3rd International Symposium on Asphalt Pavements & Environment

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Damage Quantification Of Bituminous Surfacing Seals With A Finite Element Modelling Approach

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Surfacing seal FEM approach

Objective 1

Develop seal model architecture

- Structures: single, double & cape seals
- Variables: structural, time & traffic related
- Failure mechanisms: adhesion, cohesion & embedment

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Objective 2

Quantify seal response model output

- Load repetitions to adhesion failure initiation
- Load repetitions to cohesion failure initiation
- Load repetitions for embedment development

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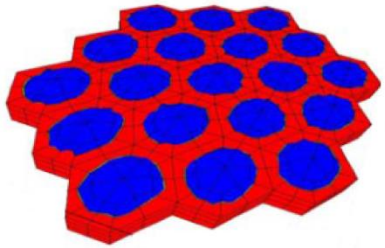
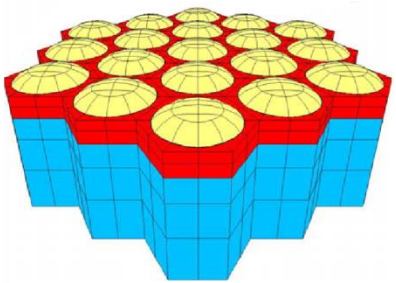
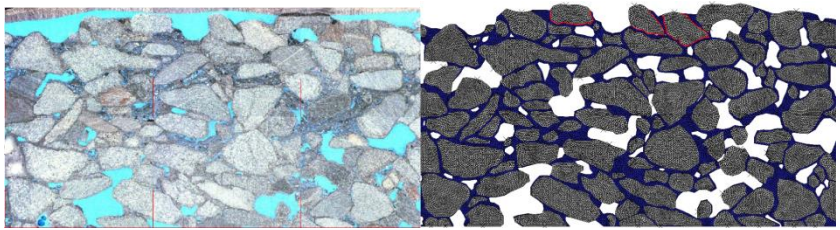
Background information 1



[Milne, 2004]



[Huurman, 2010]



[Huurman, 2008]

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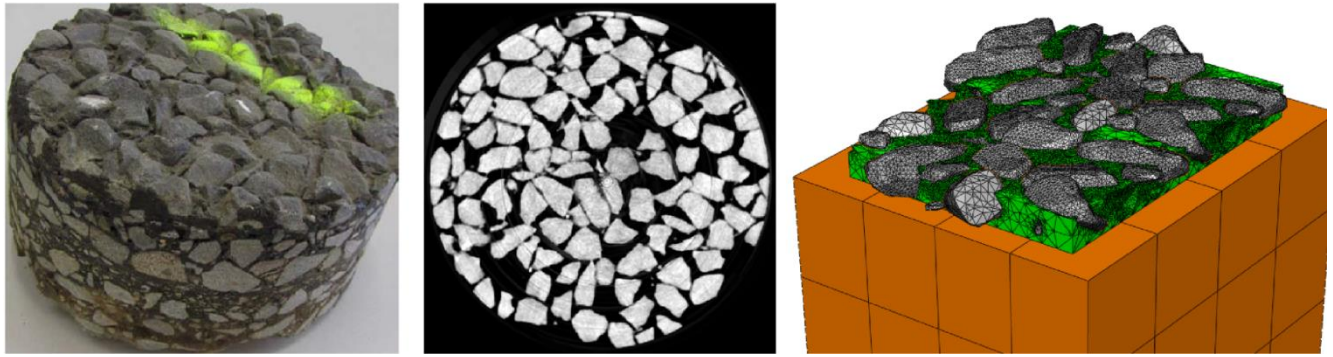
Background information 2



[Kathirgamanathan, 2012]

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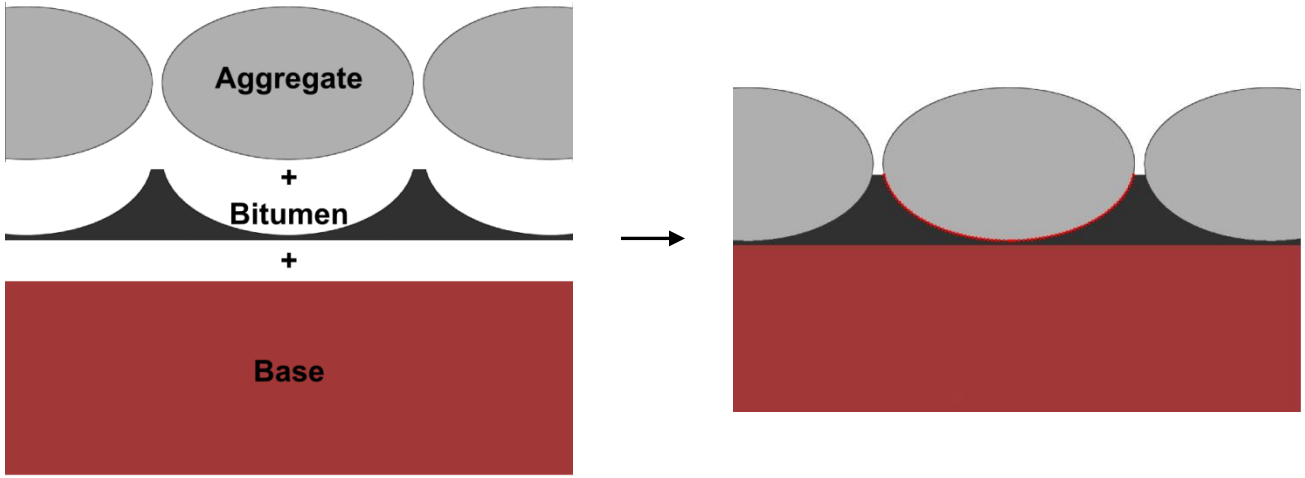
Model development 1

Unique components



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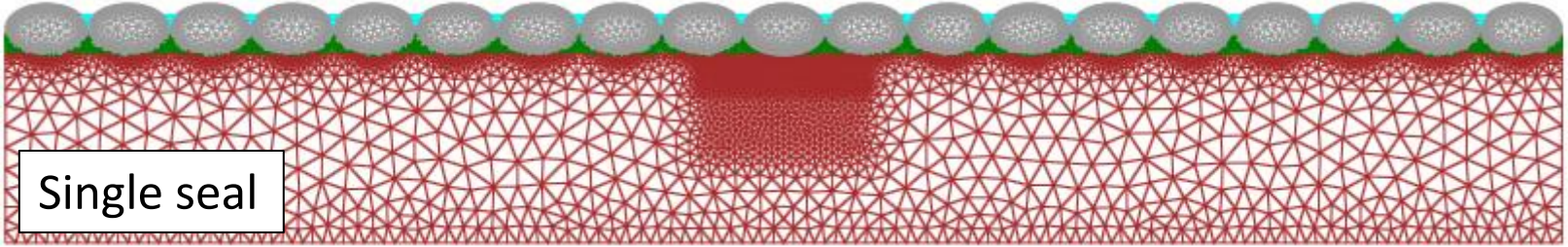
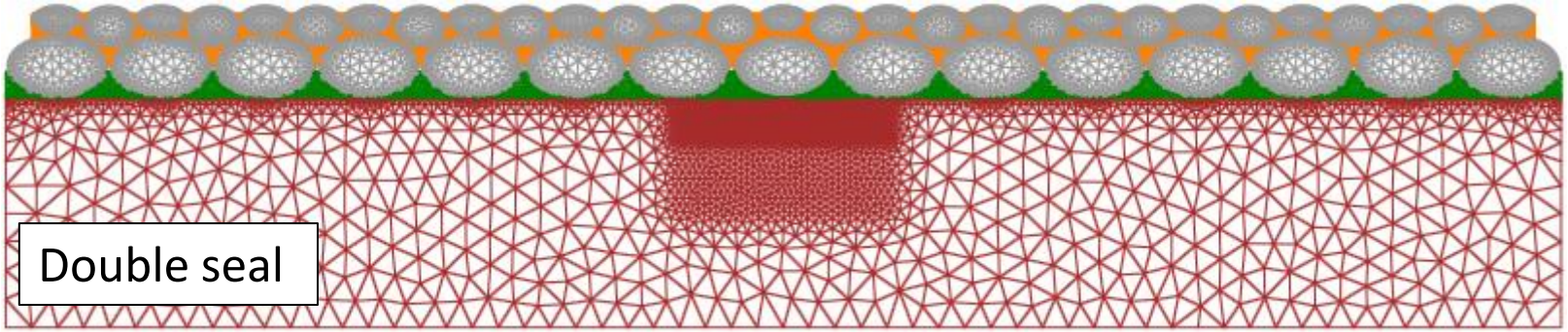
Model development 2





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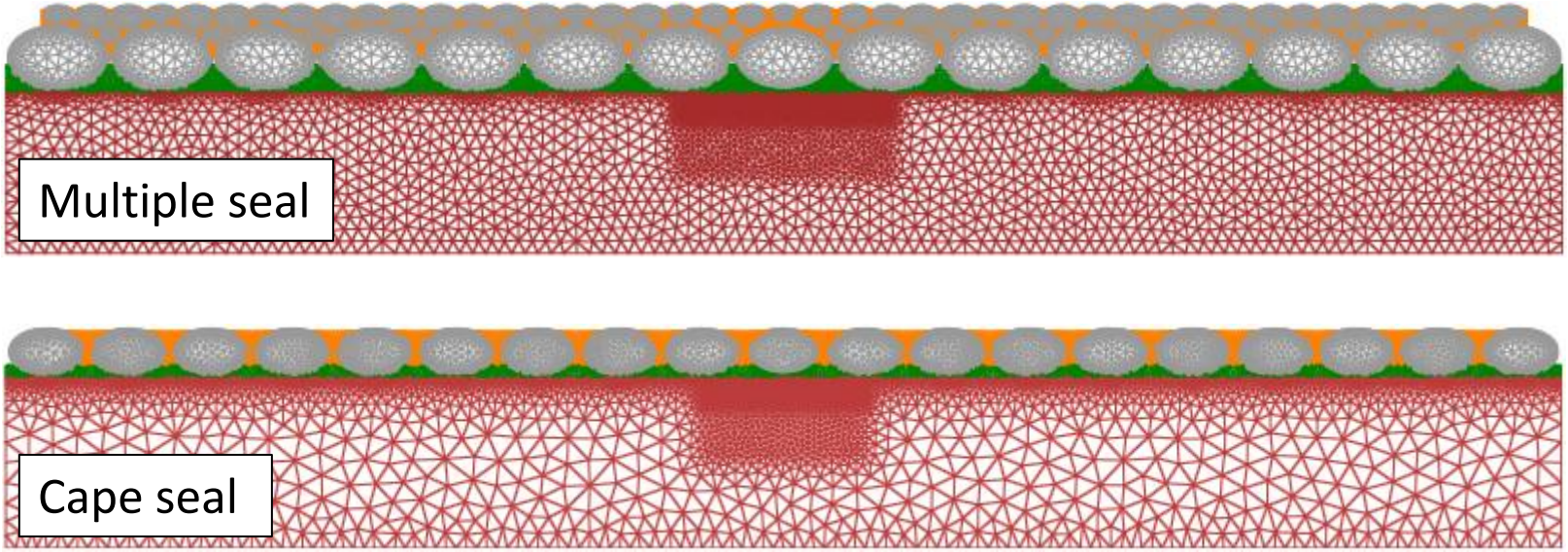
Model development 3



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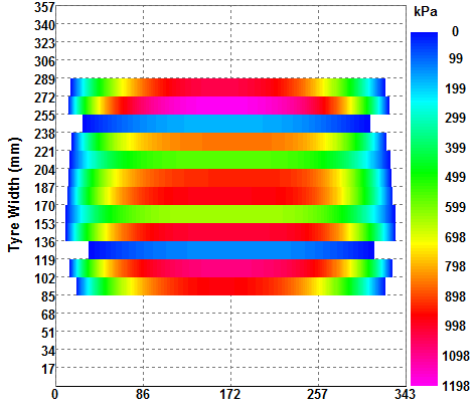
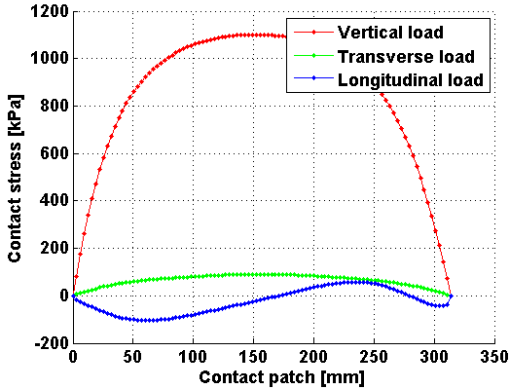
Traffic model





[De Beer and Fisher, 2013]

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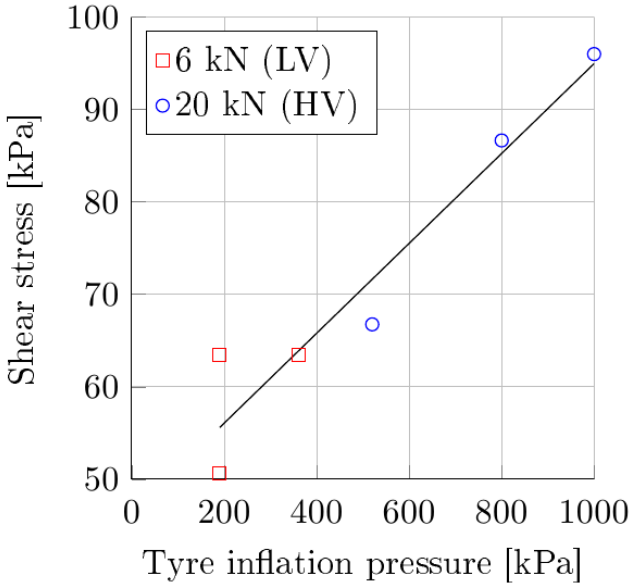
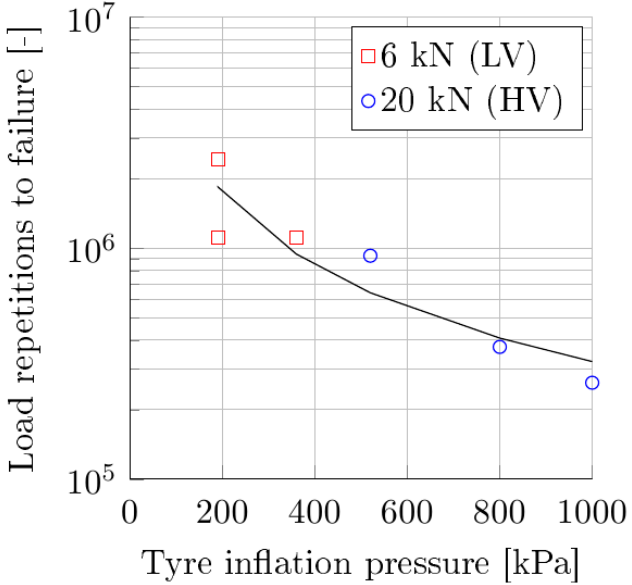
Simulation results: Adhesion





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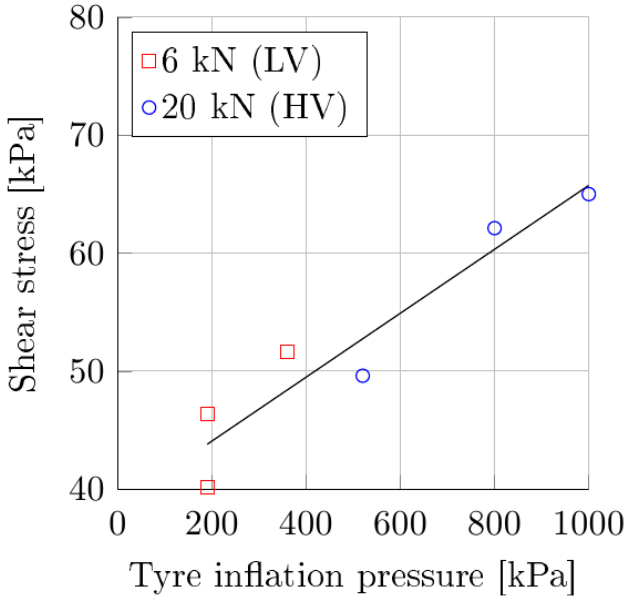
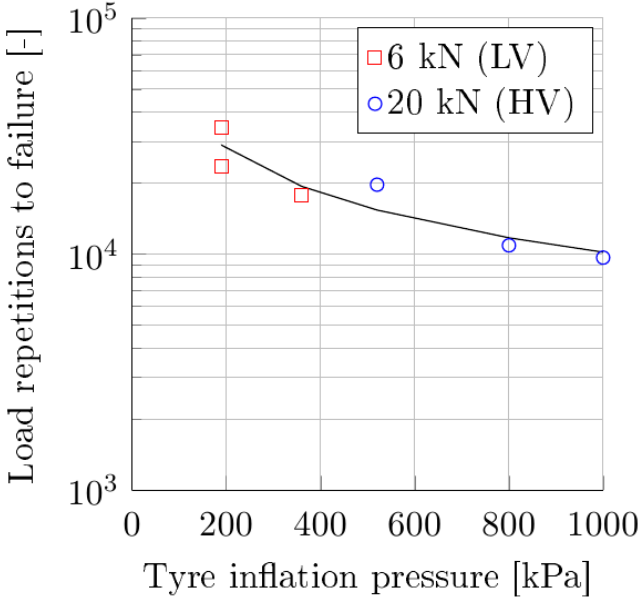
Simulation results: Cohesion





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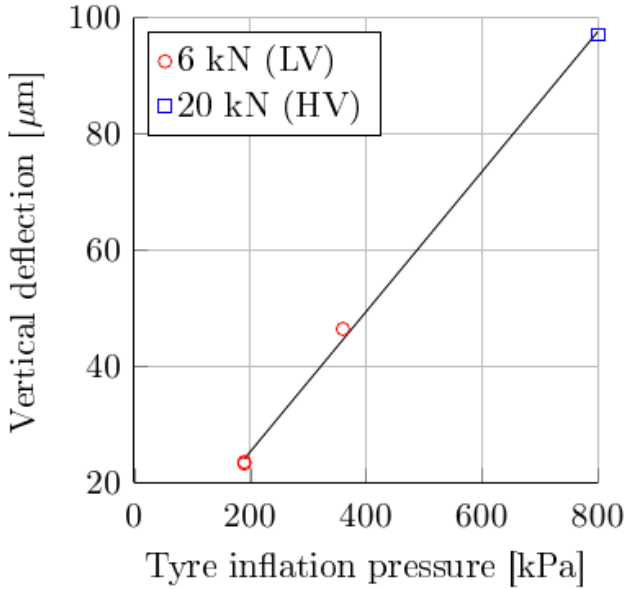
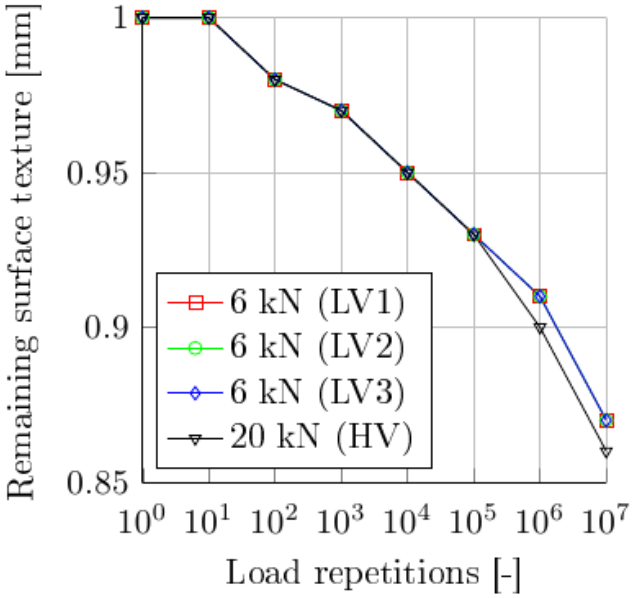
Simulation results: Embedment





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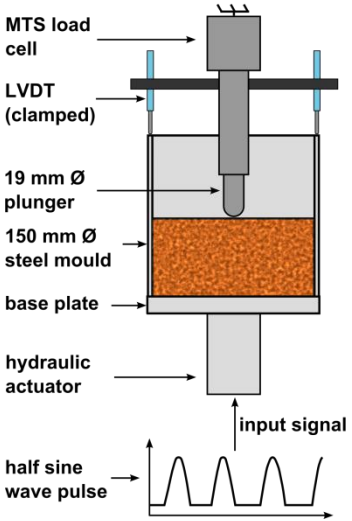
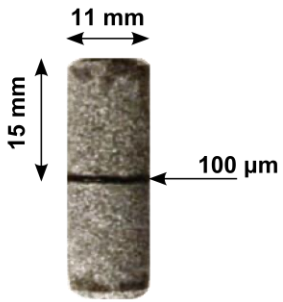
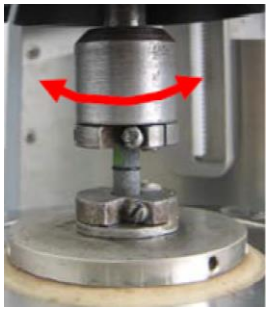
Transfer function development

Embedment



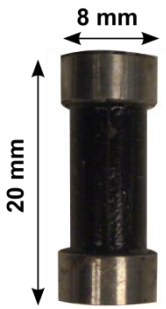
Adhesion





[Huurman, 2008]

Cohesion



[Huurman, 2008]

Surfacing seal FEM approach

Model verification: Adhesion 1

Minimum critical binder application rates for ball pen. value of 1 mm

Traffic analysis per lane per day					Average least dimension (ALD)				
AADT	HV	LV	E80s	ELVs	4	6	8	10	12
5848	20	5828	13	6628	0.57[i]	0.87	1.16	1.45	1.73
4501	50	4451	49	6451	-	0.72	1.01	1.3	1.58
3692	100	3592	121	7592	-	0.63	0.92	1.21	1.49
3028	200	2828	288	10828	-	0.56	0.85	1.13	1.41
2697	300	2397	472	14397	-	0.52	0.8	1.08	1.36
2330	500	1830	873	21830	-	-	0.74	1.02	1.29
2037	800	1237	1522	33237	-	-	-	0.94	1.22

[i] minimum application rate $[l/m^2]$

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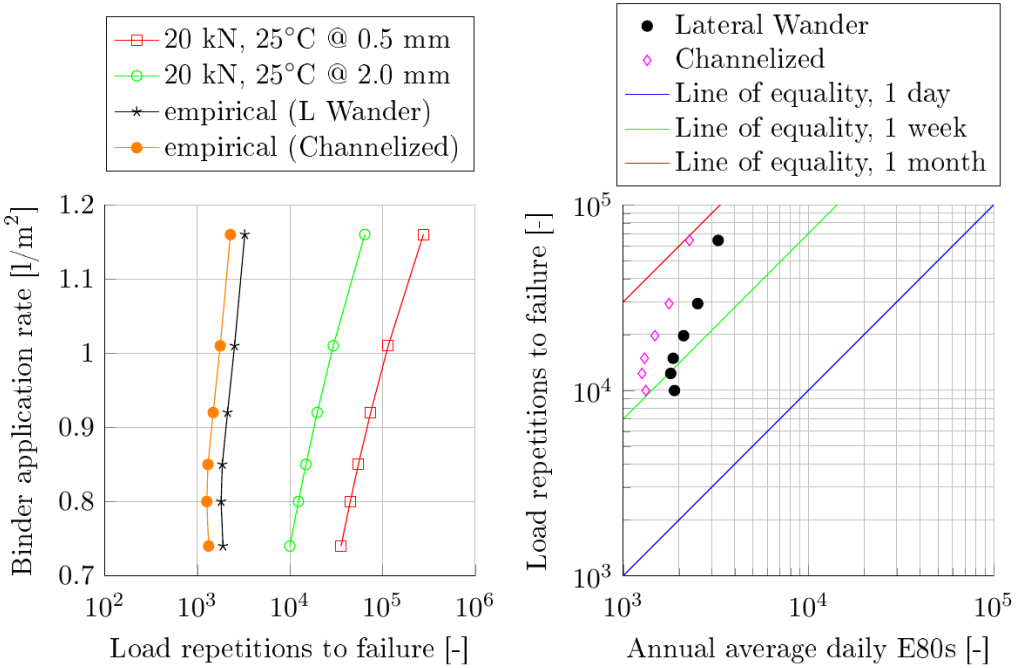
Model verification: Adhesion 2



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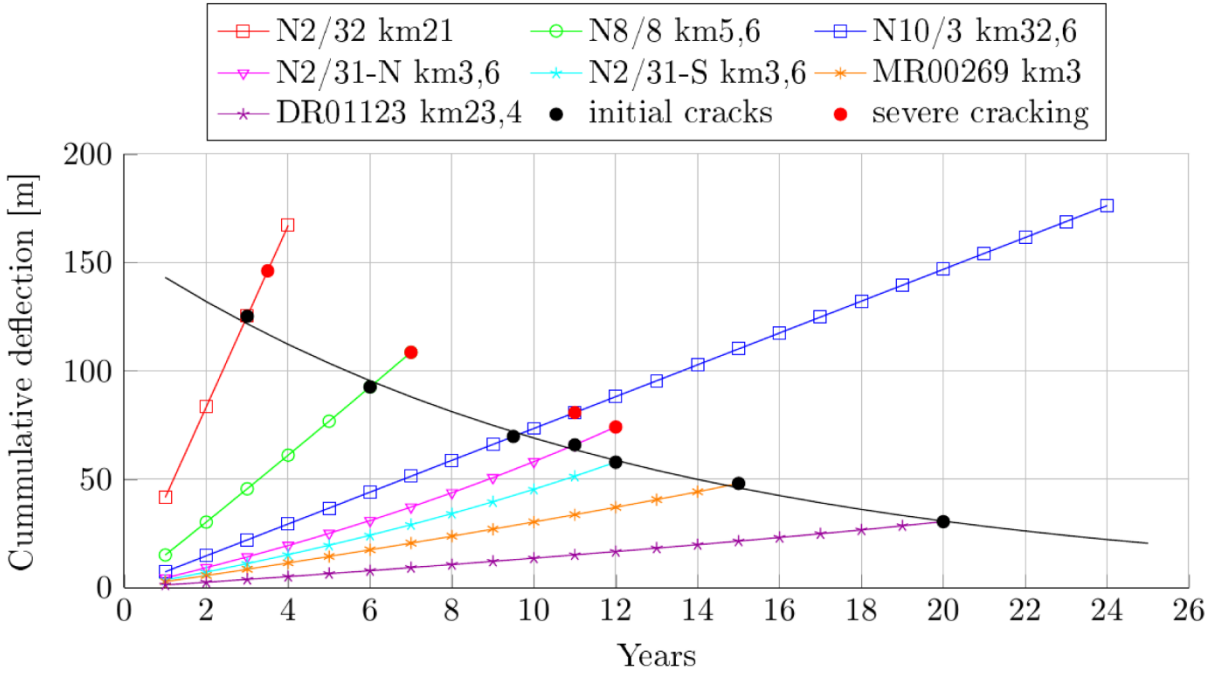
Model verification: Cohesion 1



[van Zyl, unpublished]

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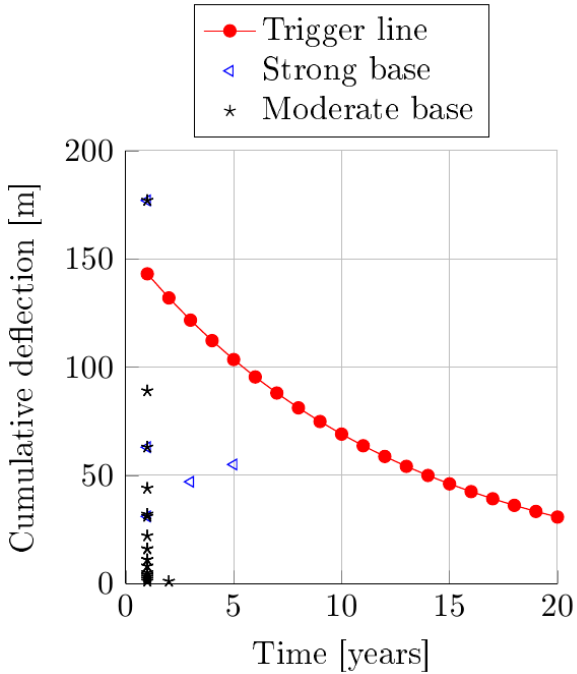
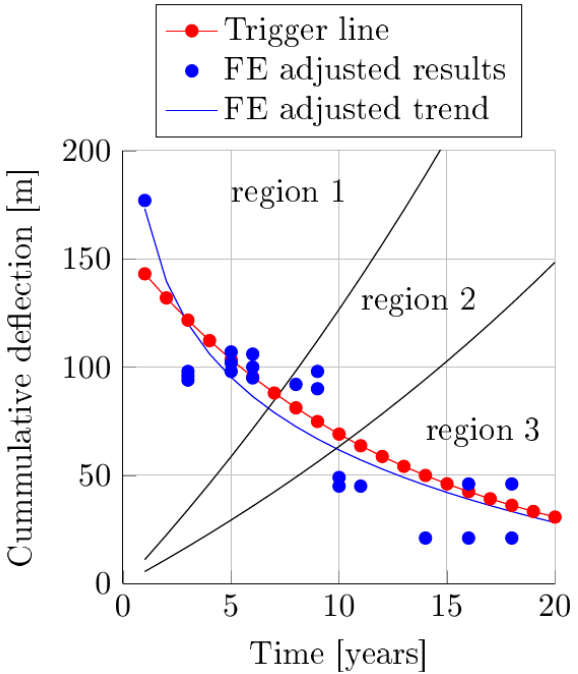
Model verification: Cohesion 2





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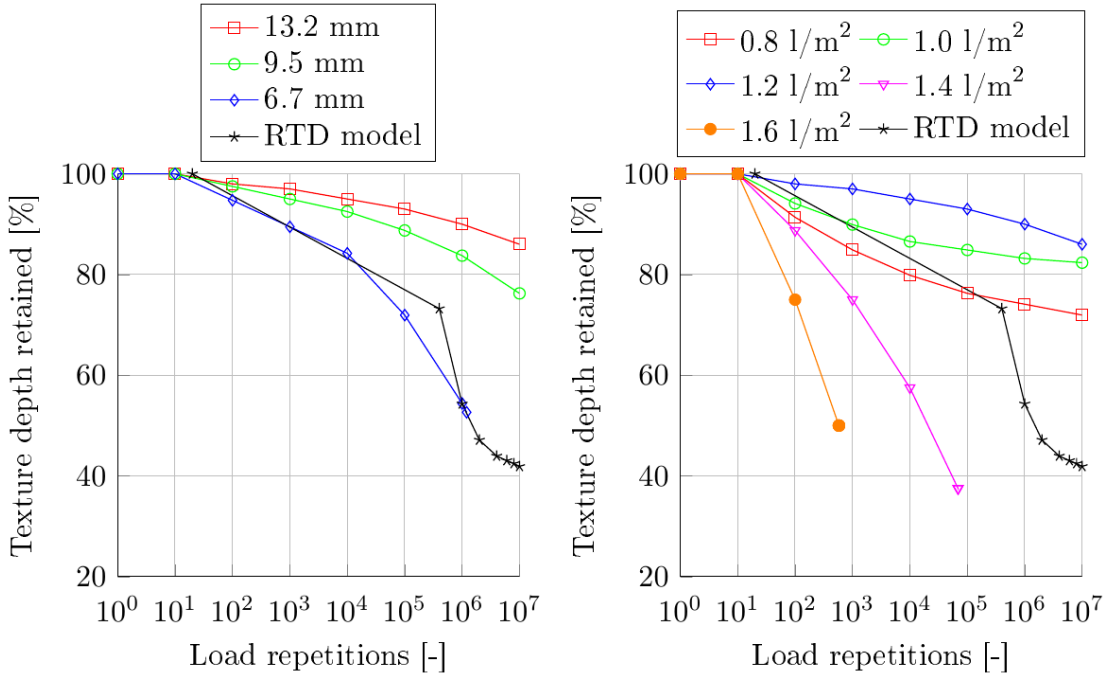
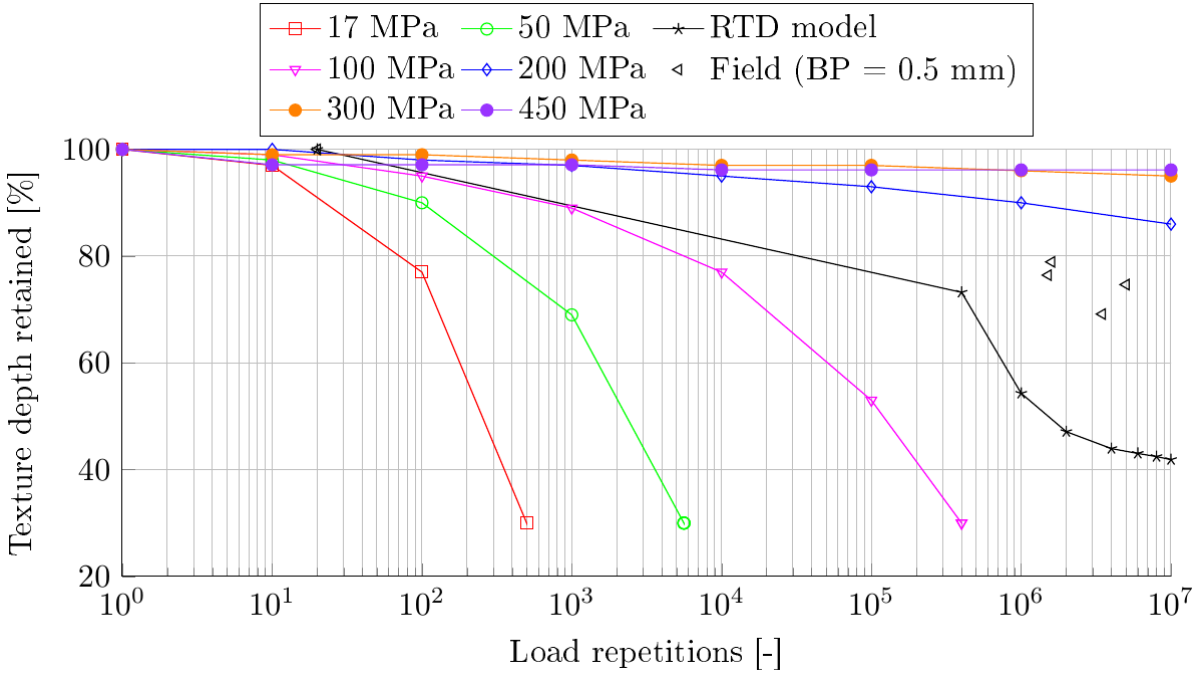
Model verification: Embedment 1



Surfacing seal FEM approach

Model verification: Embedment 2



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Conclusions

- Model quantification is laboratory dependent
- Unique damage ratios per failure mechanism
    - 3:1 adhesion
    - 2:1 cohesion
    - 11:10 embedment
- Review bitumen column DSR test setup
- Include rest periods for self-healing

Thank you

Questions?