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Nottinghamshire County Council

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Aston University
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Transport for London

Road Surface Damage Research

national highways

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RSTA COLLECTIVE MARK

Nick Thom

ADEPT
ASSOCIATION OF DIRECTORS OF ENVIRONMENT, ECONOMY PLANNING AND TRANSPORT

Contents

- Evidence from condition surveys in Nottinghamshire
- Simulation of the tyre-road contact in wet conditions
- The freeze-thaw problem

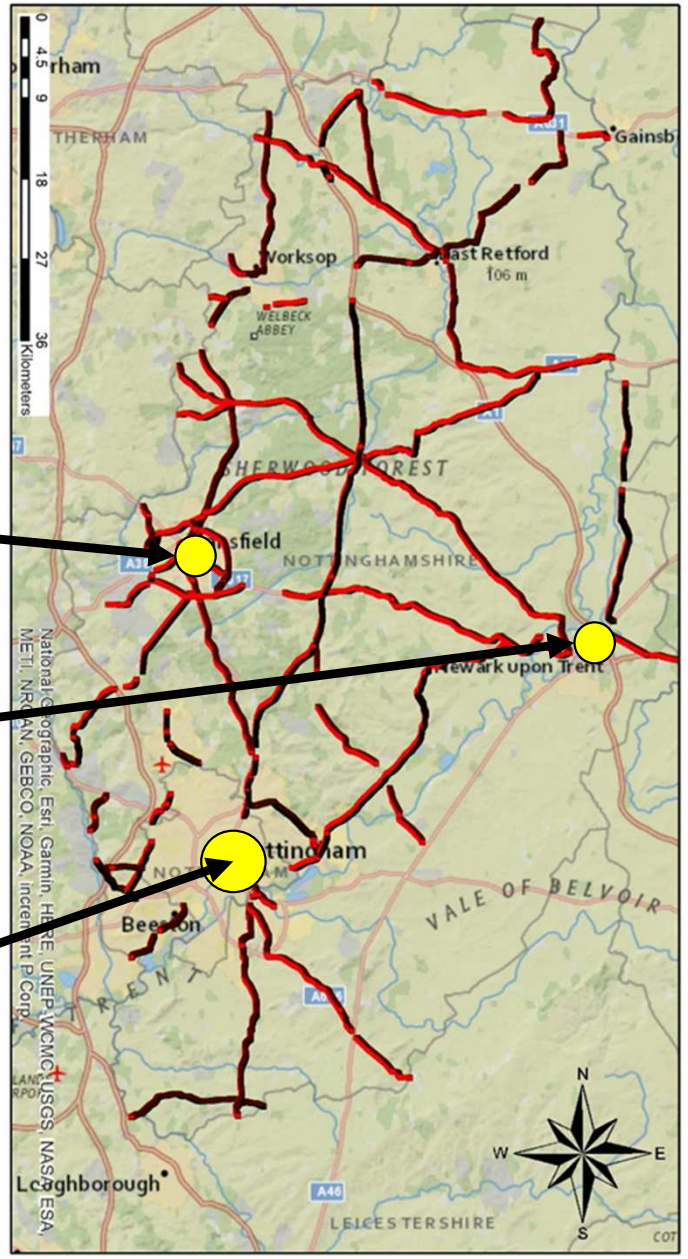
Evidence from condition surveys in Nottinghamshire

These are the roads we are talking about

Mansfield

Newark

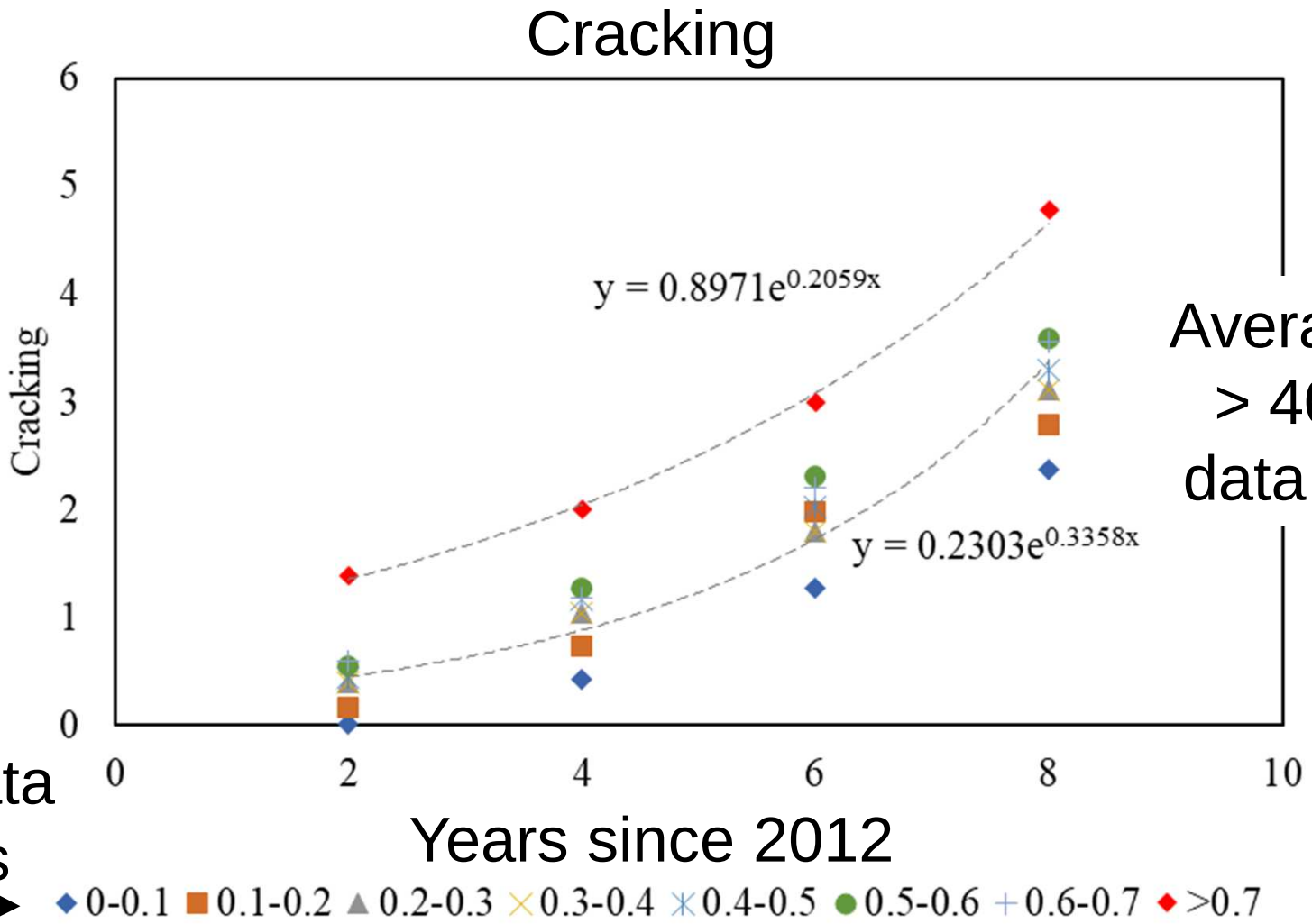
Nottingham



Data from SCANNER in
2014, 2016, 2018 and 2020

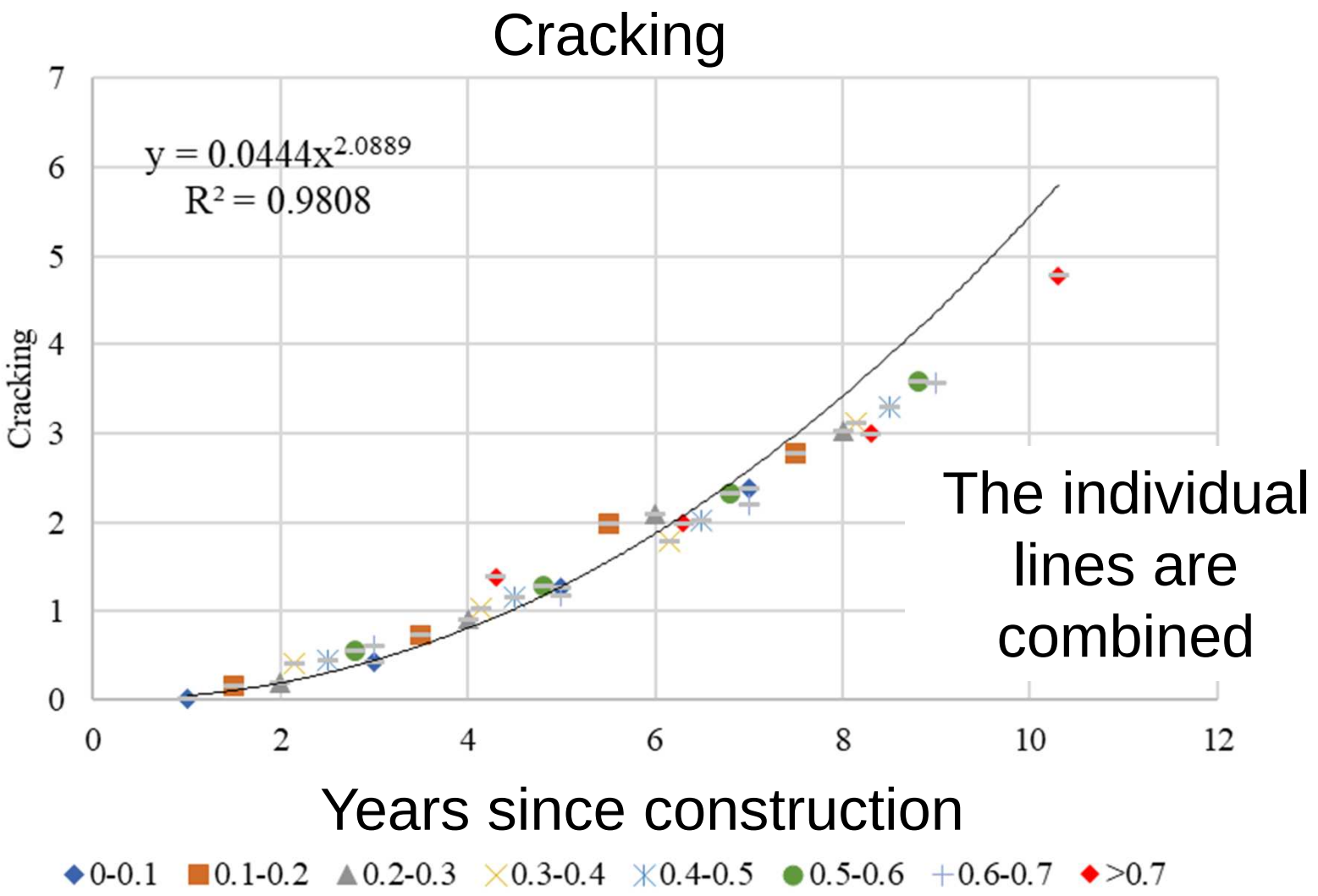
Looking at: Rutting
Cracking
Texture

Sections subject to maintenance excluded



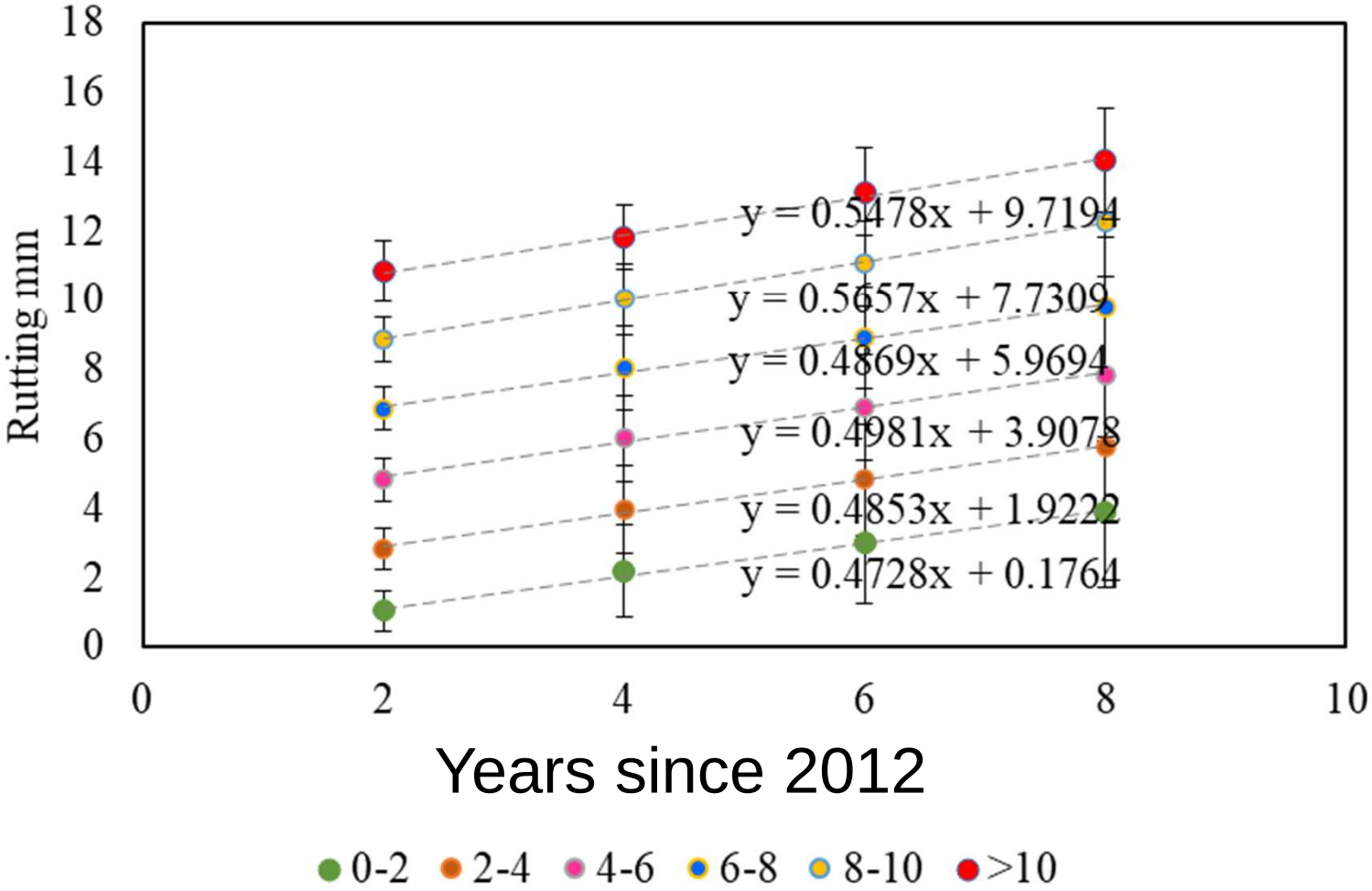
Averages of > 40,000 data points

2014 data ranges

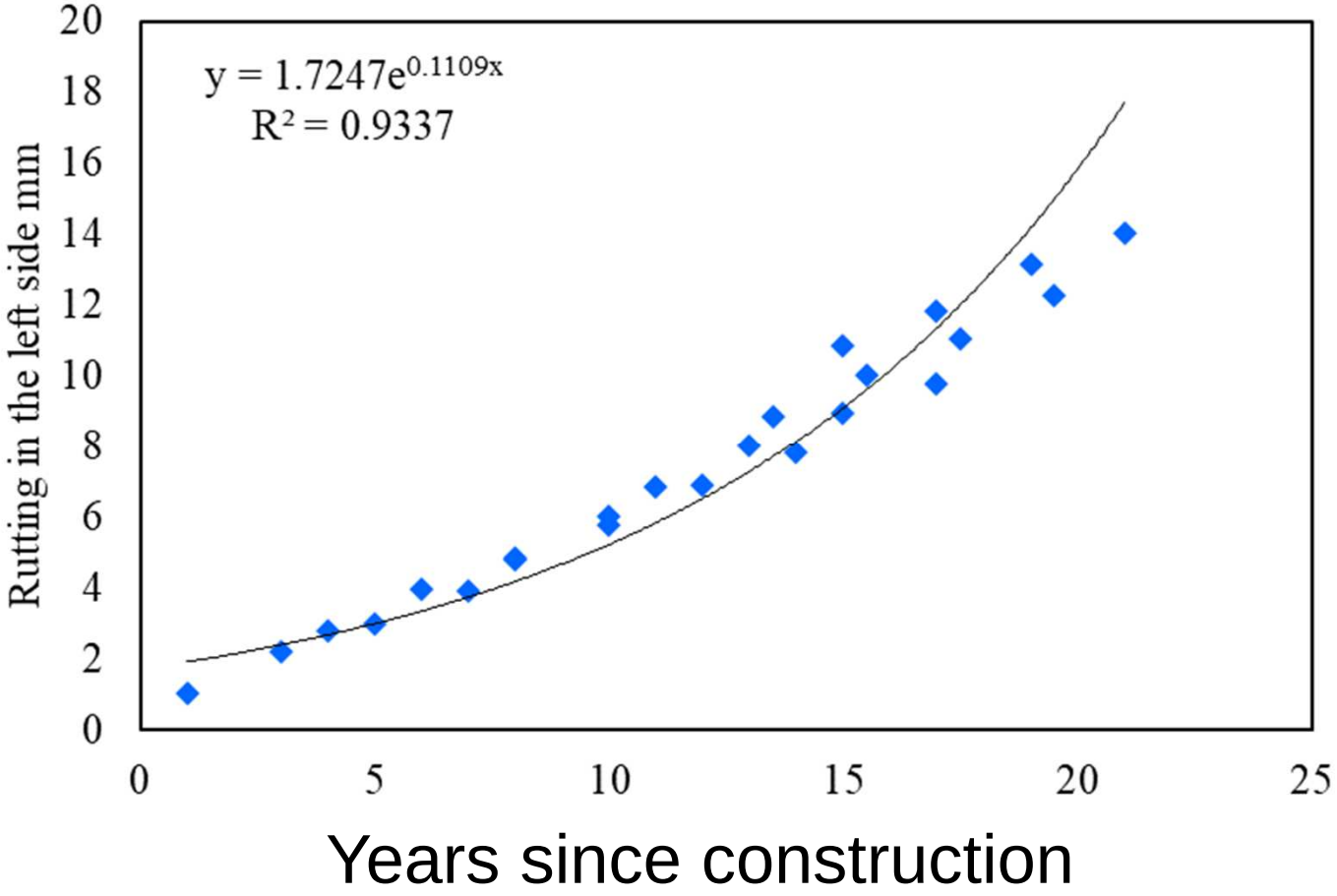


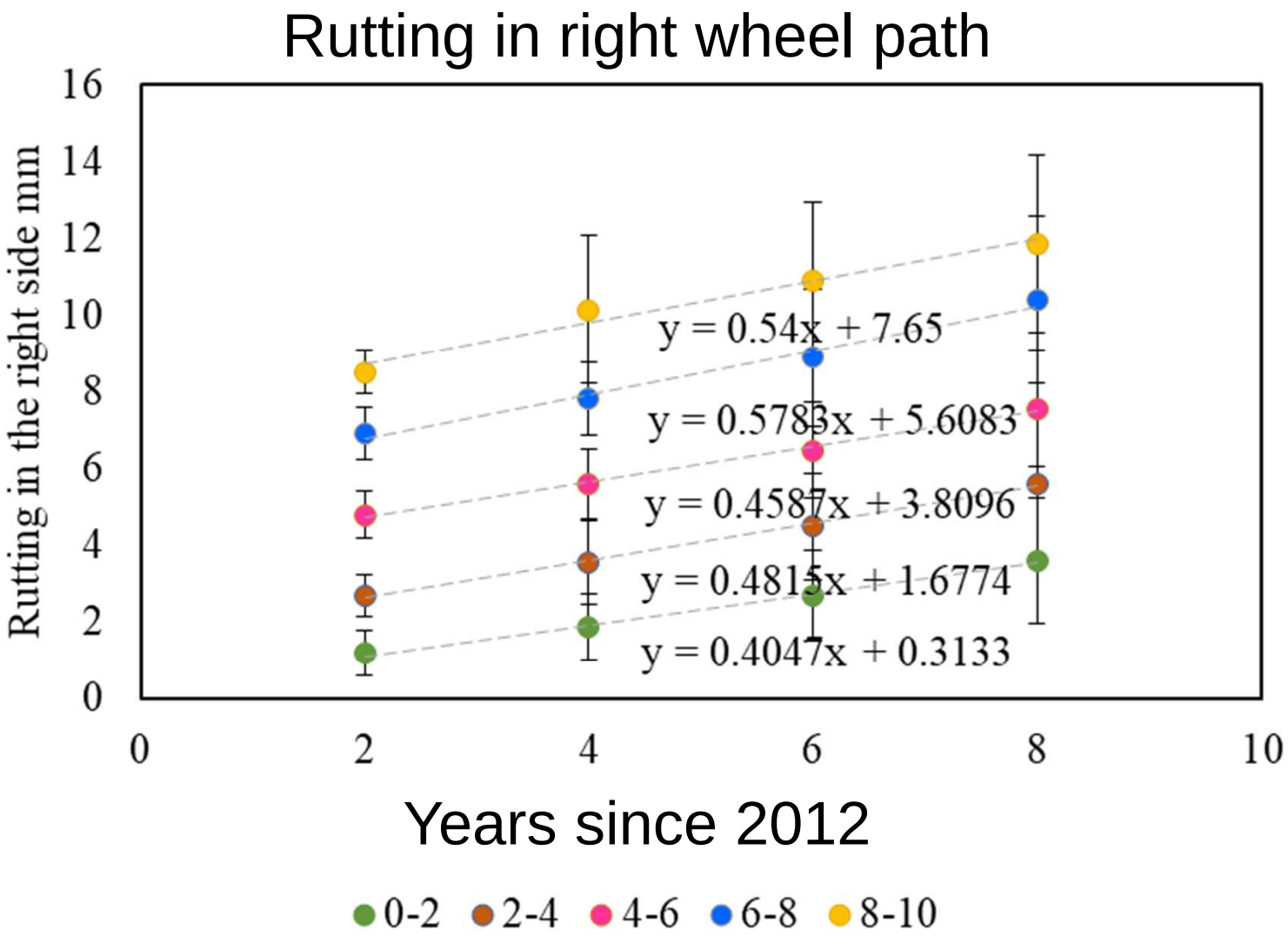
The individual lines are combined

Rutting in left wheel path

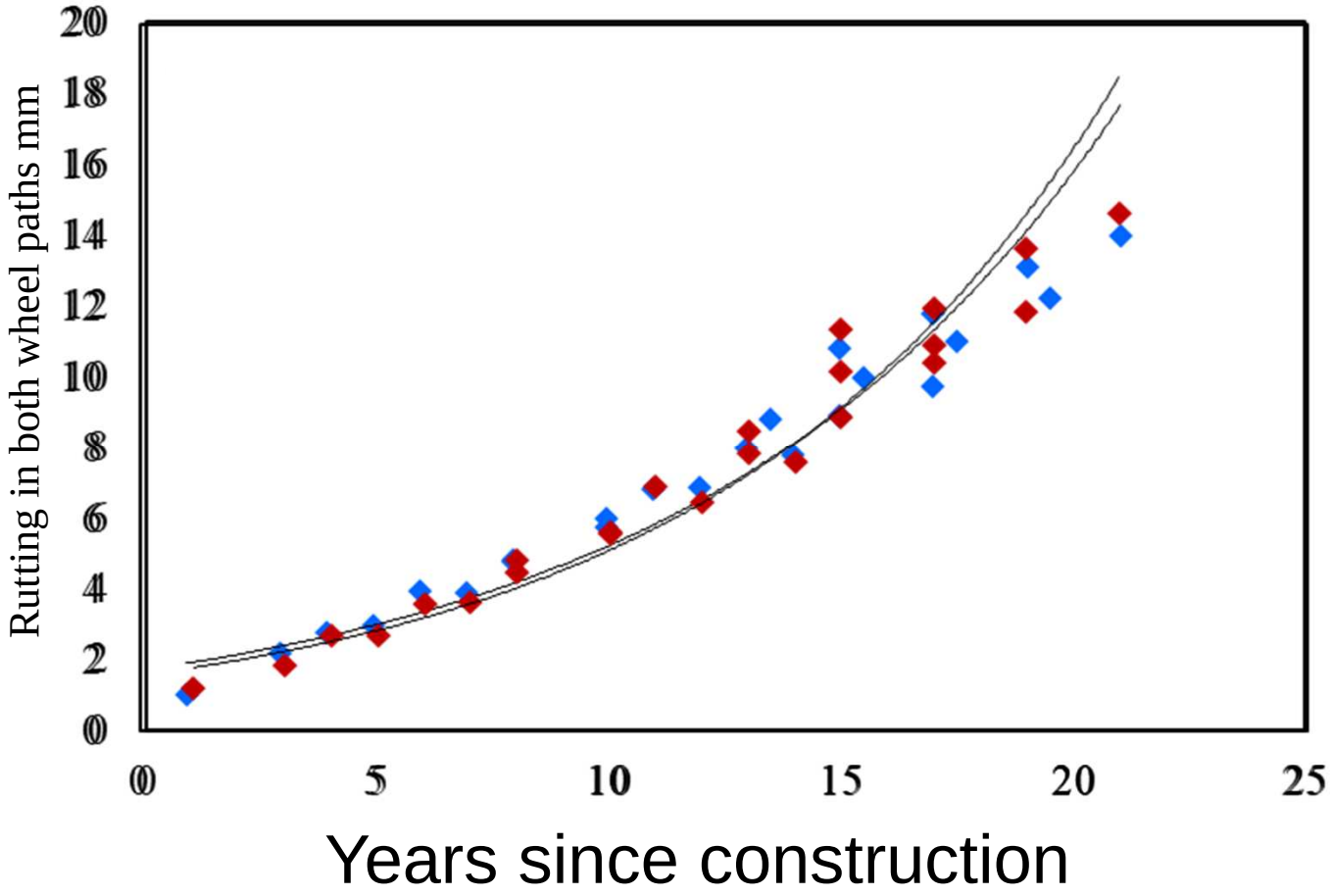


Rutting in left wheel path

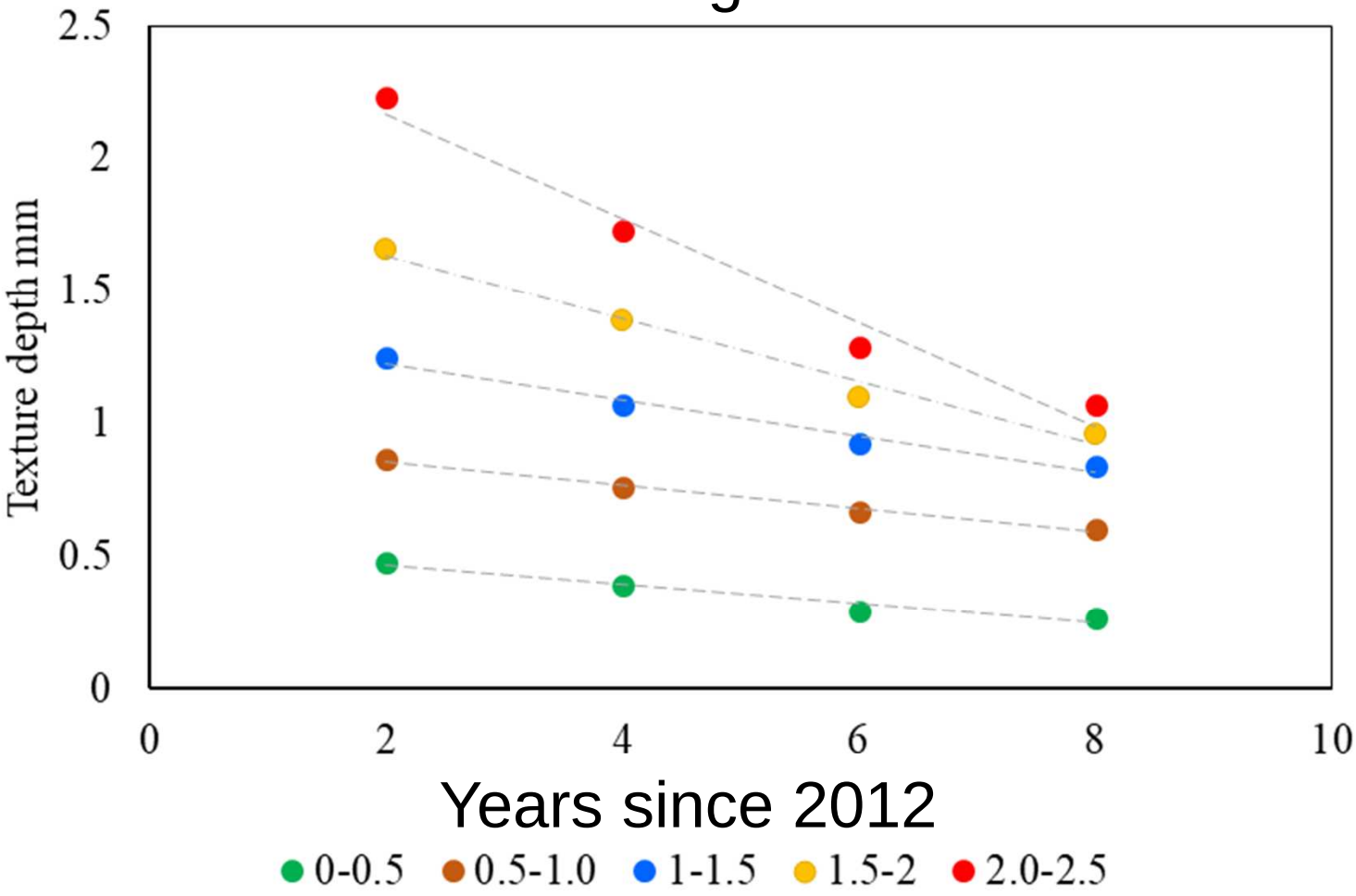



Rutting in right wheel path
Rutting in the right side mm
16
14
12
10
8
6
4
2
0
0
2
4
6
8
10
y = 0.54x + 7.65
y = 0.5783x + 5.6083
y = 0.4587x + 3.8096
y = 0.4815x + 1.6774
y = 0.4047x + 0.3133
Years since 2012
0-2
2-4
4-6
6-8
8-10

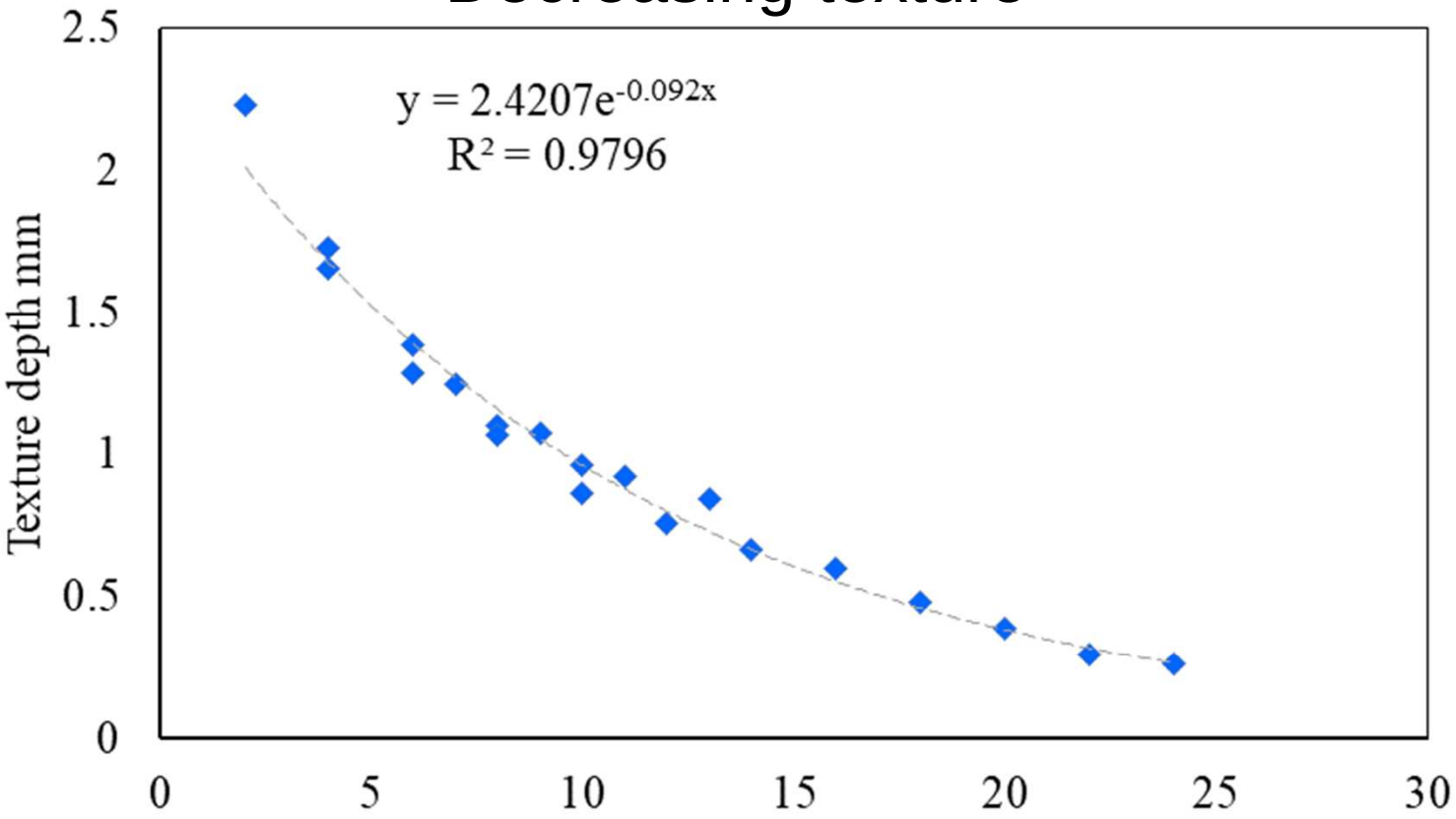
Rutting in both wheel paths



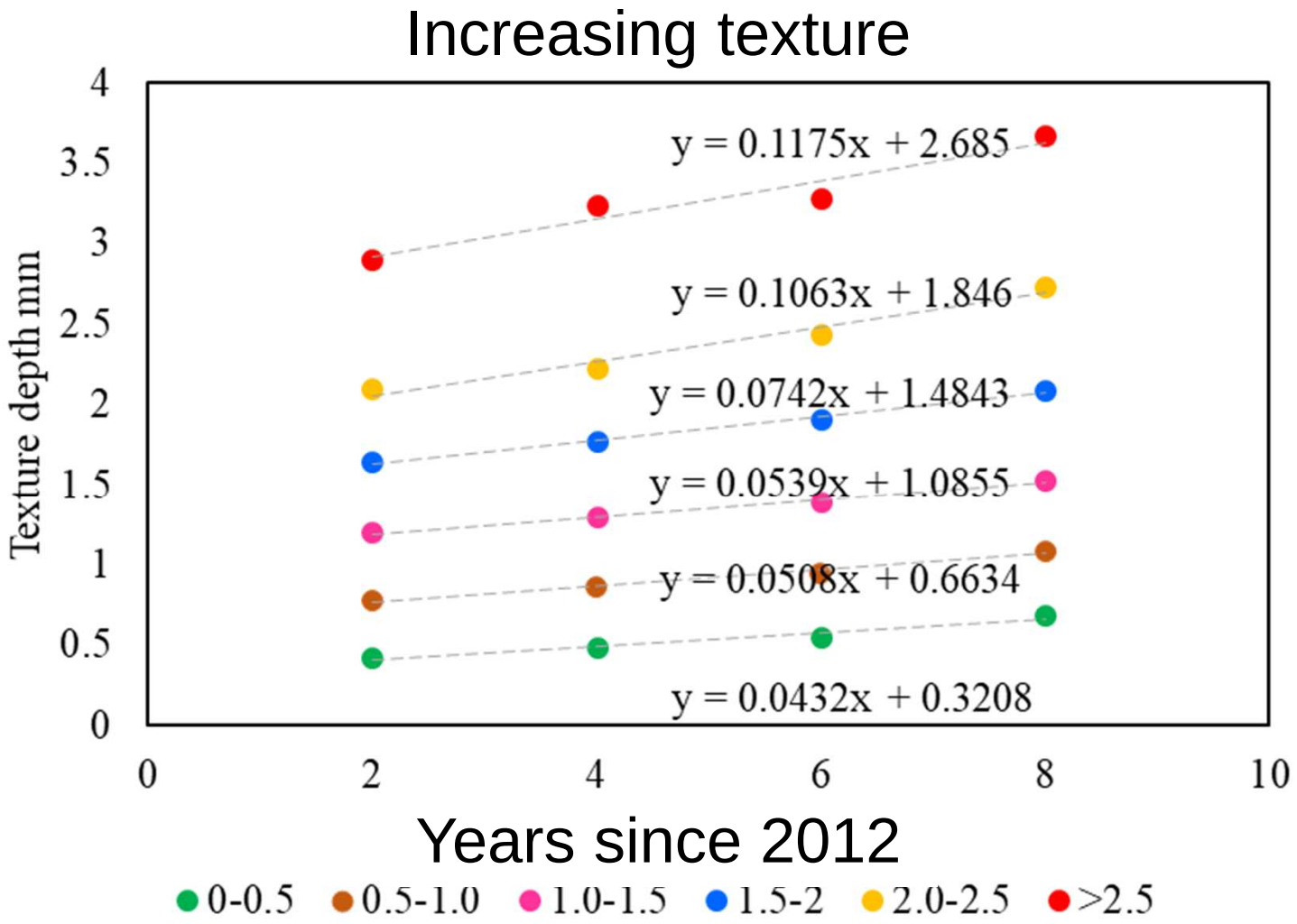
Decreasing texture



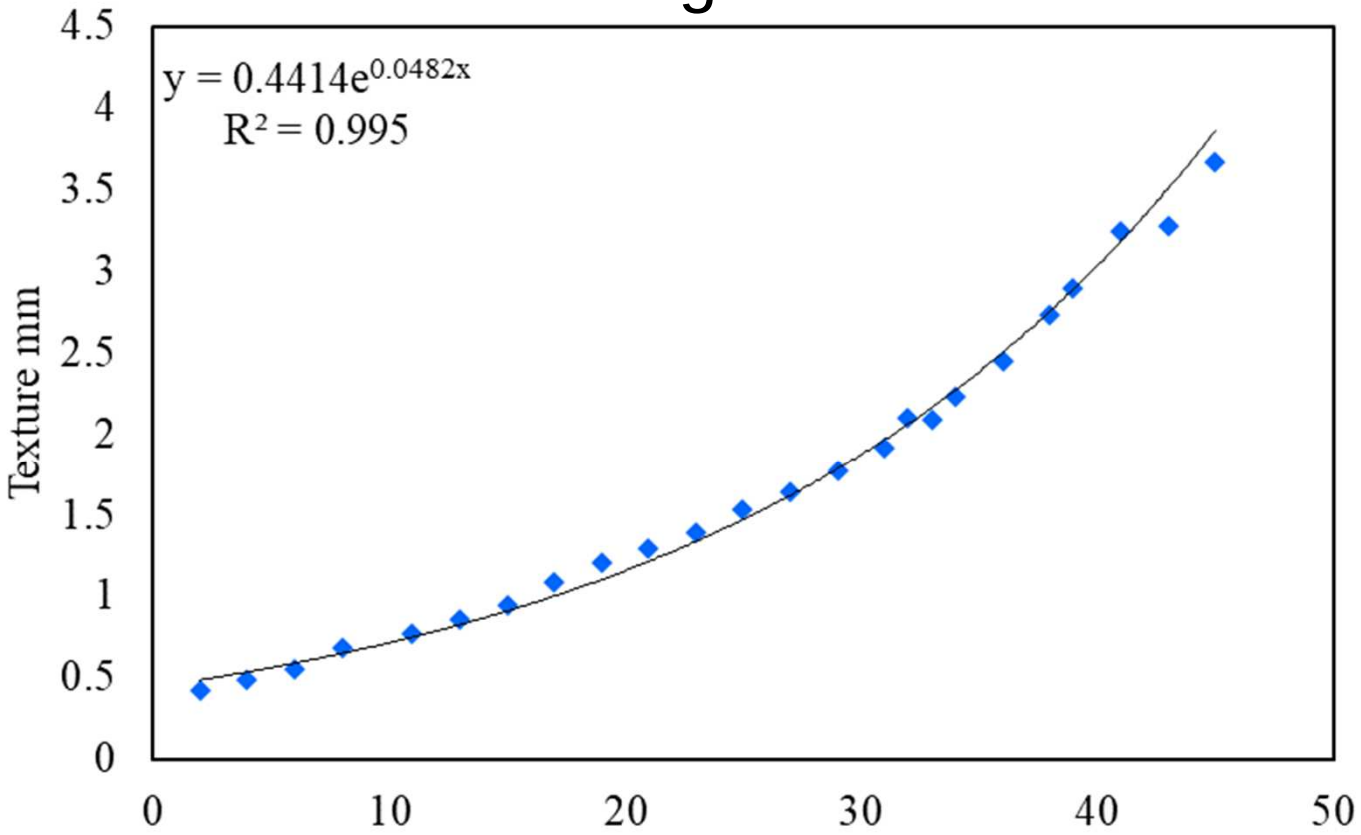
Decreasing texture



Years since construction


Increasing texture
Texture depth mm
y = 0.1175x + 2.685
y = 0.1063x + 1.846
y = 0.0742x + 1.4843
y = 0.0539x + 1.0855
y = 0.0508x + 0.6634
y = 0.0432x + 0.3208
Years since 2012
0-0.5
0.5-1.0
1.0-1.5
1.5-2
2.0-2.5
>2.5

Increasing texture



Years since construction

Simulation of the tyre-road contact in wet conditions

Dry Contact

It hurts the asphalt, but only in ways that it was designed for

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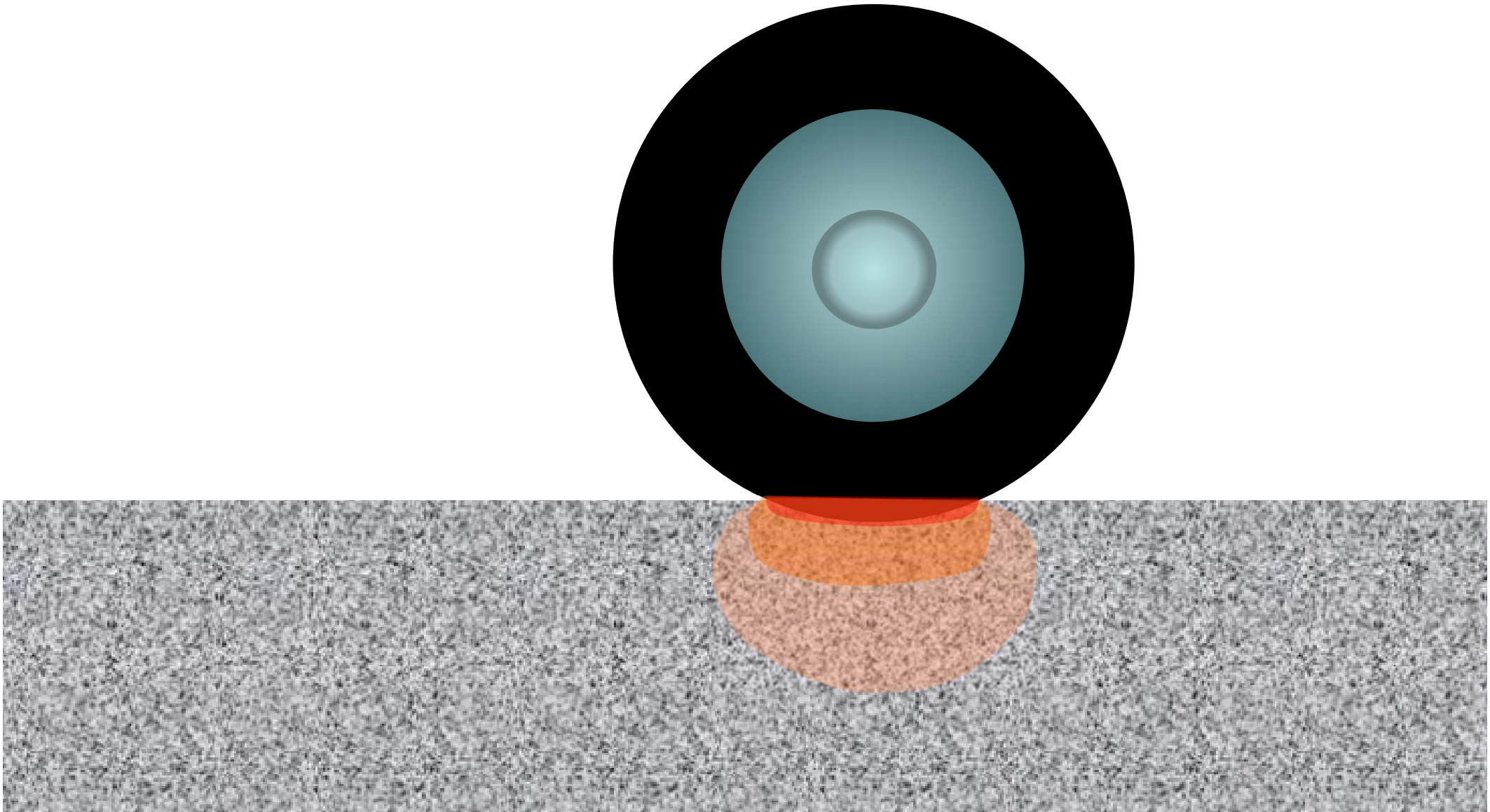
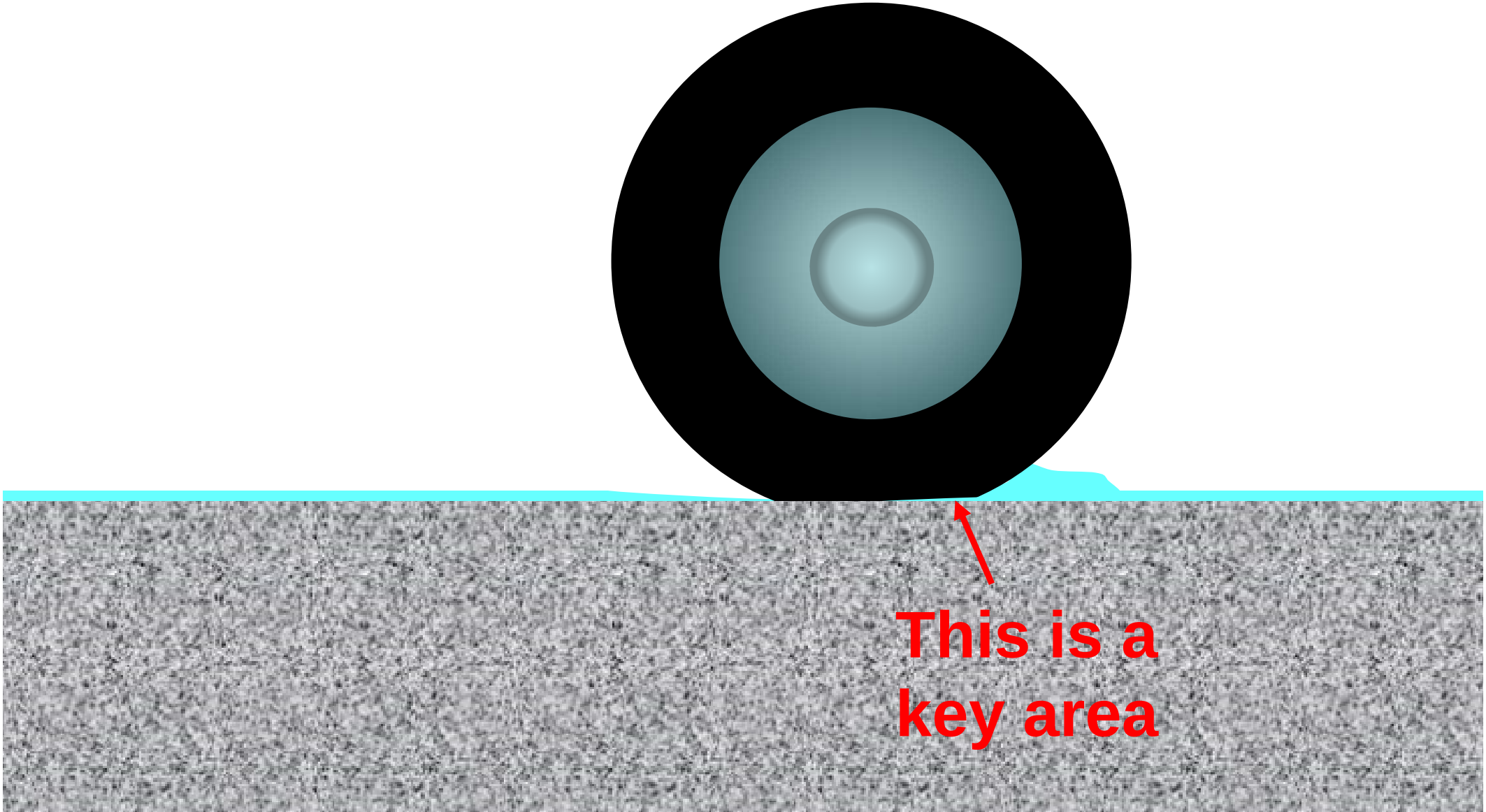
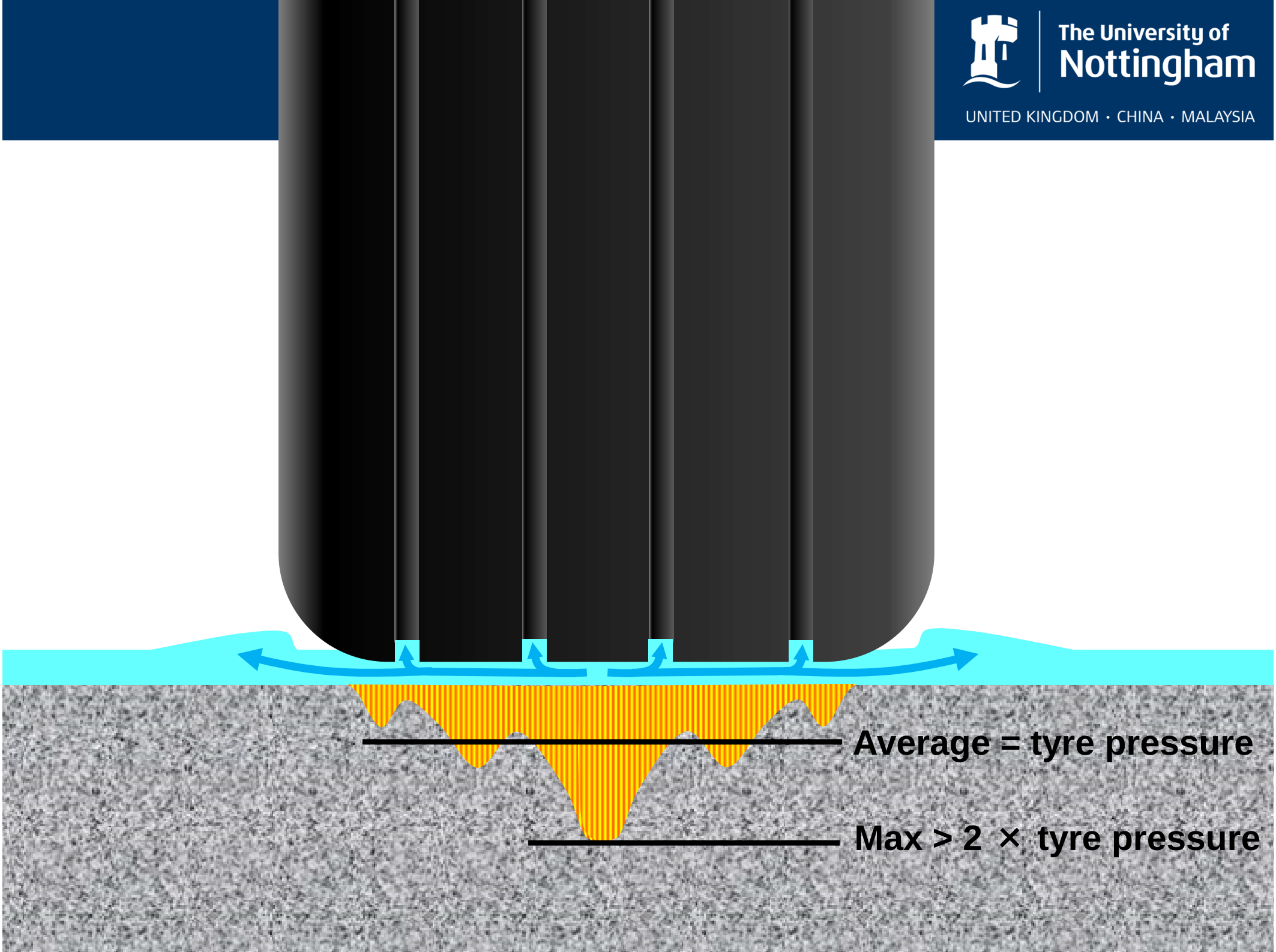
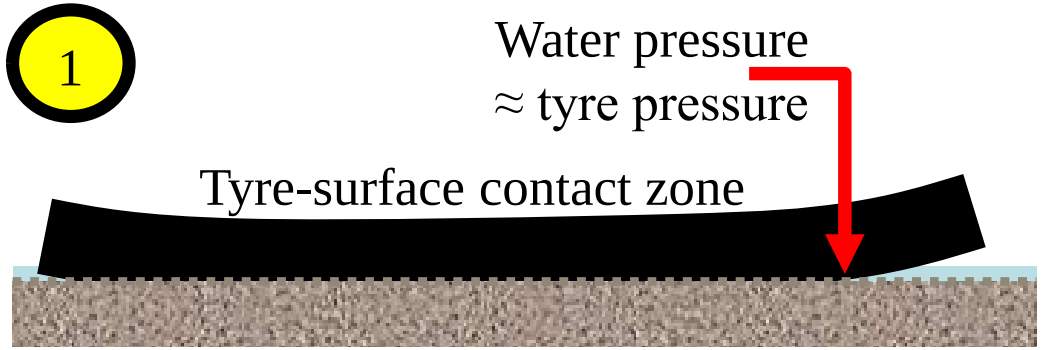


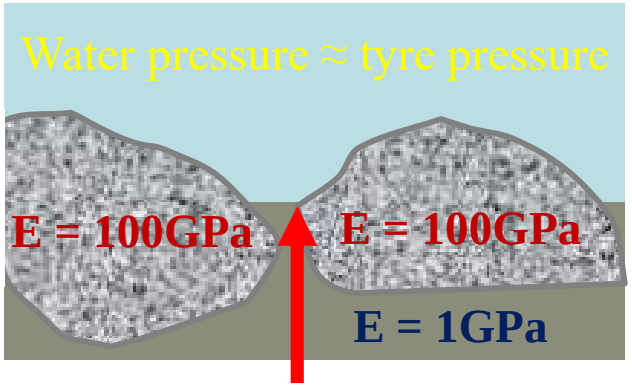

This is a
key area




1
Water pressure
≈ tyre pressure
Tyre-surface contact zone

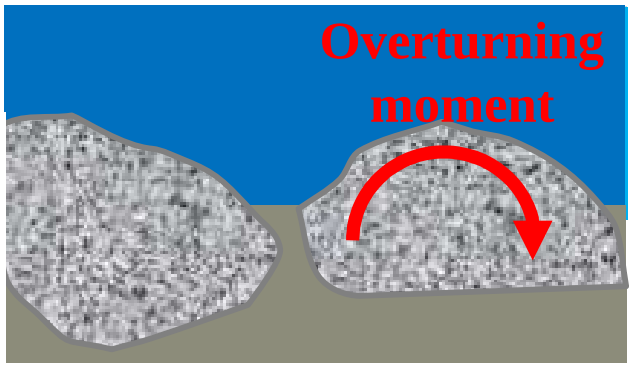
1

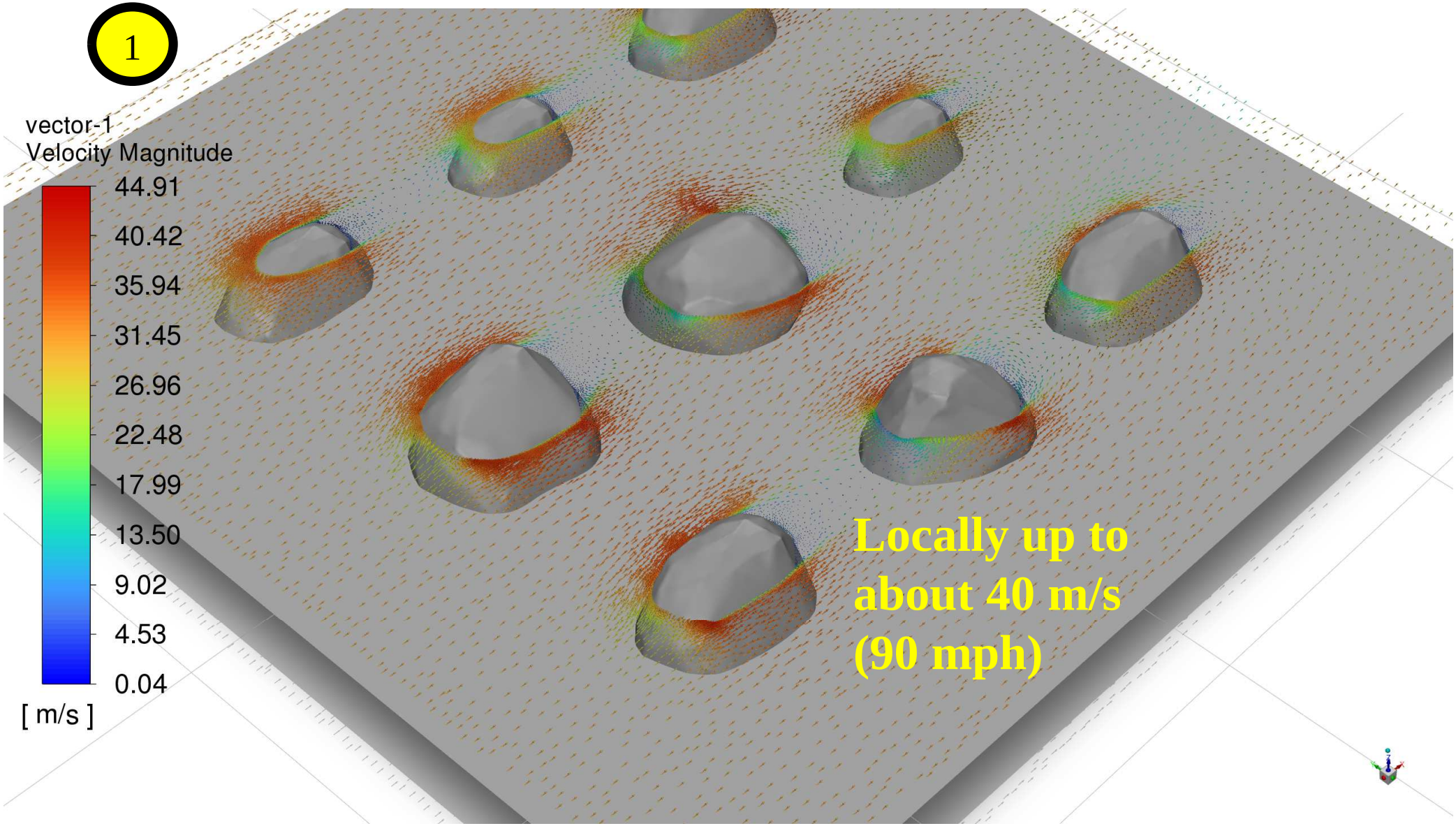
a

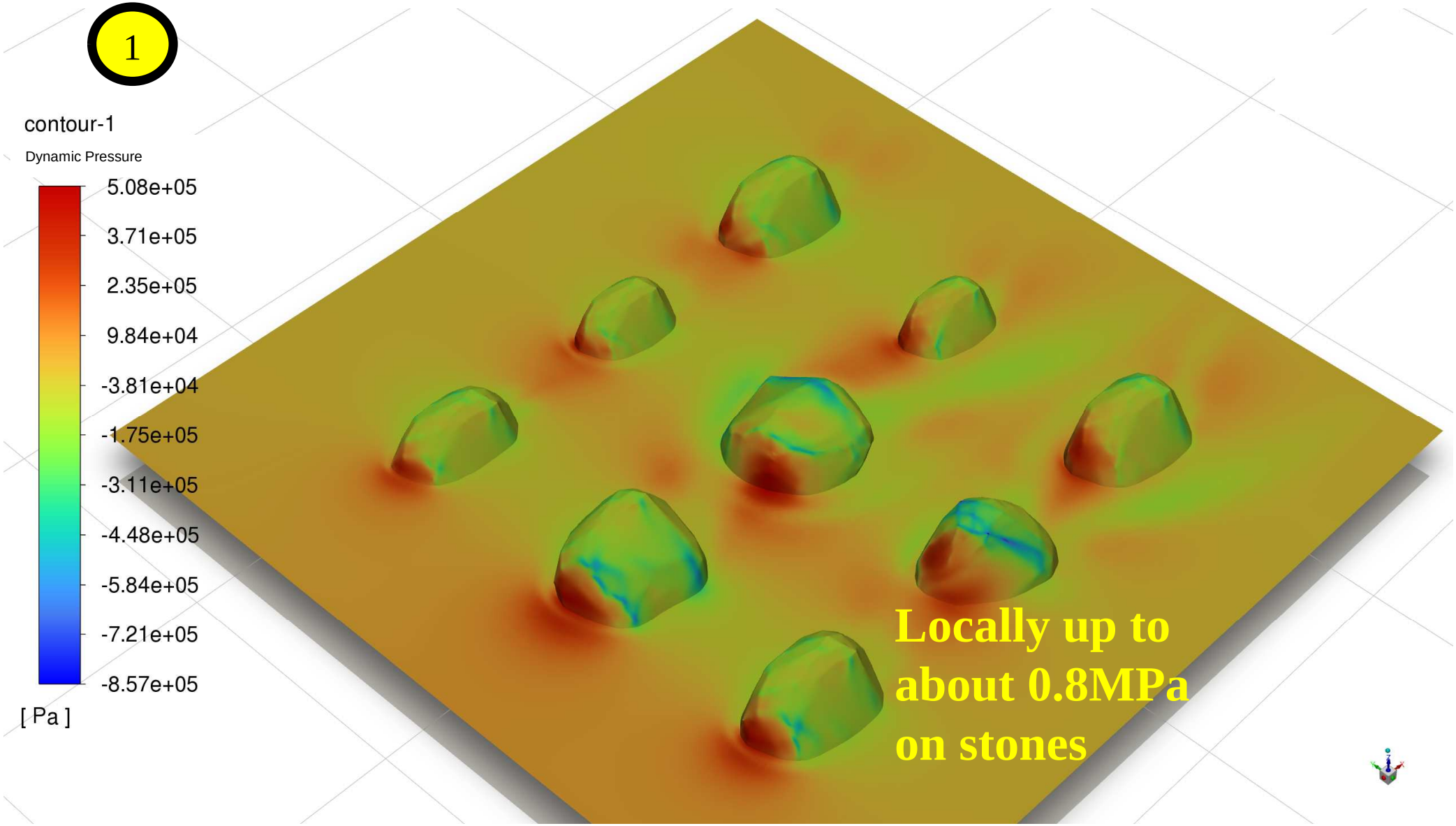


Very high stress
(infinite in theory)

b

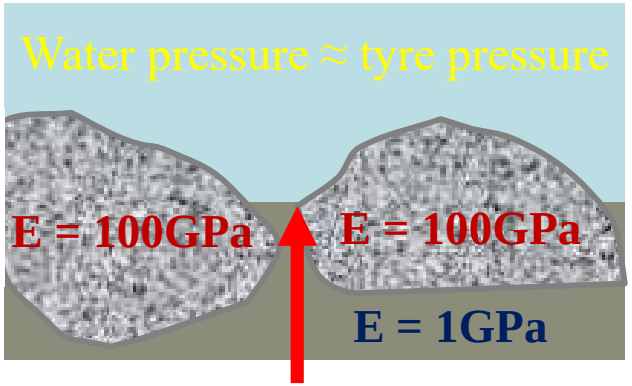



1
vector-1
Velocity Magnitude
44.91
40.42
35.94
31.45
26.96
22.48
17.99
13.50
9.02
4.53
0.04
[m/s]
Locally up to about 40 m/s (90 mph)


1
contour-1
Dynamic Pressure
5.08e+05
3.71e+05
2.35e+05
9.84e+04
-3.81e+04
-1.75e+05
-3.11e+05
-4.48e+05
-5.84e+05
-7.21e+05
-8.57e+05
[Pa]
Locally up to about 0.8MPa on stones

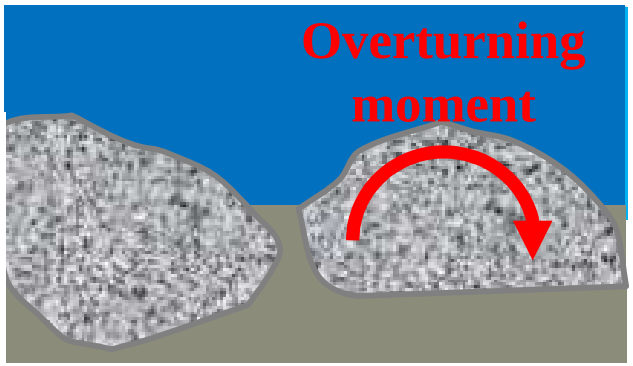
1

a

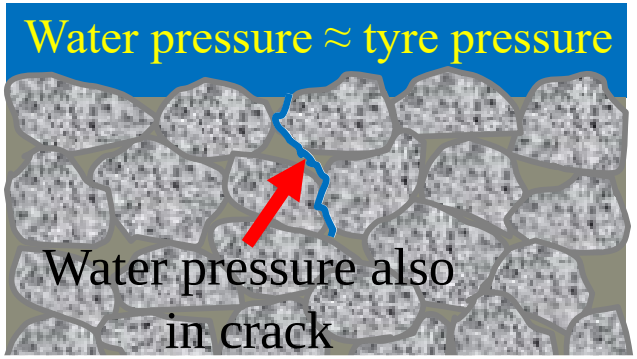


Very high stress
(infinite in theory)

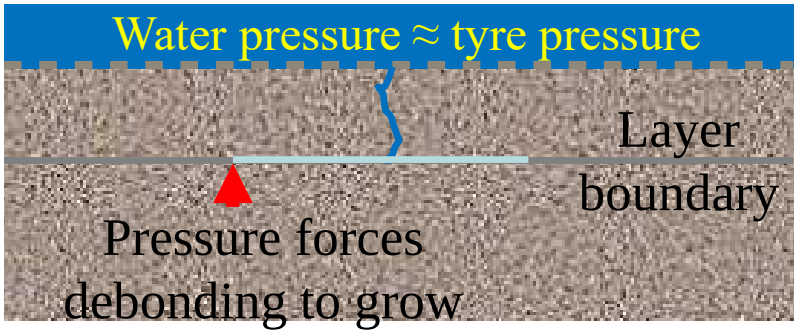
b



c

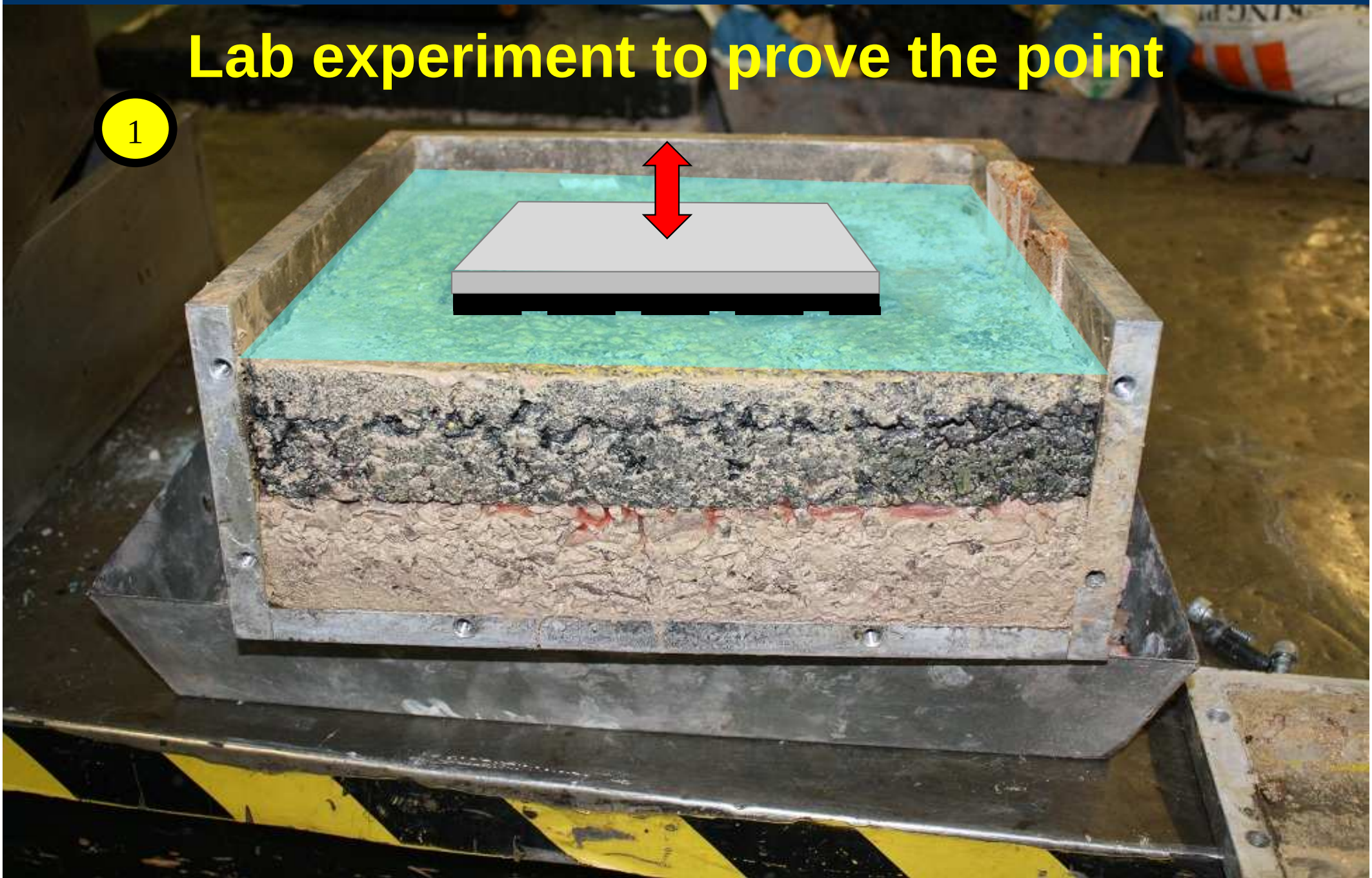


d

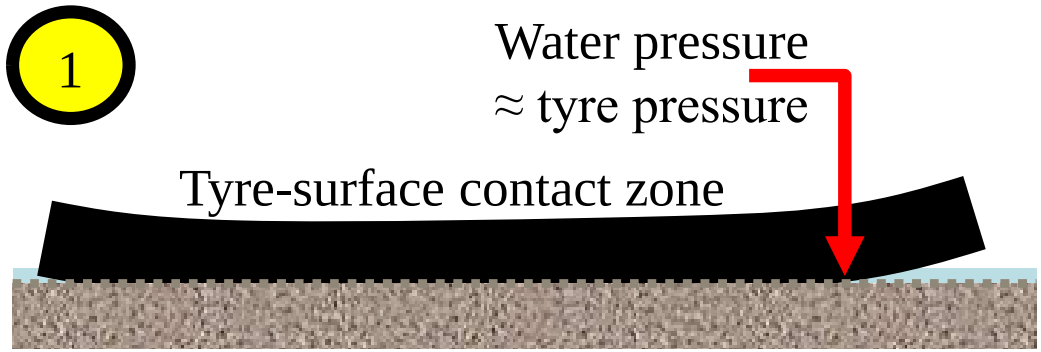


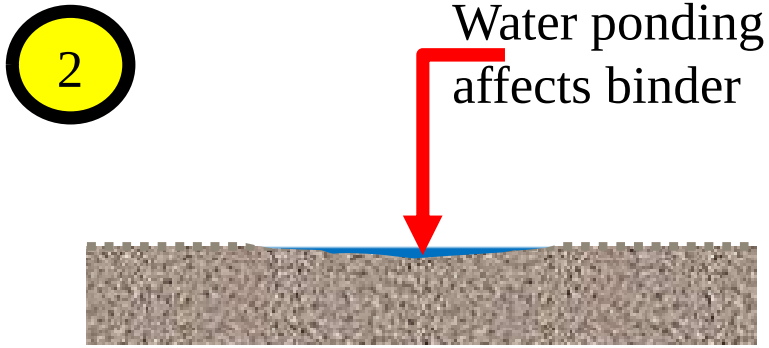
Lab experiment to prove the point

1

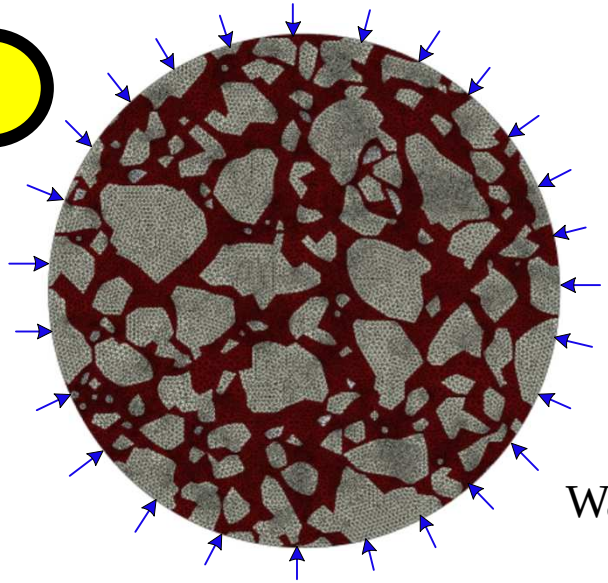



1
Red dye marks the path of water through the asphalt


1
Water pressure
≈ tyre pressure
Tyre-surface contact zone

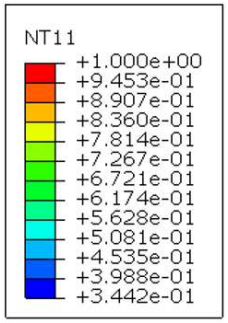

2
Water ponding
affects binder

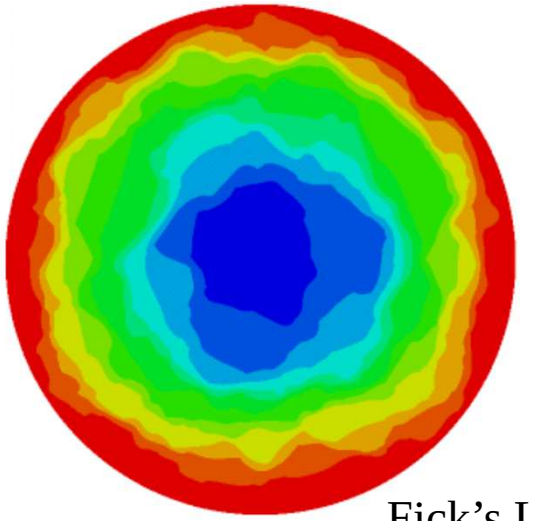
2



Water

(a)

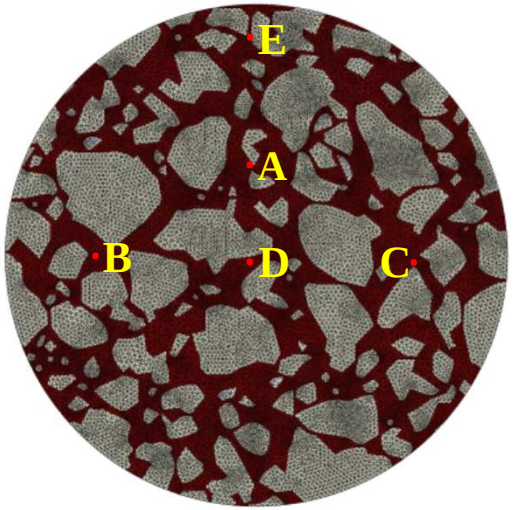




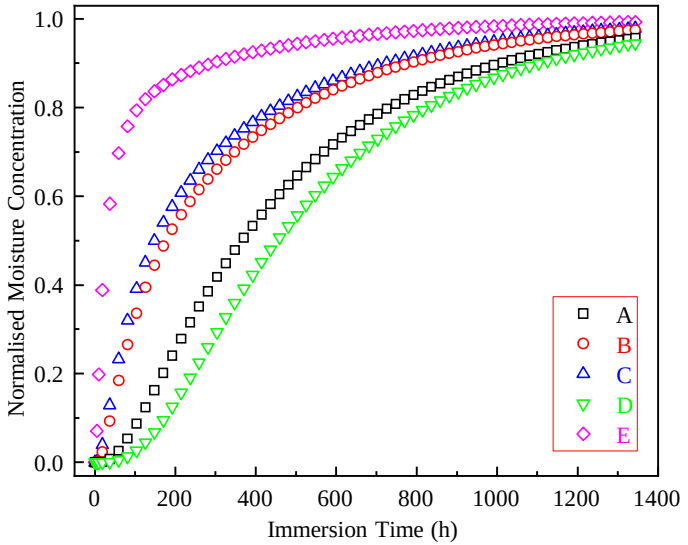
Fick's Law

(b)

water diffuses slowly into asphalt when there is surface water

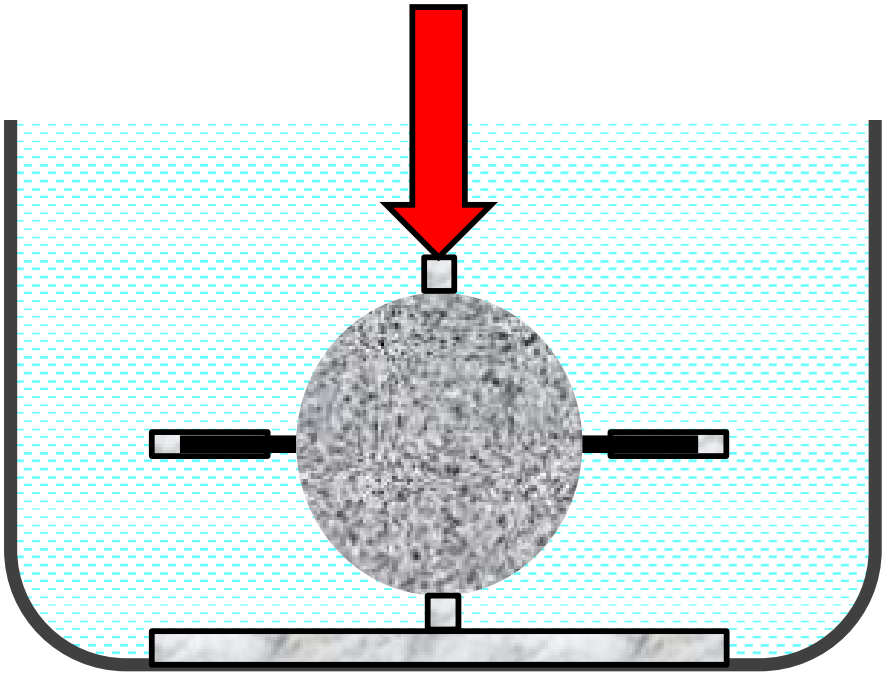


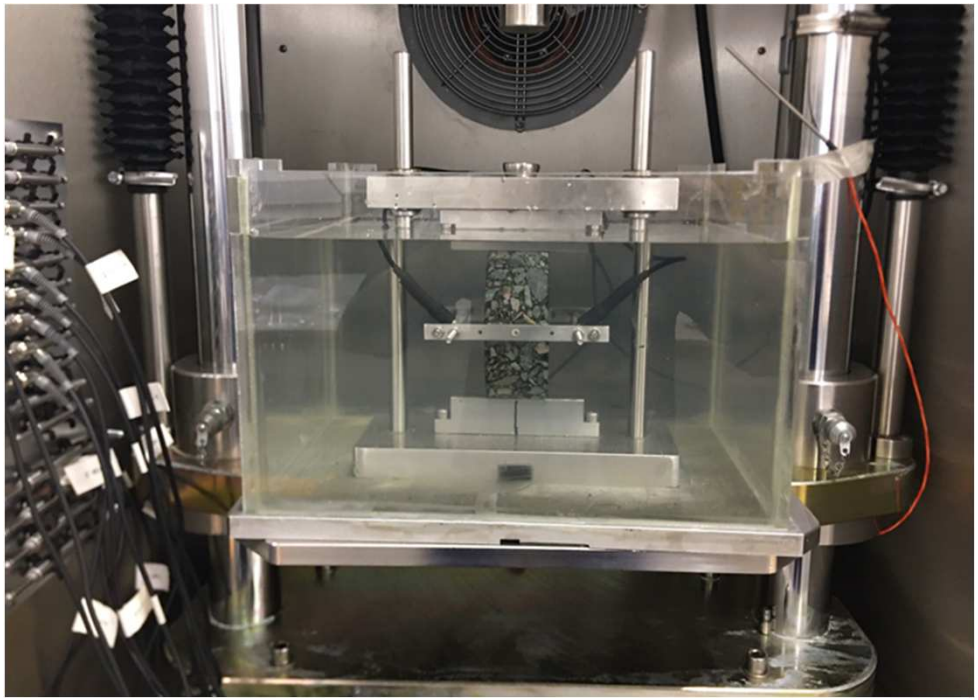
(c)

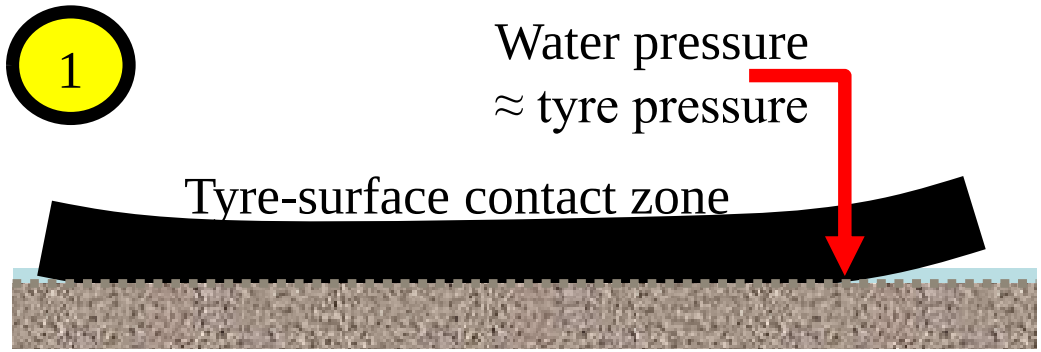


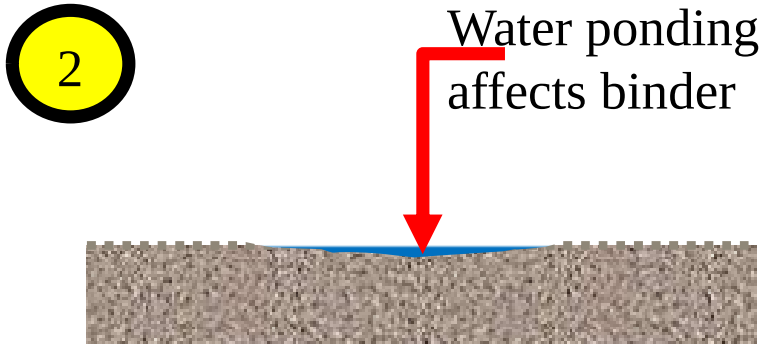
(d)

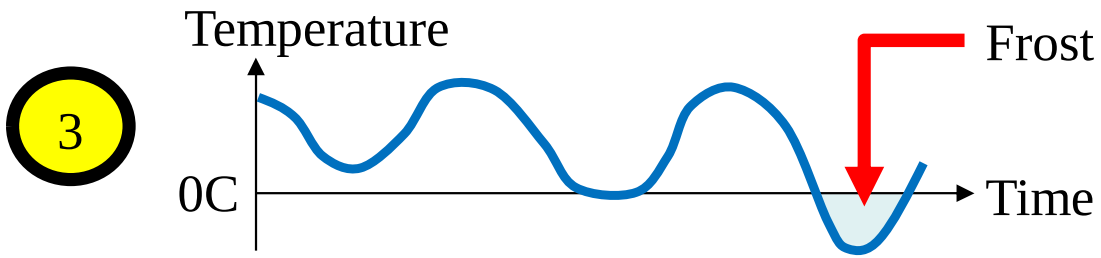
2 We are still trying to measure fatigue under water

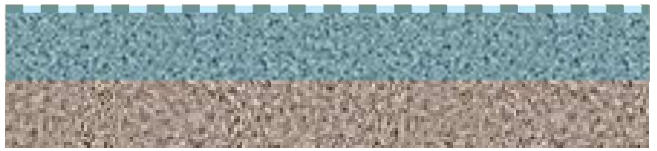





1
Water pressure
≈ tyre pressure
Tyre-surface contact zone

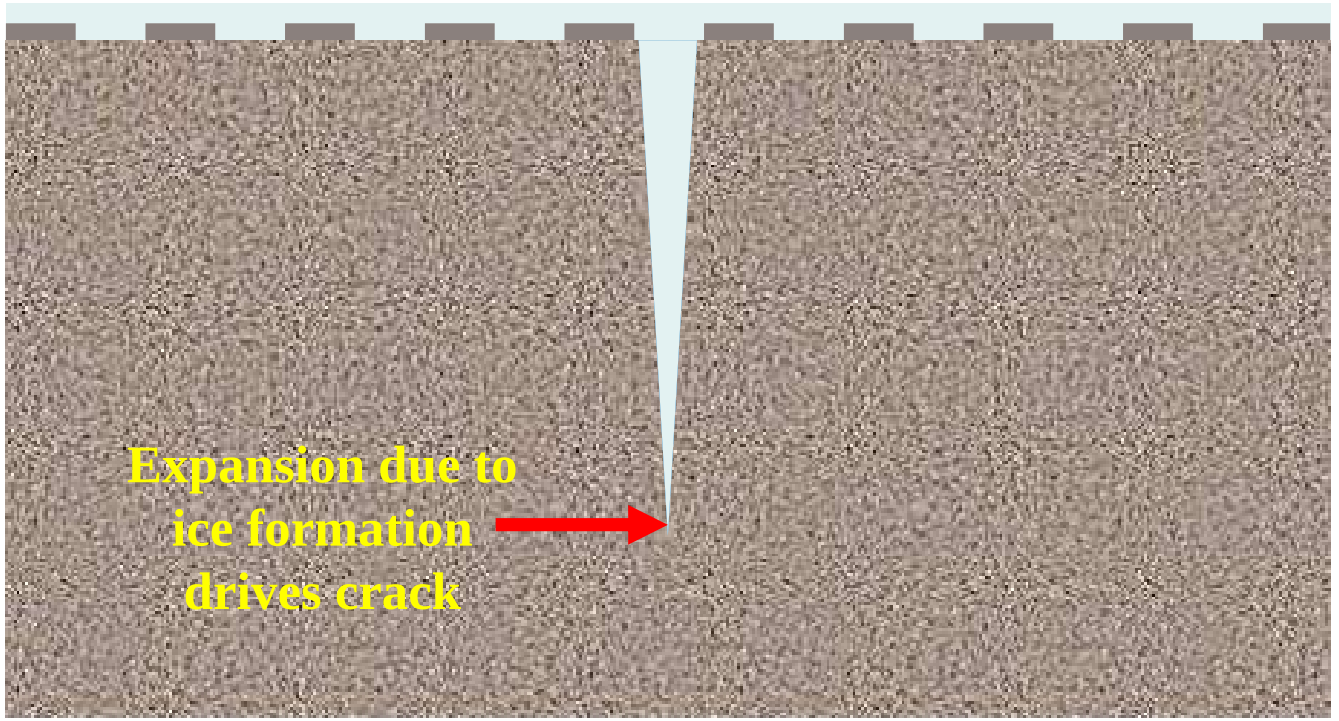

2
Water ponding
affects binder


3
Temperature
Frost
0C
Time

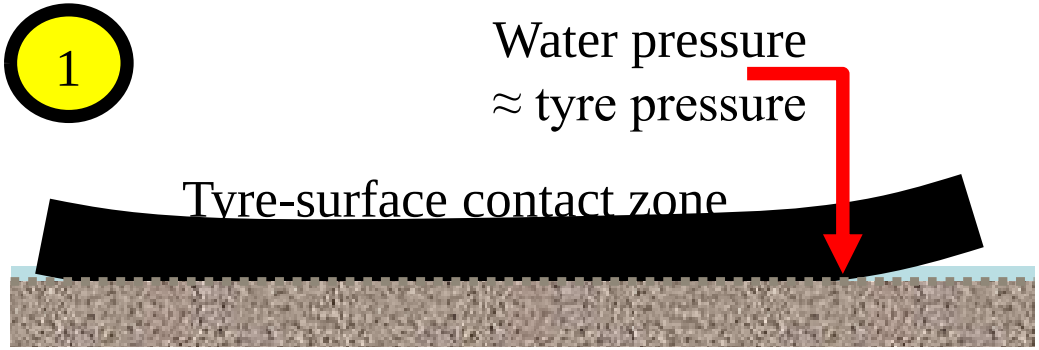


The freeze-thaw problem

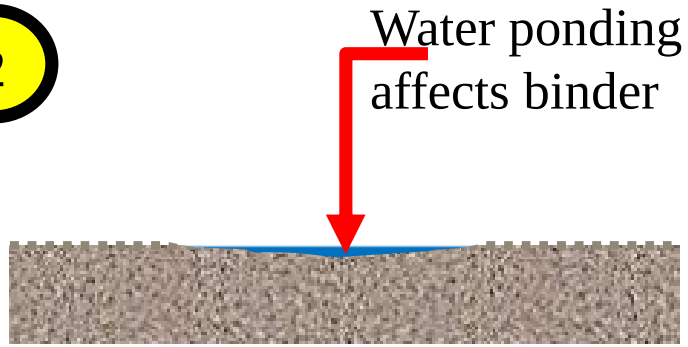
3



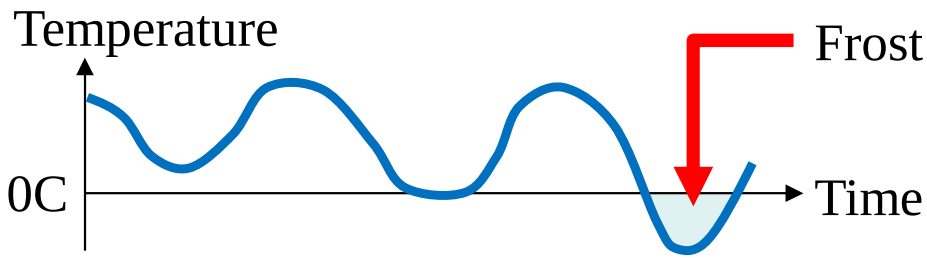
1

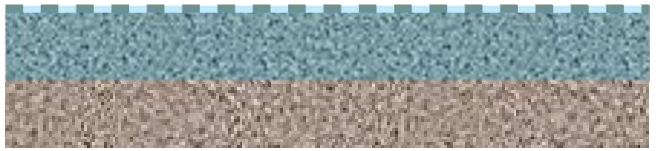

Water pressure
≈ tyre pressure
Tyre-surface contact zone

2

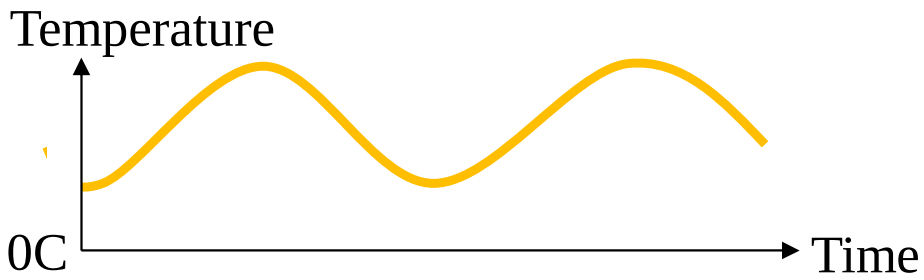

Water ponding
affects binder

3


Temperature
Frost
0C
Time

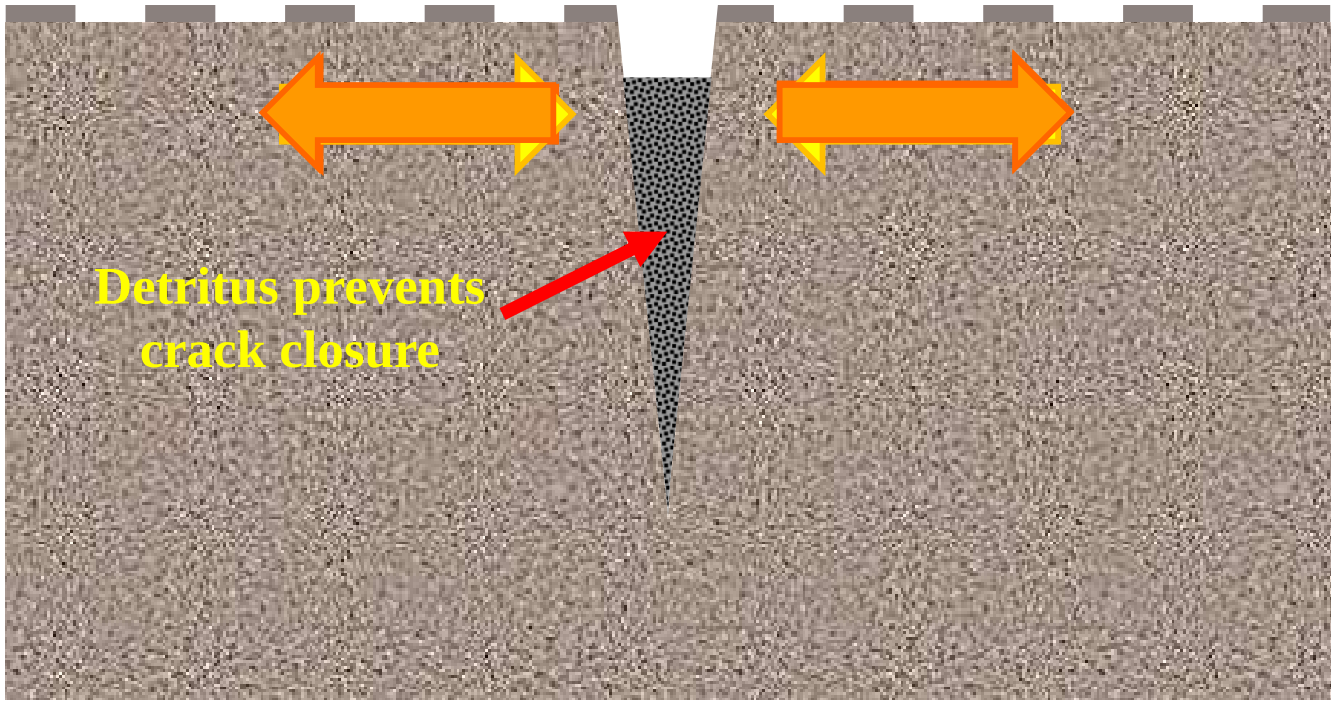


4

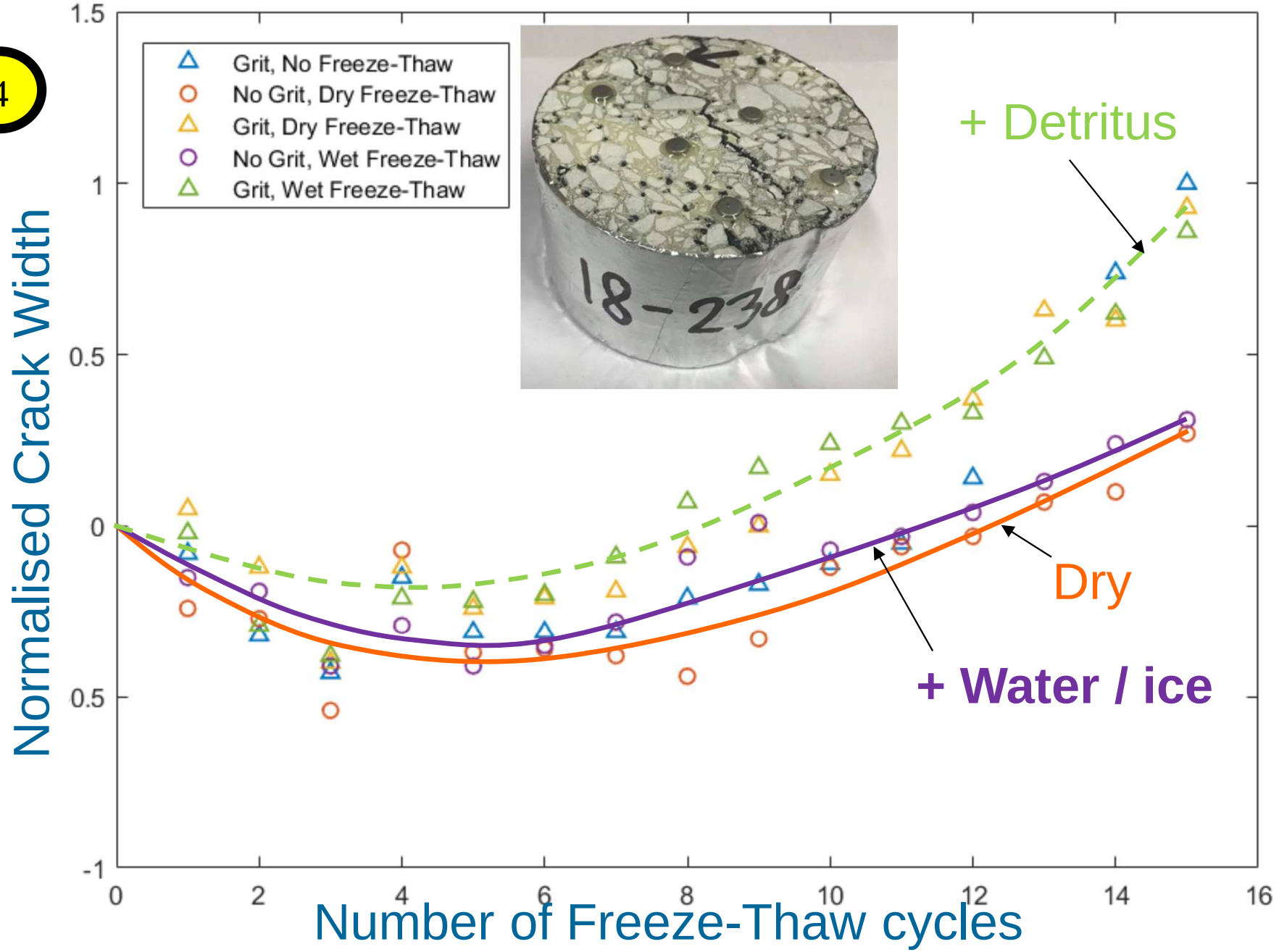

Temperature
0C
Time


Contraction

4



4


Grit, No Freeze-Thaw
No Grit, Dry Freeze-Thaw
Grit, Dry Freeze-Thaw
No Grit, Wet Freeze-Thaw
Grit, Wet Freeze-Thaw
18-238
+ Detritus
Dry
+ Water / ice
Normalised Crack Width
Number of Freeze-Thaw cycles
1.5
1
0.5
0
0.5
-1
0
2
4
6
8
10
12
14
16


And this is what we are trying to fight against

Conclusion

a) I hope we are getting there as far as understanding goes

- water diffuses and softens
- high water pressure leads to breakage
- freeze-thaw also creates very high pressures
- detritus leads to ever wider cracks

Conclusion

b) So now it’s time to think about prevention / cure

- stone size effect
- avoiding easy routes in for water (a.k.a. joints)
- and providing routes out (drainage)
- road vertical geometry

Thank you