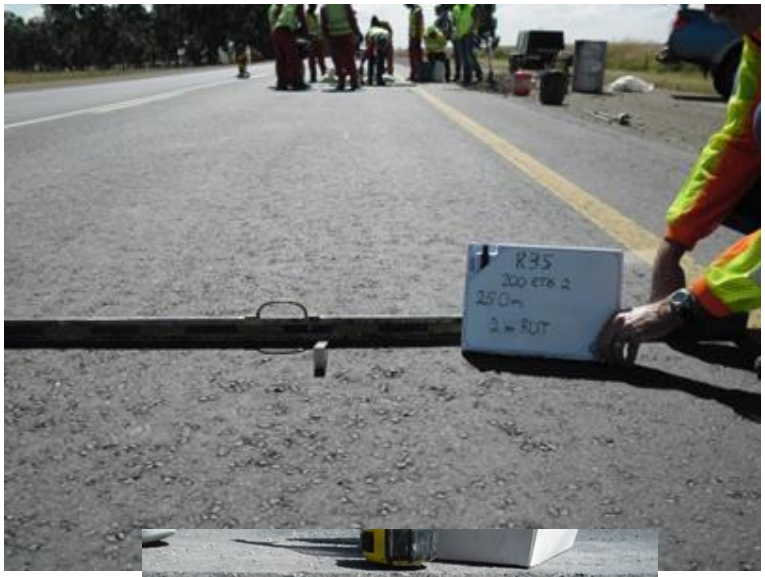




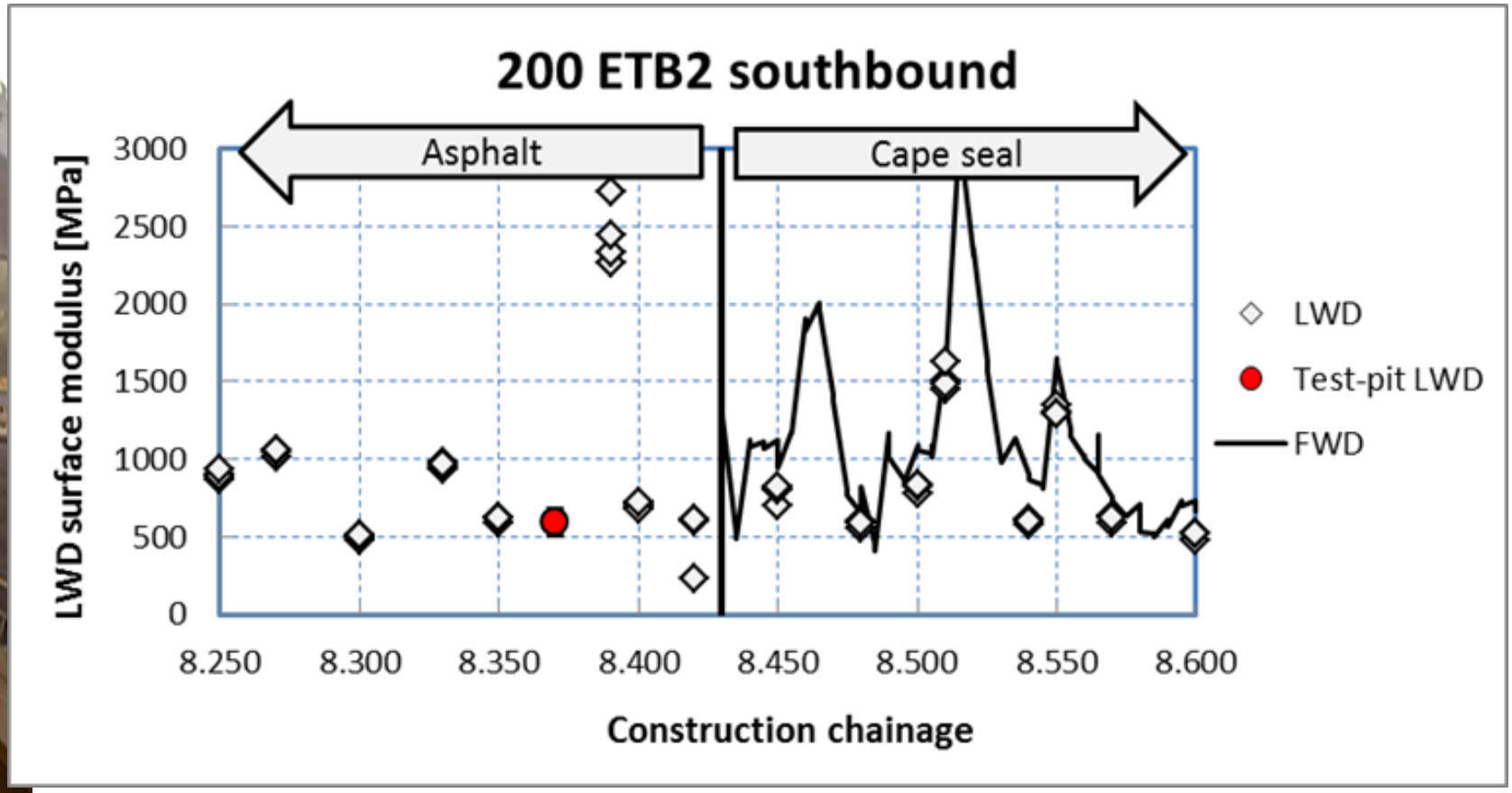




200 ETB2 SB – Visual Condition



200 ETB2 SB – Deflection



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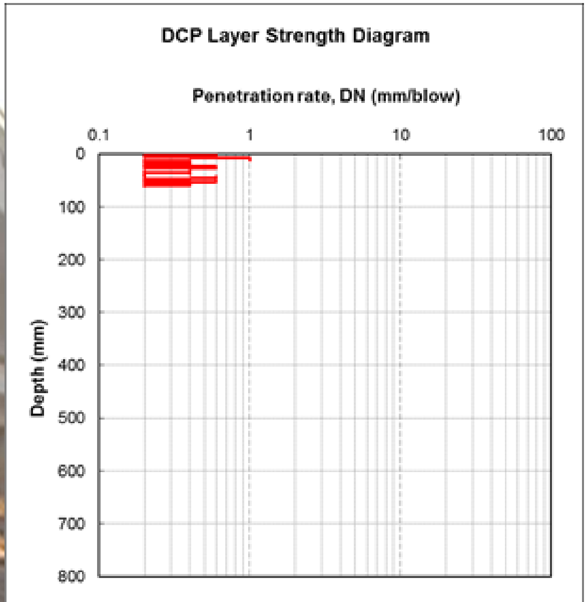
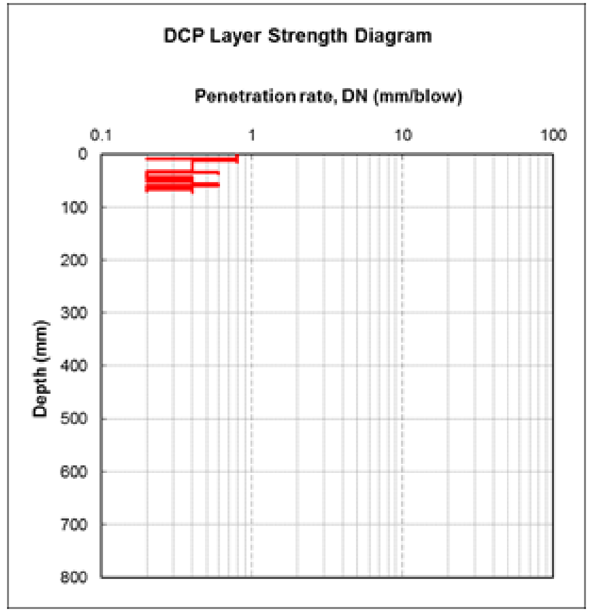
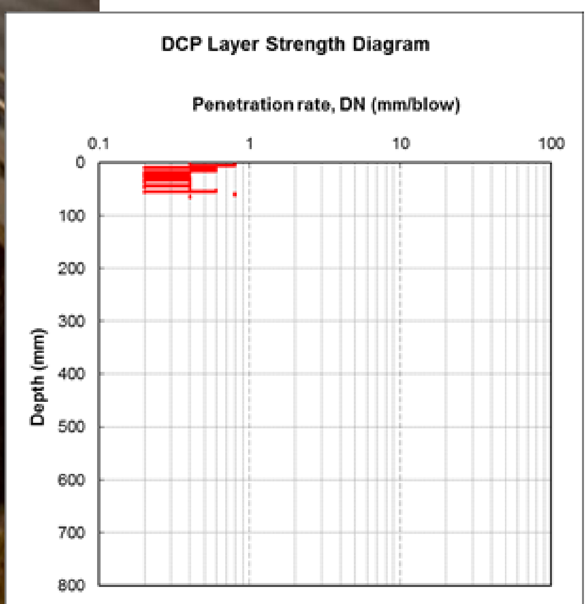
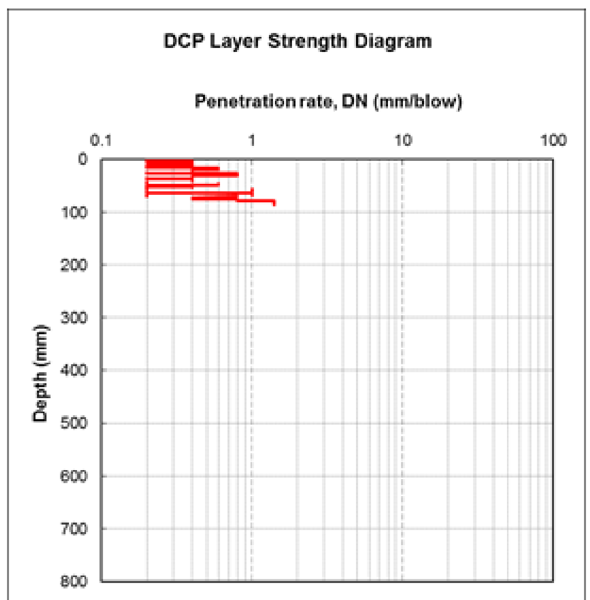
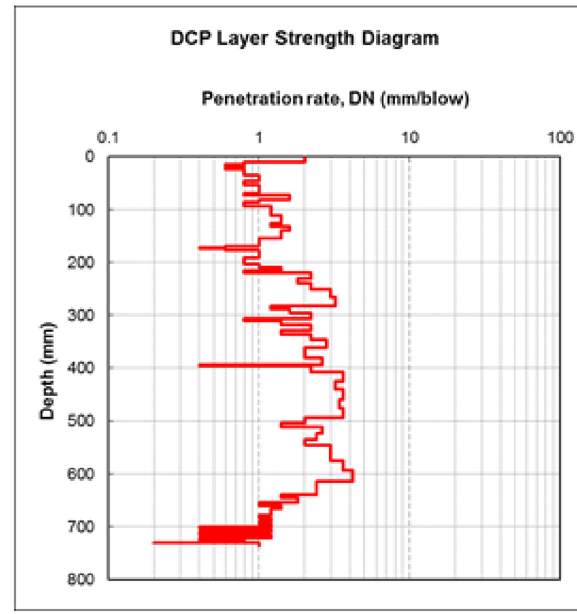




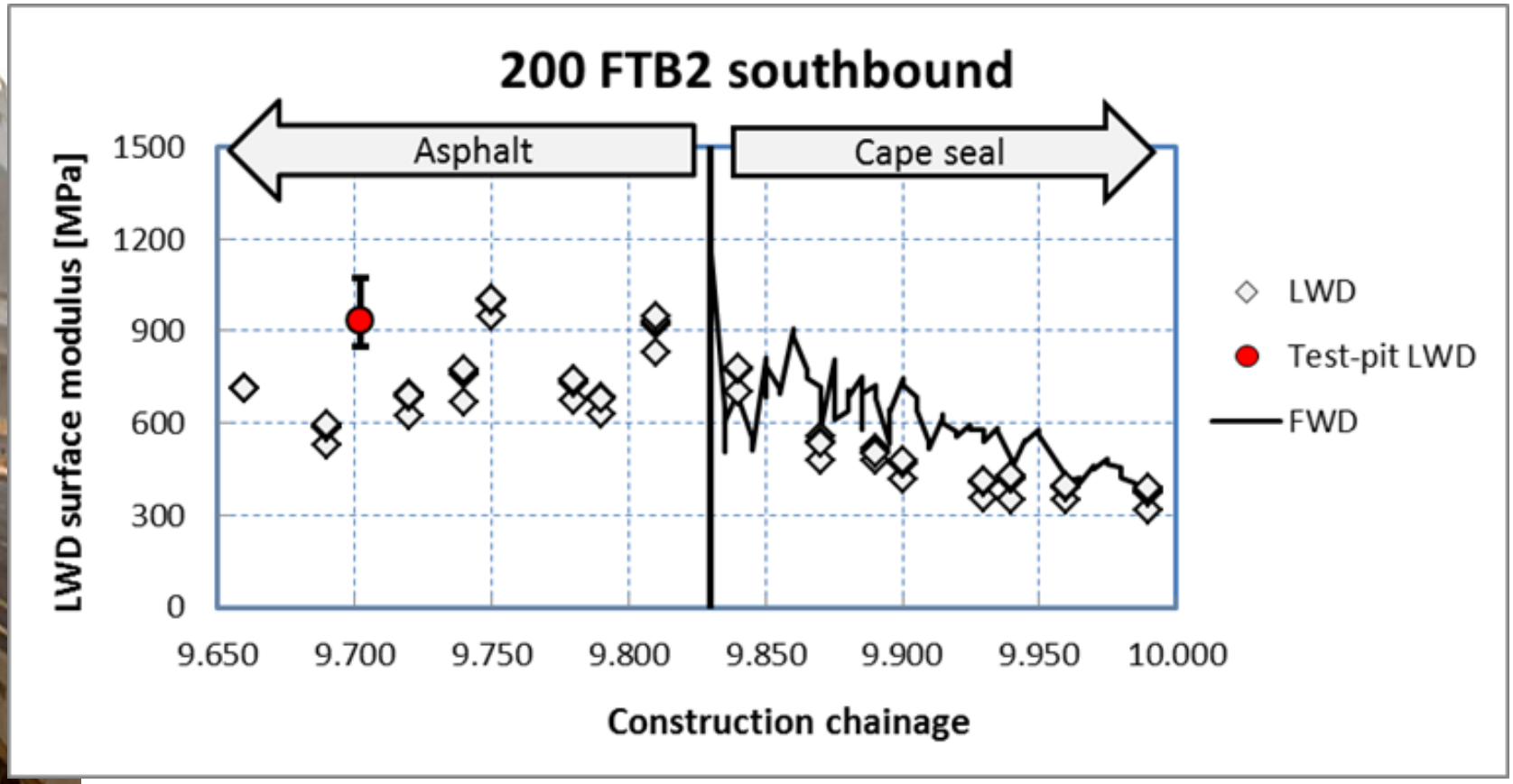




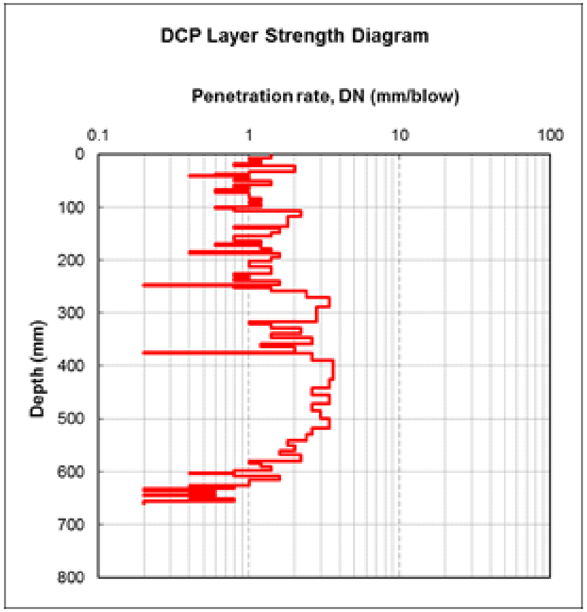


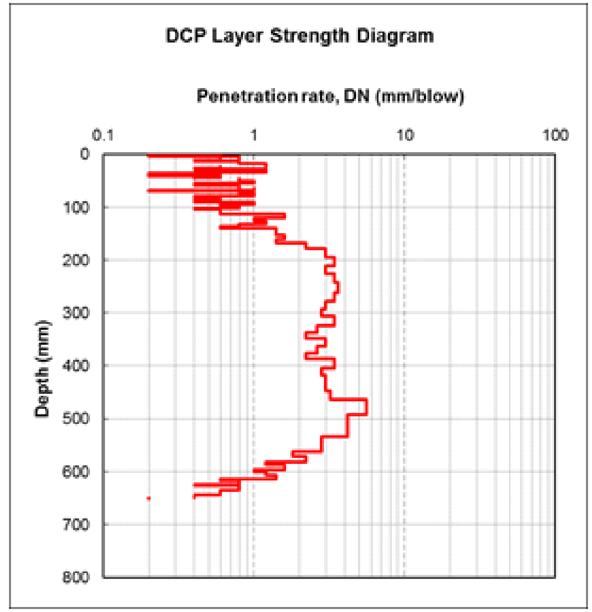
200 FTB2 SB – Visual Condition

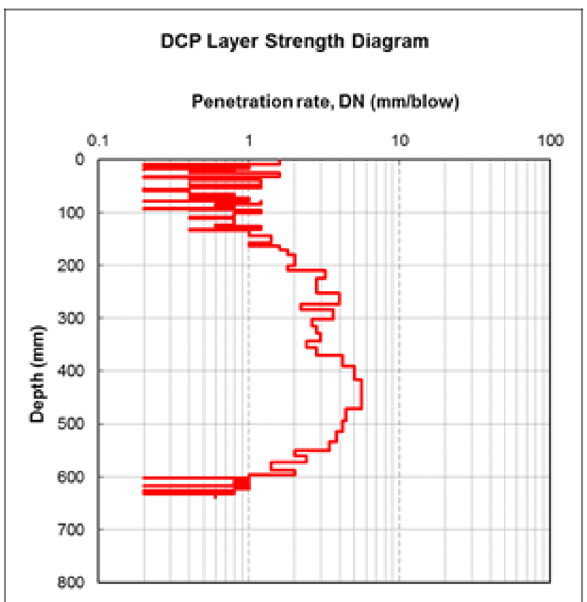
200 FTB2 SB – Deflection

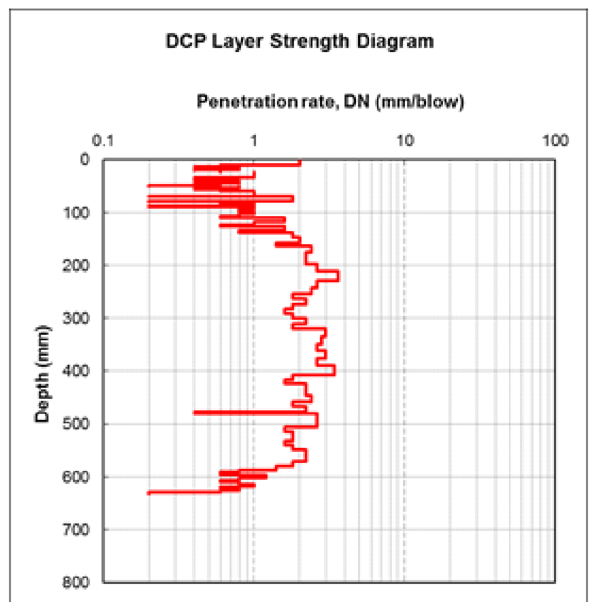


200 FTB2 SB – DCP





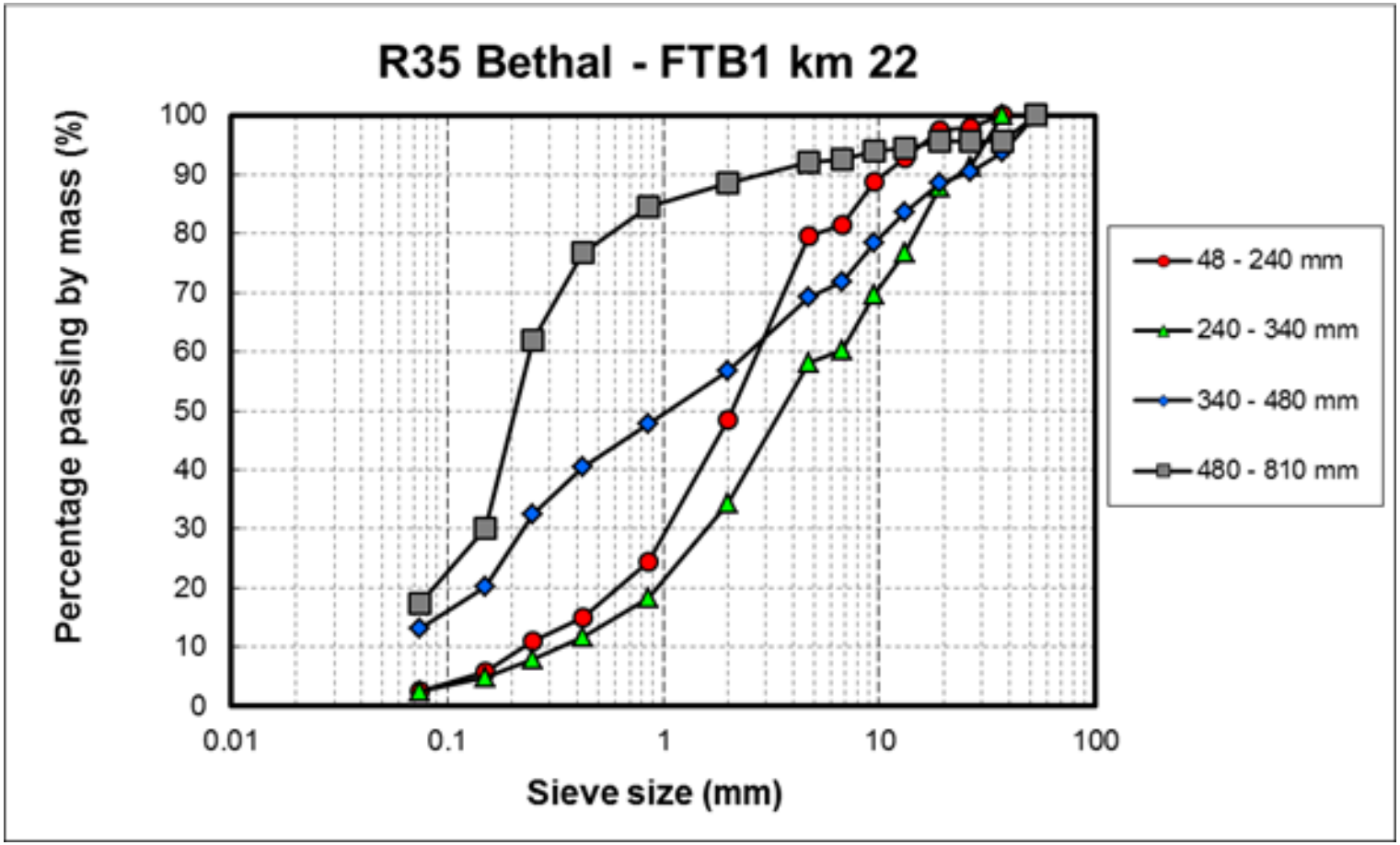




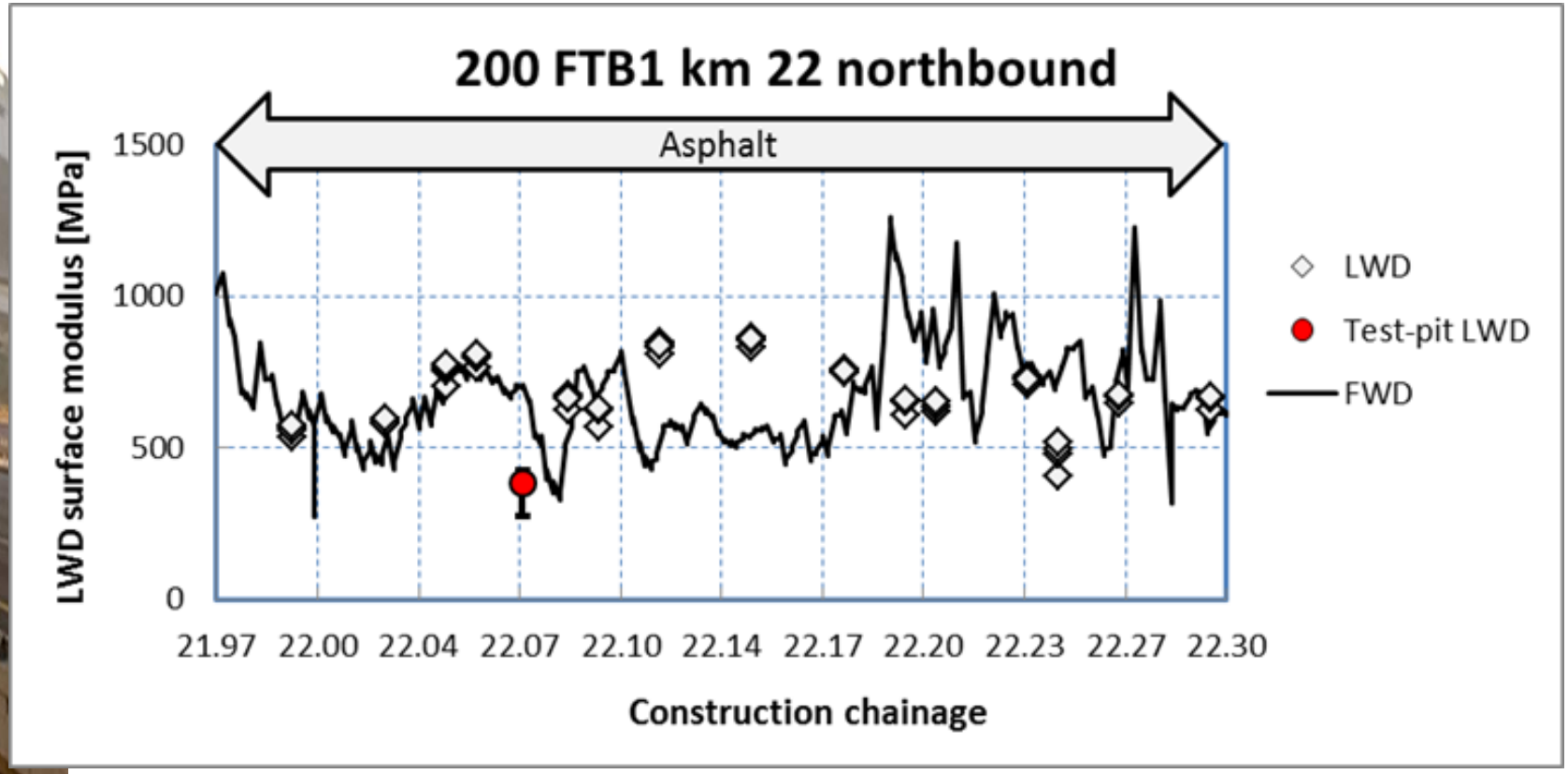
200 FTB2 km 22 – Visual February 2014

200 FTB2 km 22 – Test-pit visual

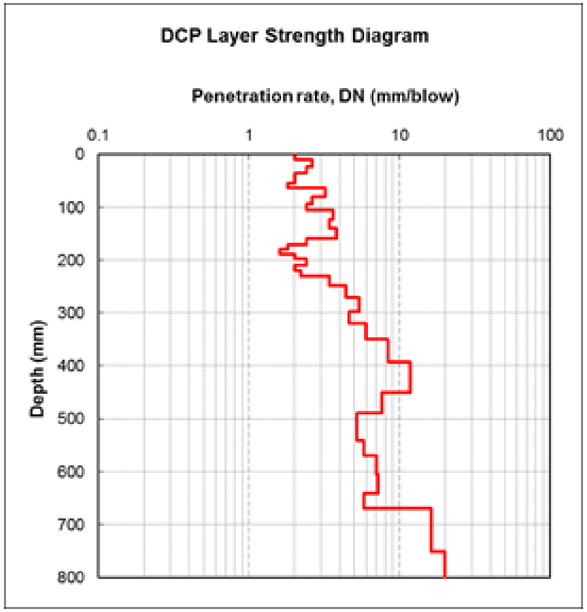
200 FTB2 km 22 NB – Grading

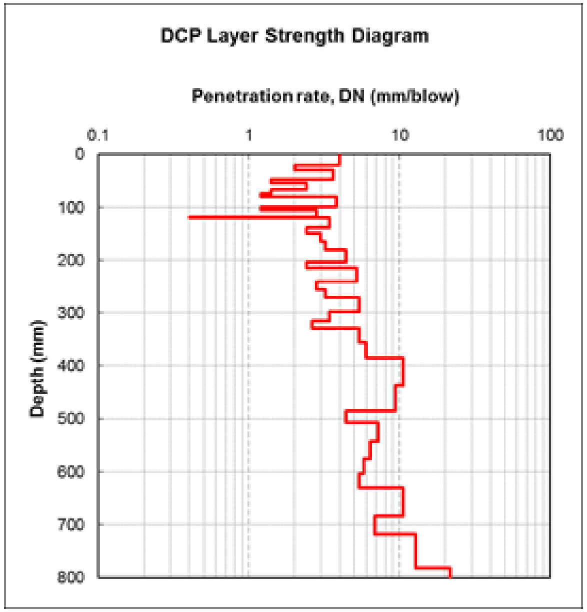


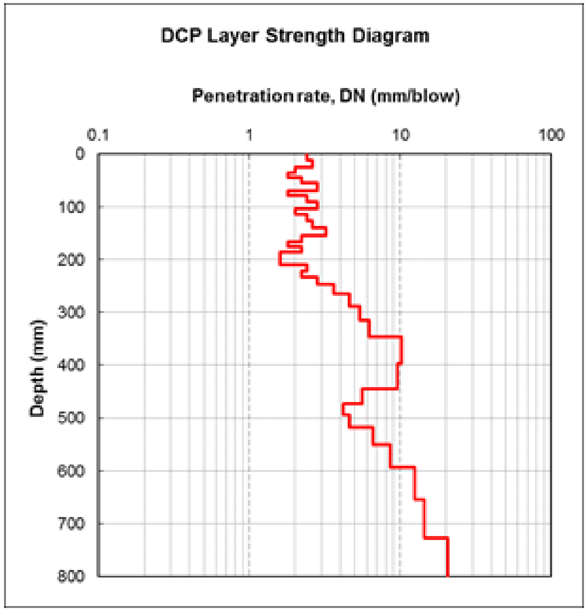
200 FTB2 km 22 NB – Deflection

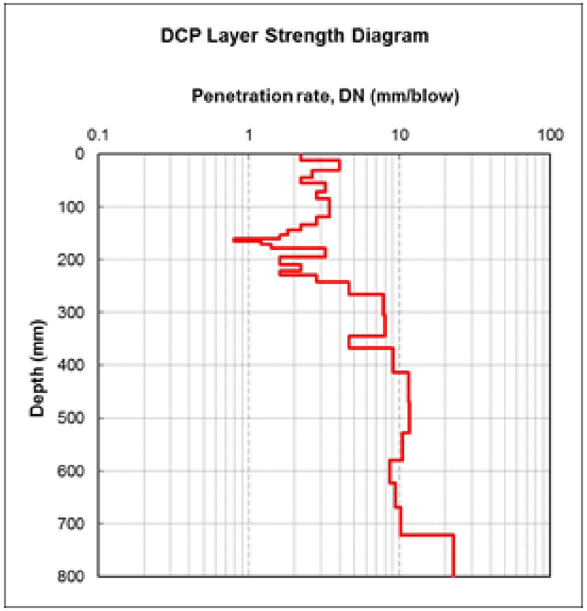


200 FTB2 km 22 NB – DCP



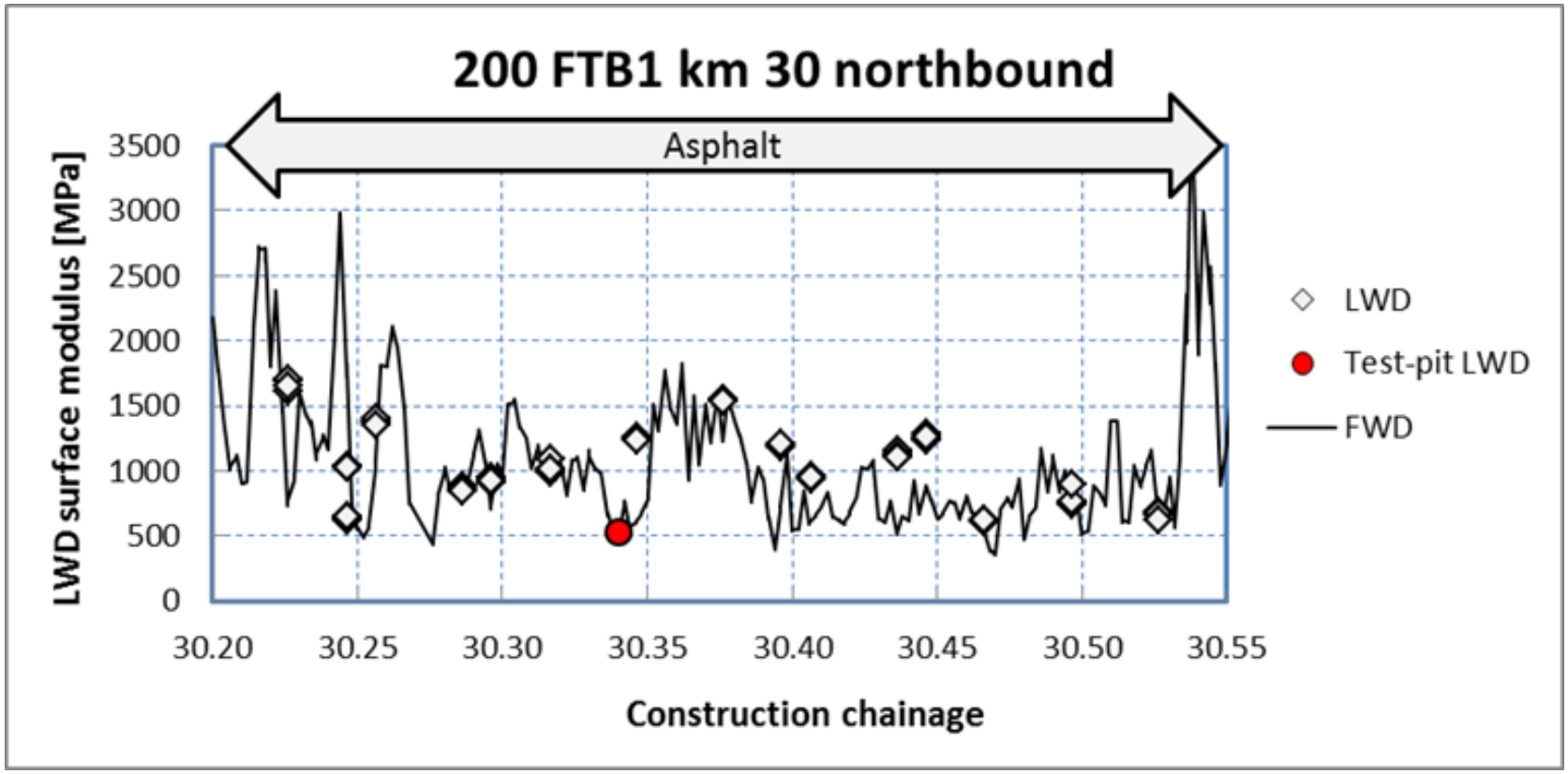




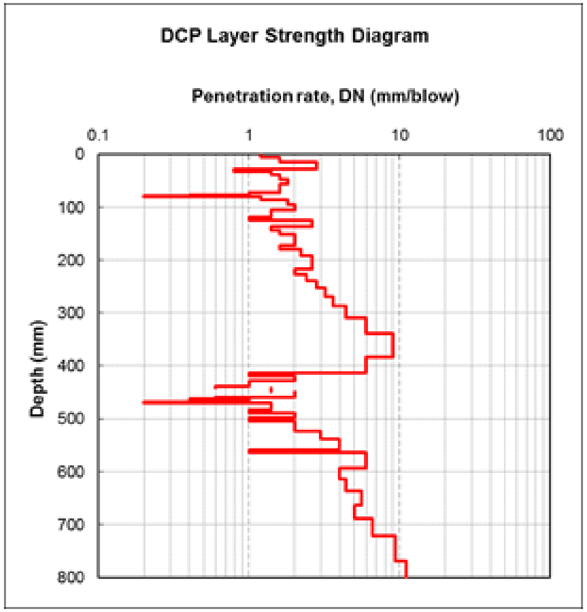


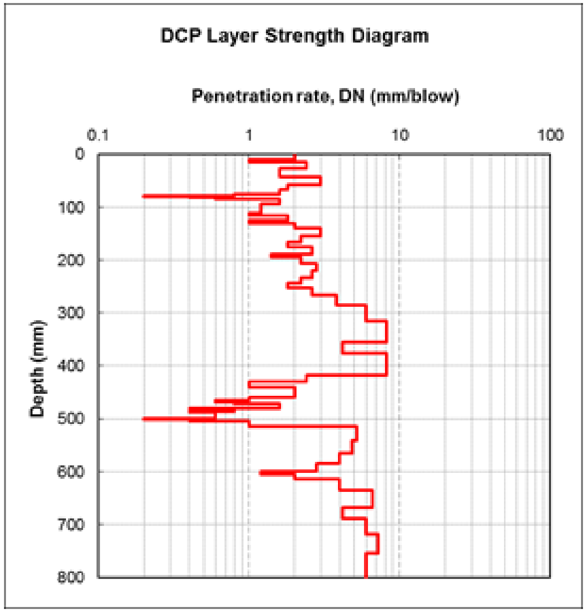
200 FTB2 km 30 – Test-pit visual

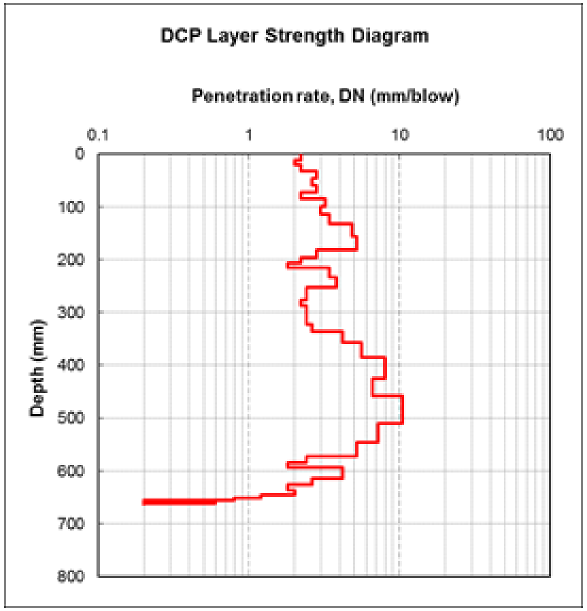
200 FTB2 km 30 NB – Deflection

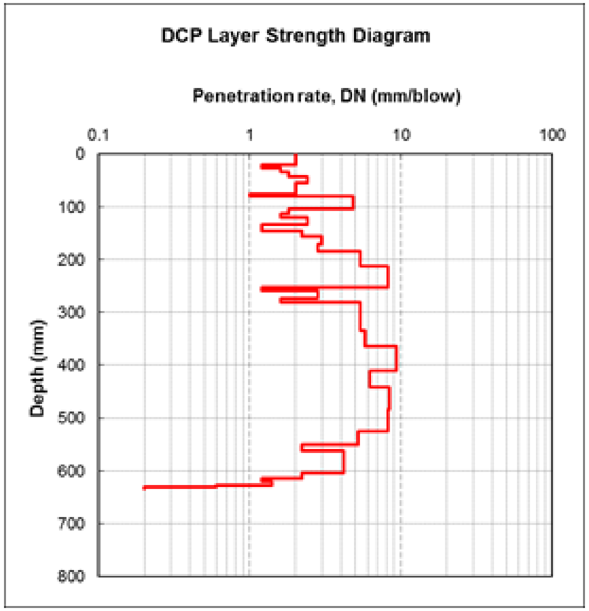


200 FTB2 km 30 NB – DCP

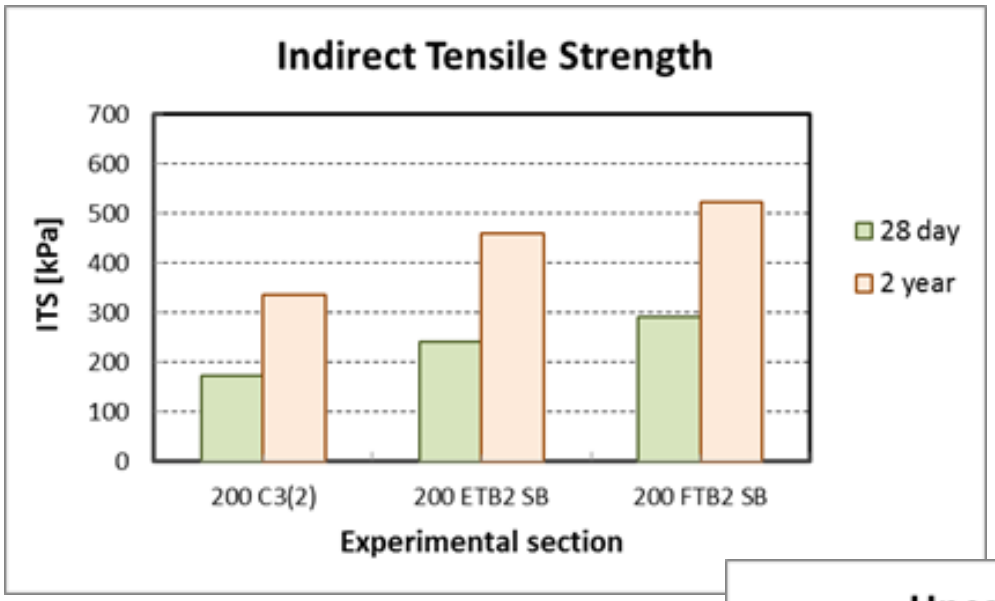


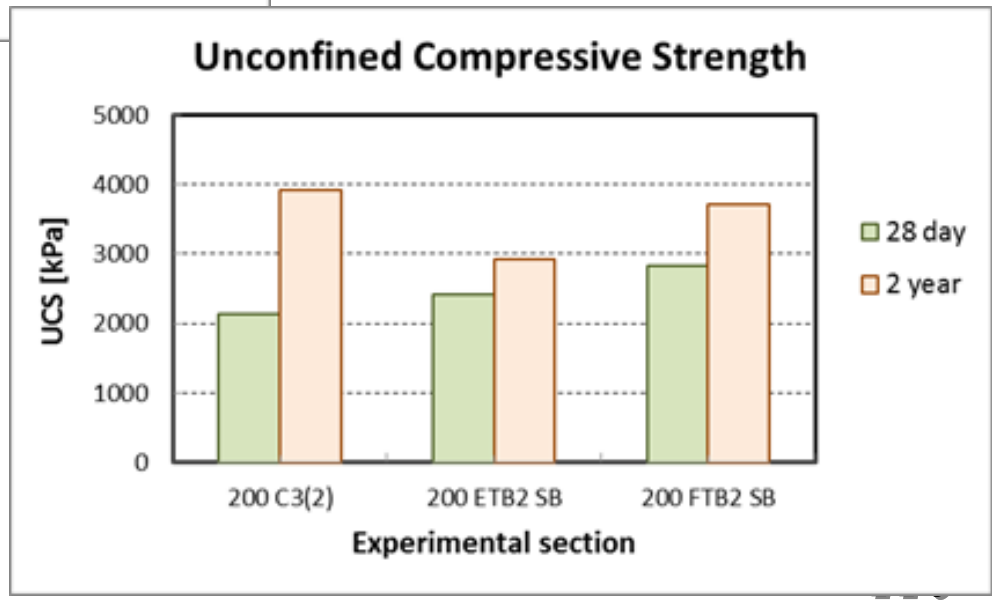




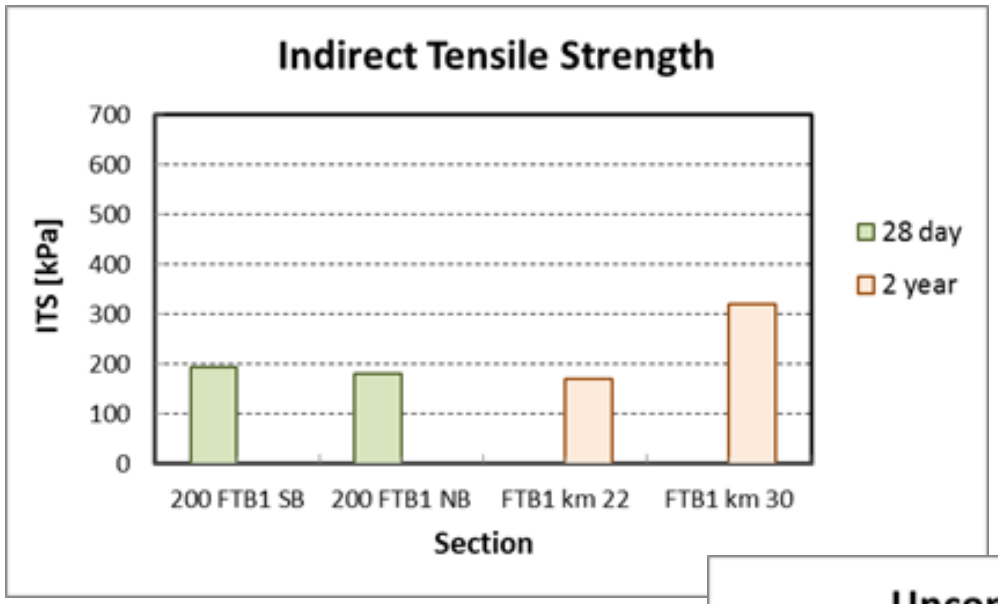


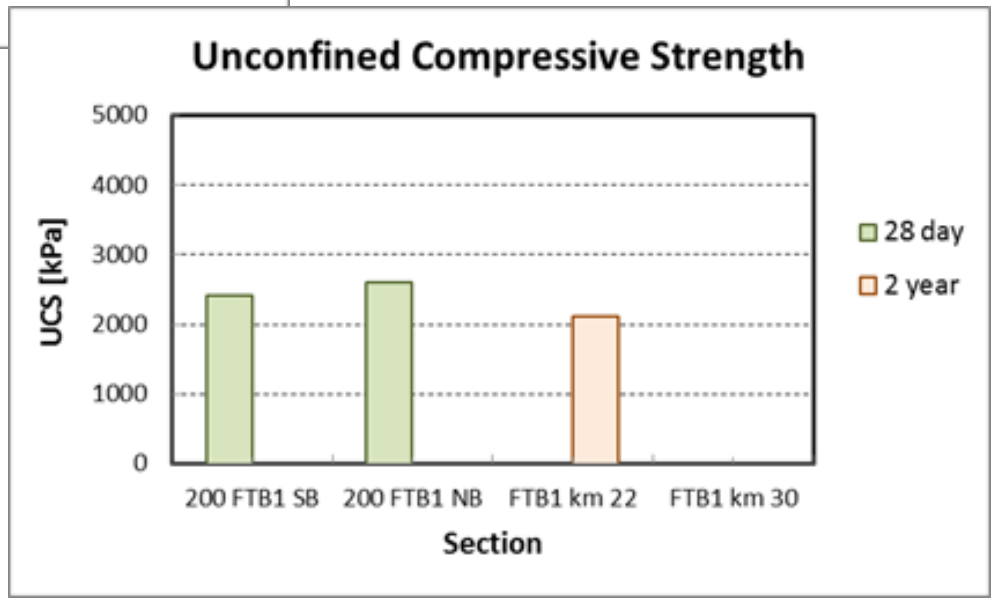
Combined results – Material strength – 2 % cement



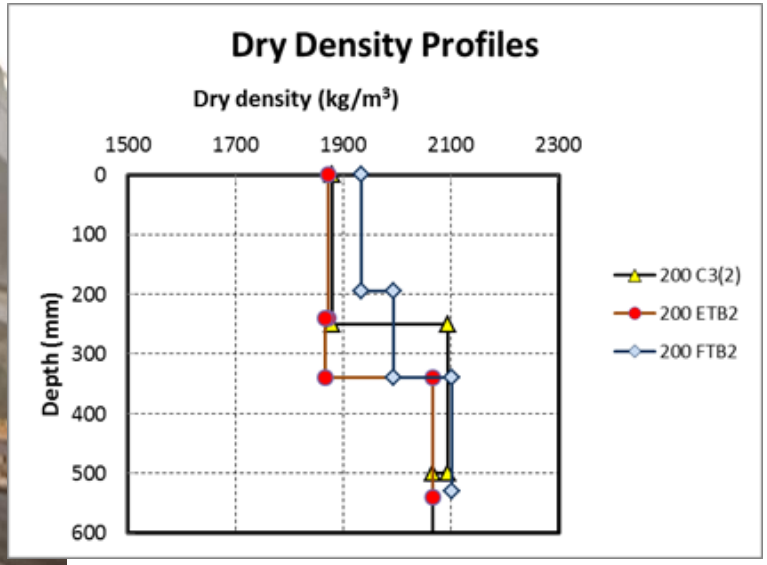


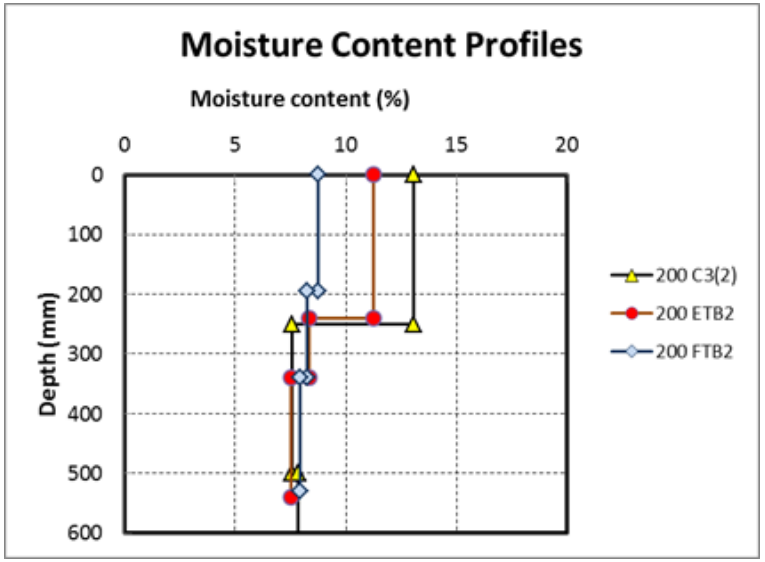
Combined results – Material strength – 1 % cement

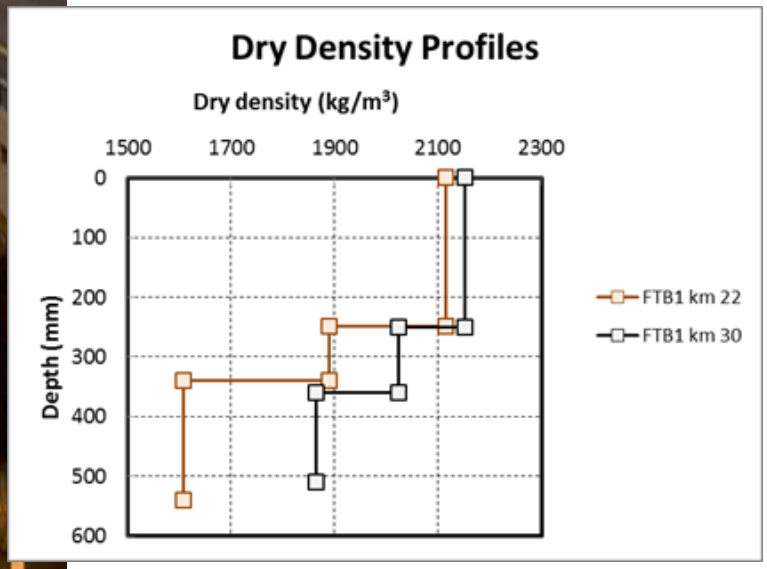


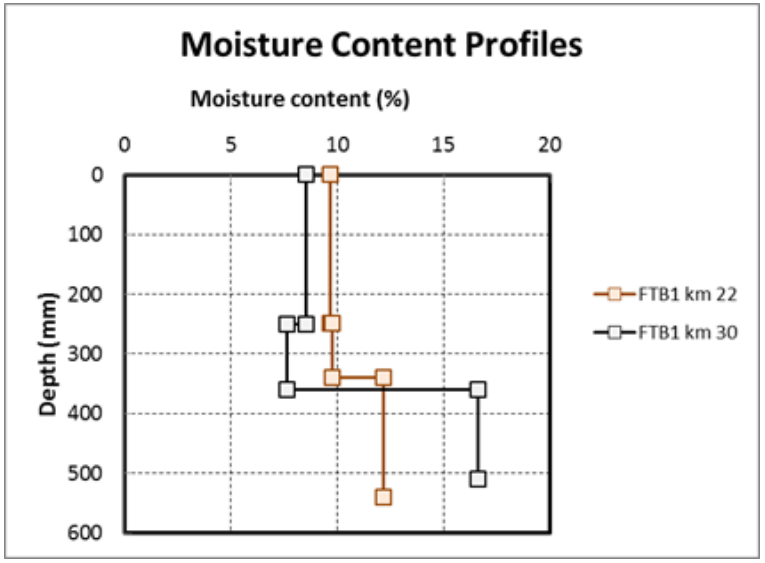


Combined results – Density and moisture content

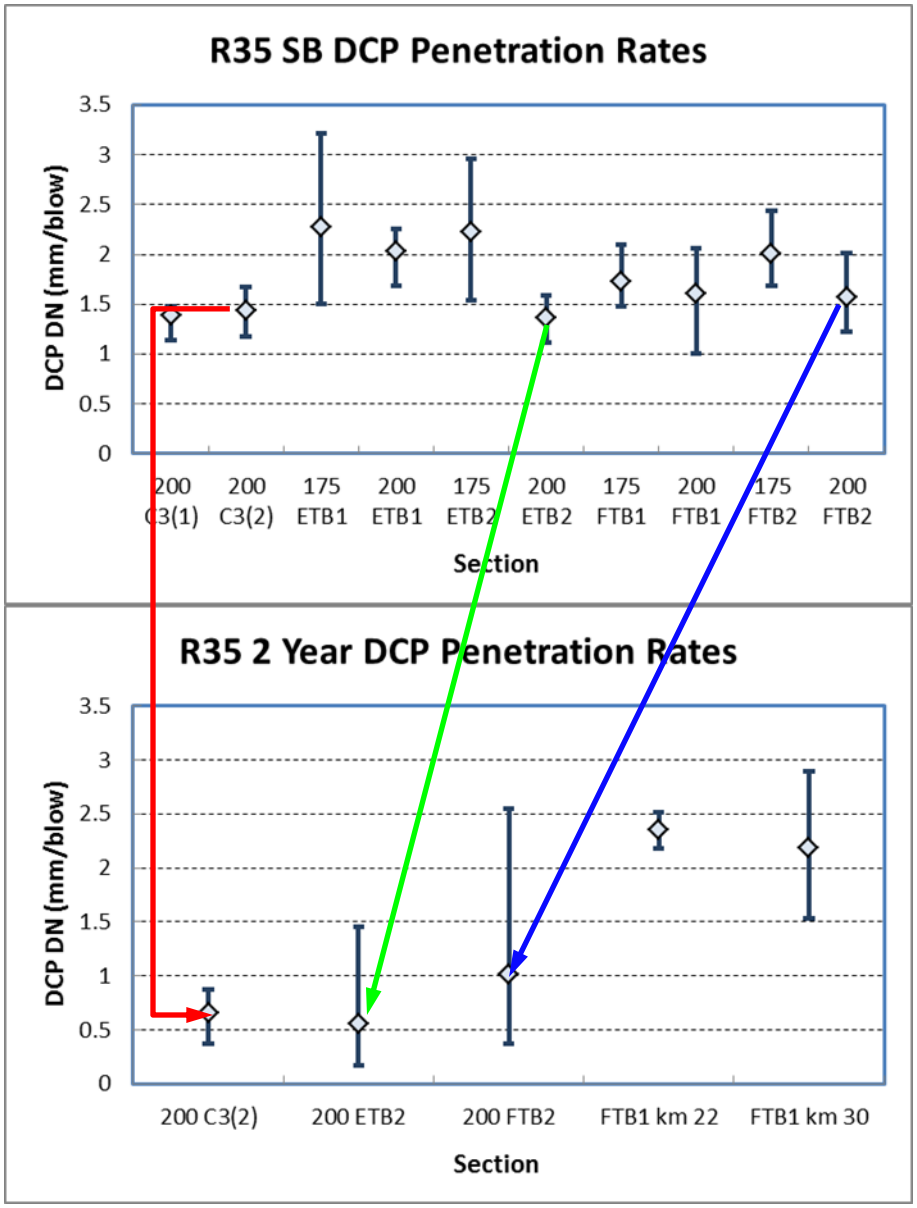




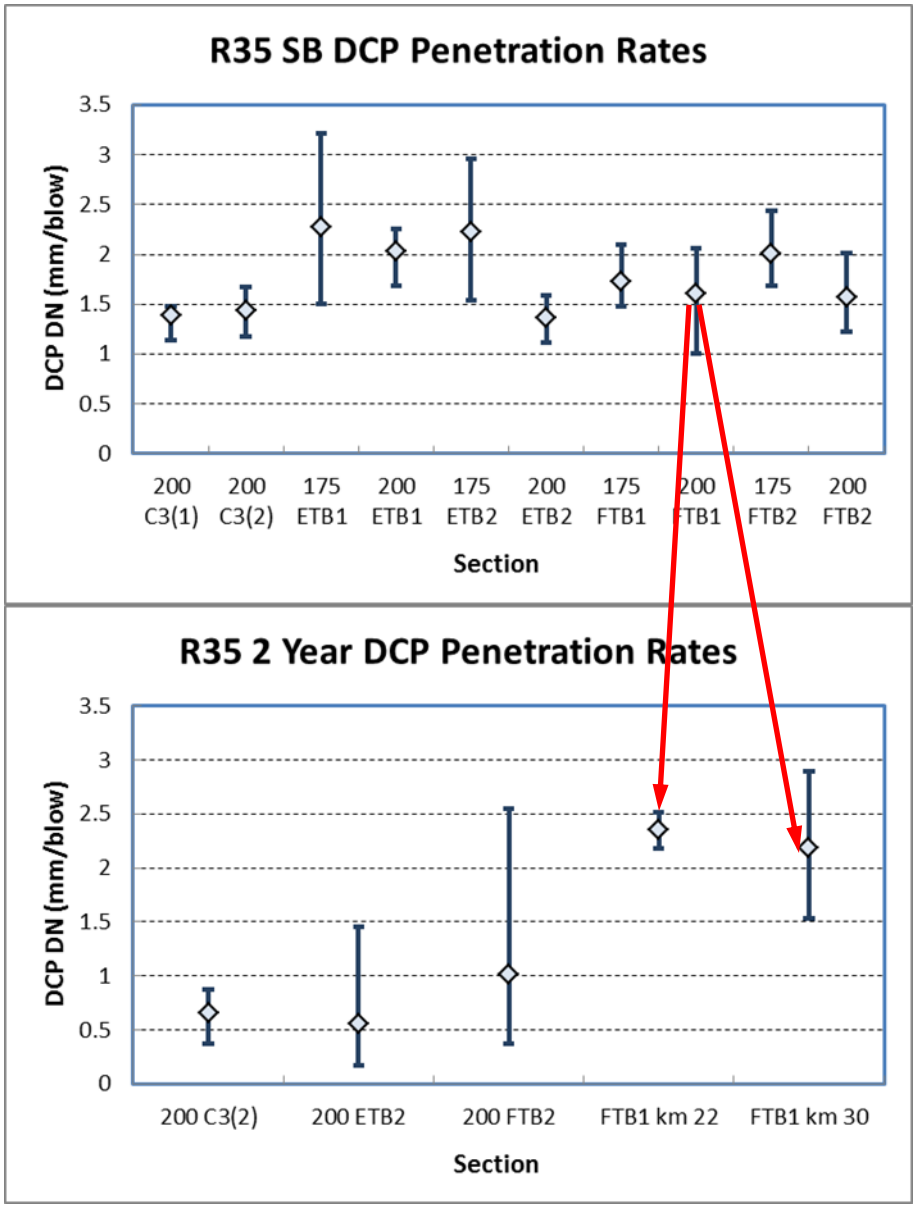




Combined results – DCP

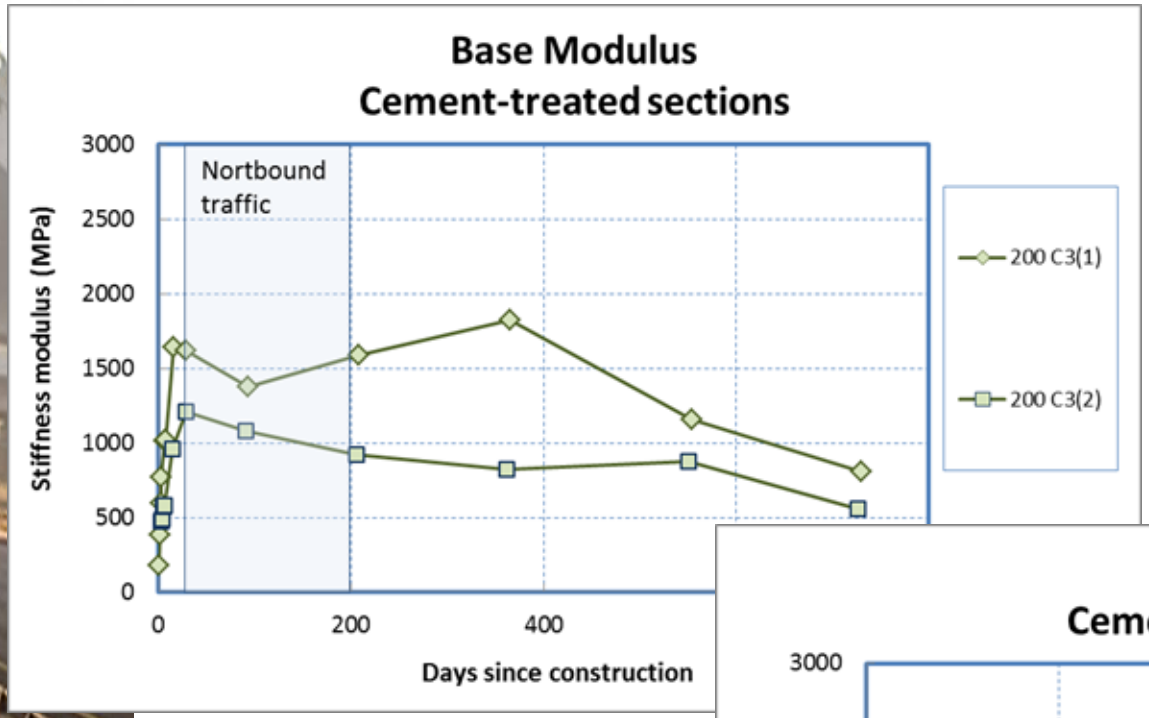


Combined results – DCP

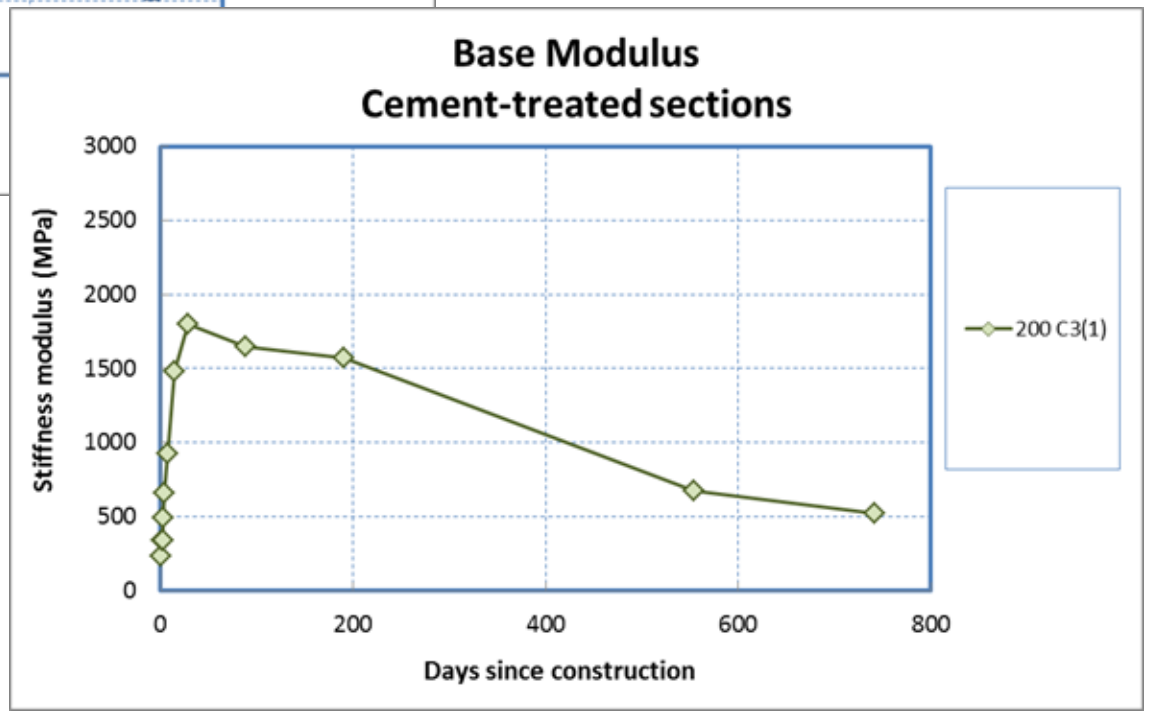


Combined results – FWD

Southbound

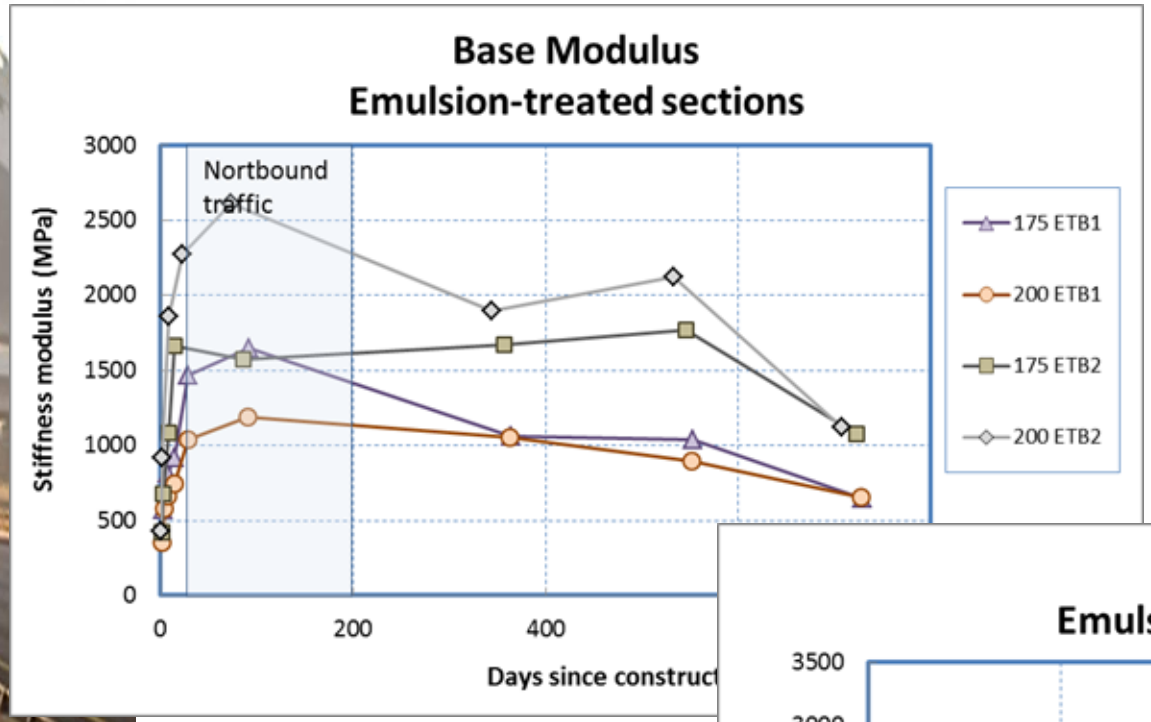


Northbound



Combined results – FWD

Southbound



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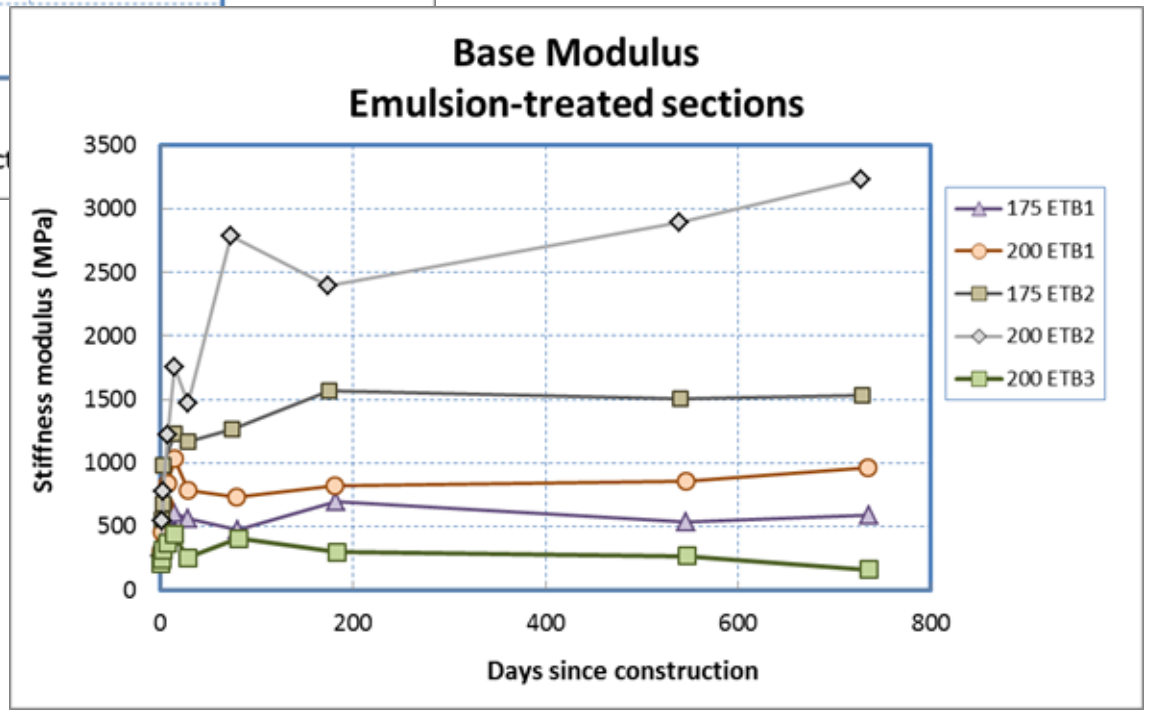
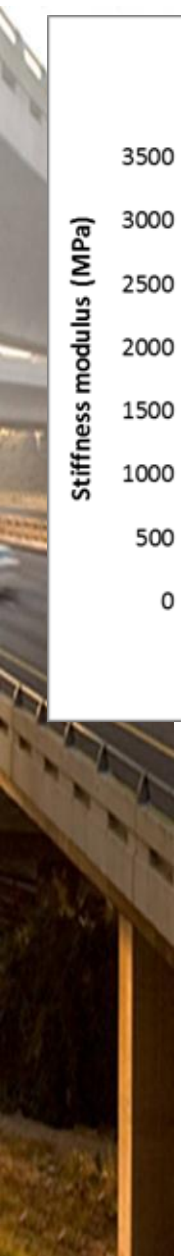
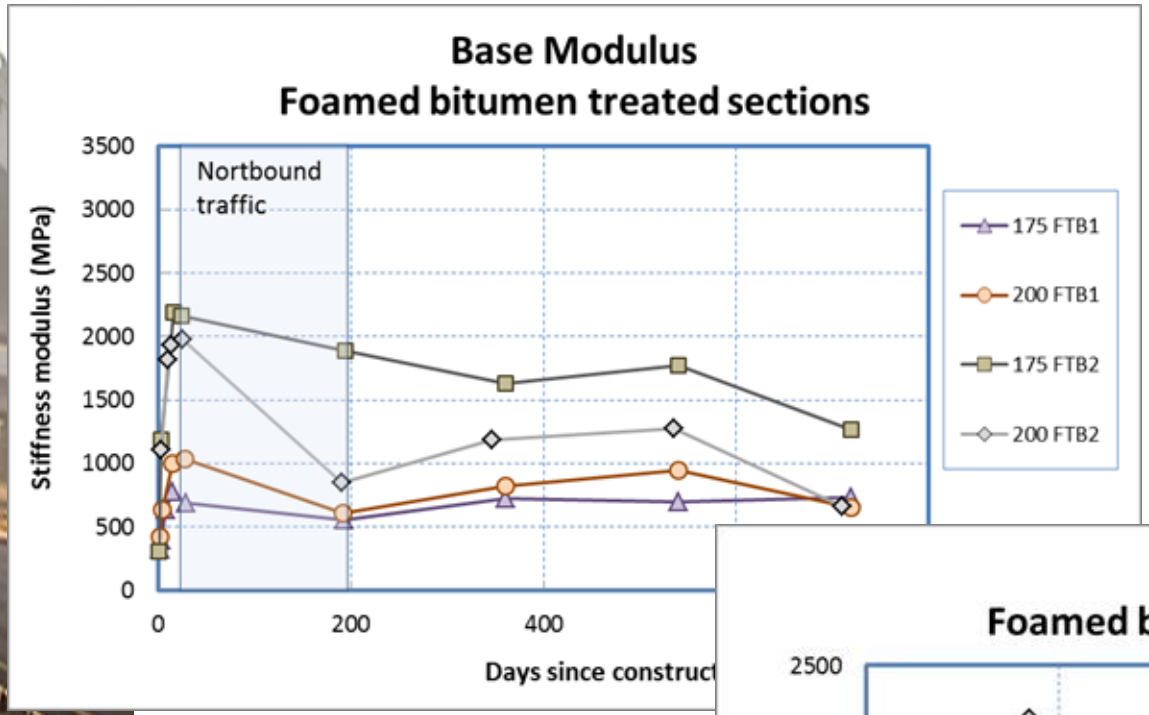


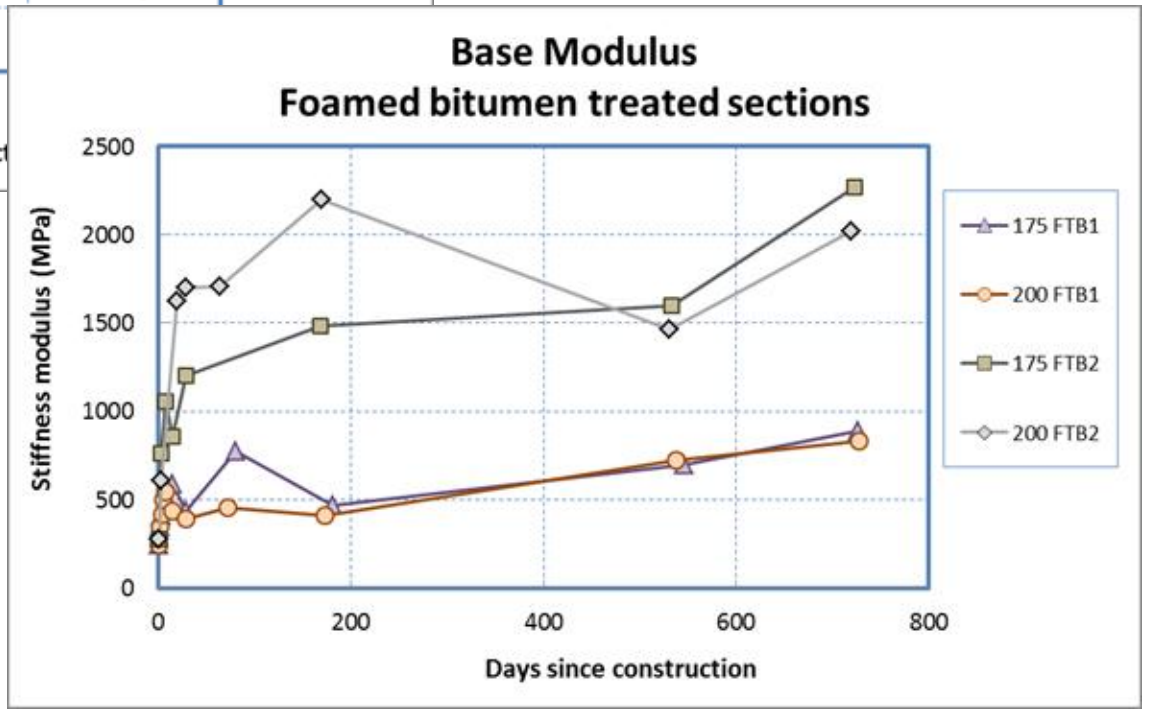
Combined results – FWD



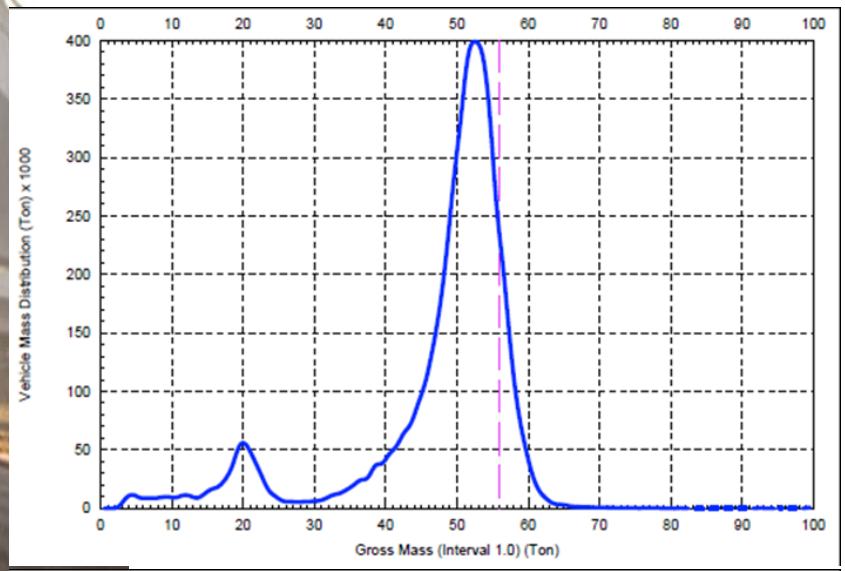
Southbound

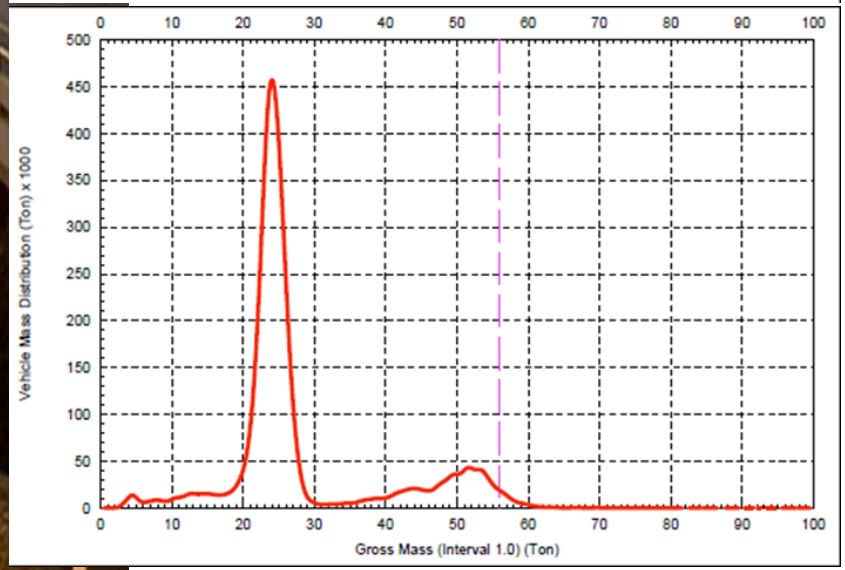


Northbound



Combined results – Traffic





- Southbound
  - **155 947** HV in 2013
  - 706 196 E80 in 2013
  - **997 552** E80 from Aug 2012 to April 2014
- Northbound
  - **152 916** HV in 2013
  - 134 301 E80 in 2013
  - **179 068** E80 from Jan 2013 to April 2014

Comparison with design

- Design traffic estimate
  - 1.2 meSA for 2 years
  - 1.0 meSA from Aug 2012 to April 2014
- Recorded traffic
  - Southbound
    - 0.99 meSA from Aug 2012 to April 2014
  - Southbound
    - 0.18 meSA from Jan 2013 to April 2014

Comparison with design – Cemented crushing

- Design estimate of area affected by crushing after 1 meSA
  - Asphalt surfacing – 10 %
  - Cape seal – 30 %

- Outcome
  - Very difficult to determine extent but some crushing may have been observed at core locations on cape seal sections

Comparison with design – Stiffness reduction

- Design estimate of area to reach constant stiffness after 1 meSA
- Outcome
  - No rigorous analysis done yet
  - Difference between cement and BSM shown by both design models and field observation
  - BSM emulsion retained higher field stiffness than BSM foam – not shown by design

Cement		BSM foam				BSM emulsion			
C3		FTB1		FTB2		ETB1		ETB2	
AC	S4	AC	S4	AC	S4	AC	S4	AC	S4
30 %	48 %	0%	1%	0	1%	1%	2%	0%	1%

Comparison with design – Permanent deformation

- Design estimate of average rut after 1 meSA
- Outcome
  - Detailed rut measurements still to be done
  - Difference between Cape seal and asphalt not identified at design stage
  - Design estimates not far removed from field
    - Shear strength parameters used in design not the usual published values

	Cement		BSM foam				BSM emulsion			
	C3		FTB1		FTB2		ETB1		ETB2	
	AC	S4	AC	S4	AC	S4	AC	S4	AC	S4
Design	0.2	0.2	0.2	0.3	0.1	0.1	1.1	1.1	0.5	0.5
Field	0.8	5.3			0.3	5.5			1.7	3.8

Conclusions

- Very little distress on experimental sections after 2 years
  - Deep, well-balanced pavements
- Problems on mainlines sections related to subgrade problems
  - Identification during design stage?
- Past design models are not fundamentally flawed but input must be correct