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WHY FIXED SLIP DEVICES CAN NOT MEASURE THE SPEED GRADIANT DUE TO THE PAVEMENT

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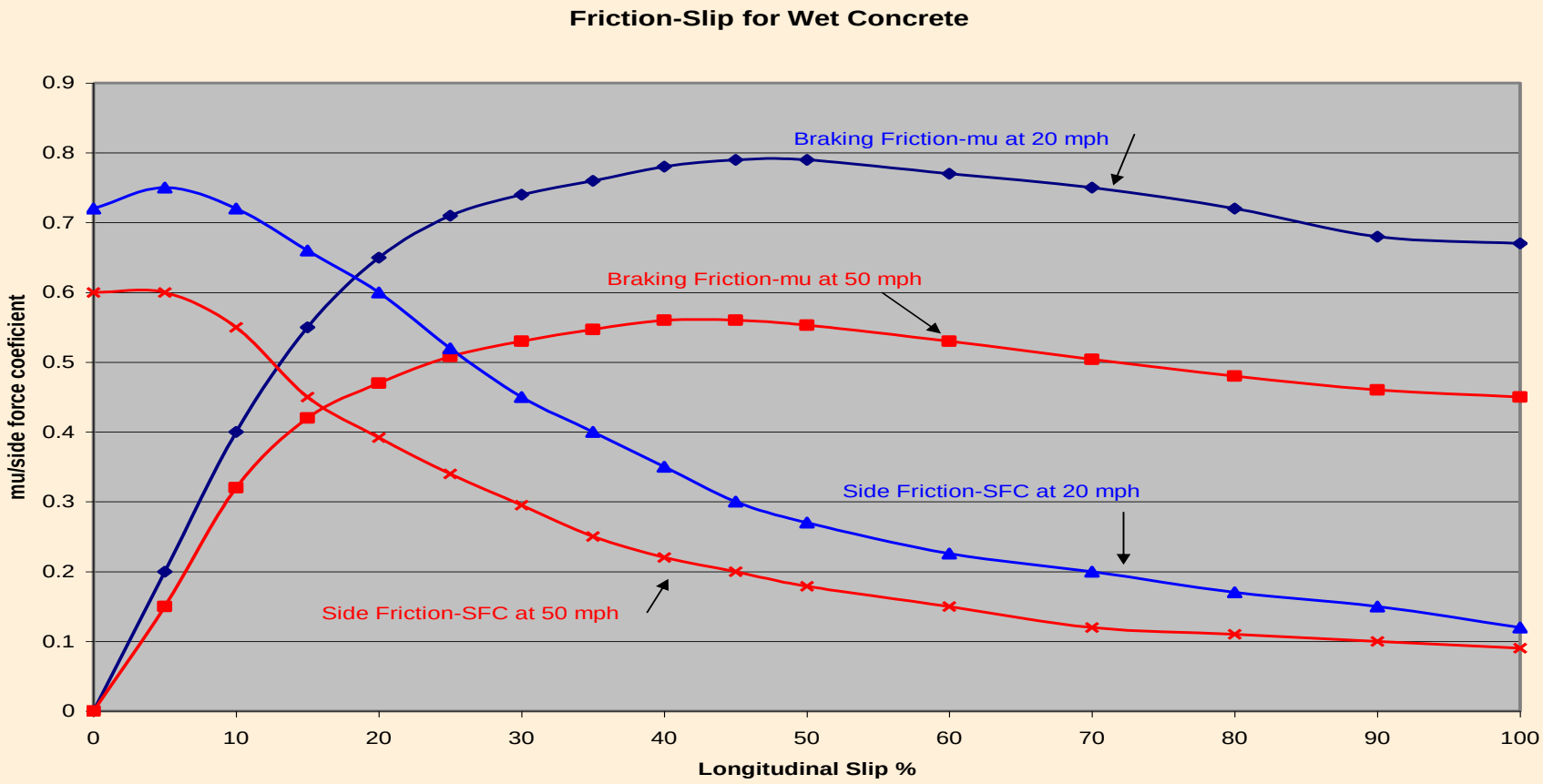
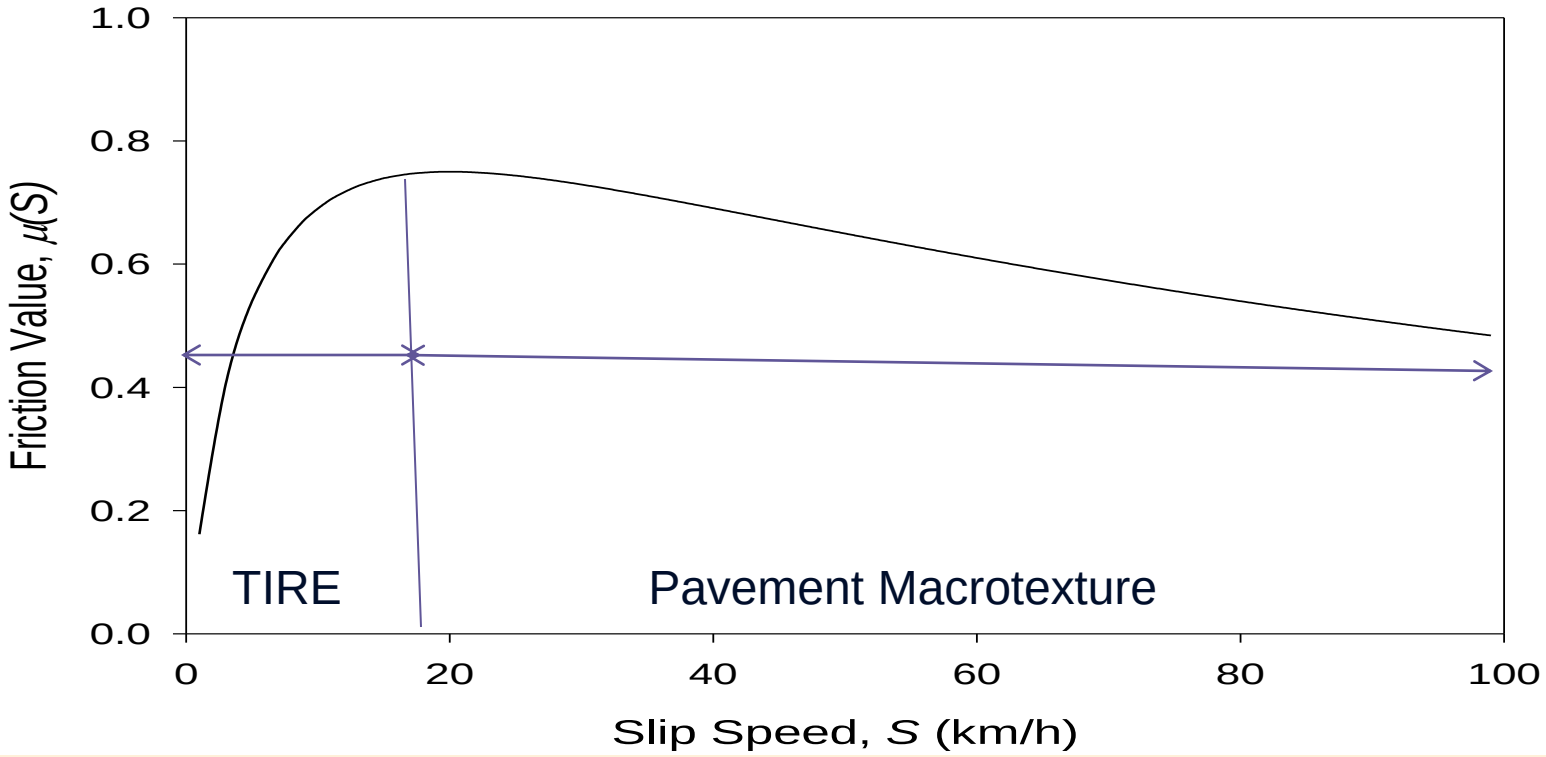
This paper covers why measurements at various speeds with continuous friction measurement equipment (CFME) are not able to measure the speed - friction gradient of the pavement as determined by the macro-textural features of the surface

Most CFMEs measure friction in the slip ratio range of 10% to 18%. In this range it is shown that the friction versus slip speed of these devices are mainly determined by the coupled properties of the surface micro-texture and relevant tire properties and to a minimal extent only by pavement macro-texture properties.

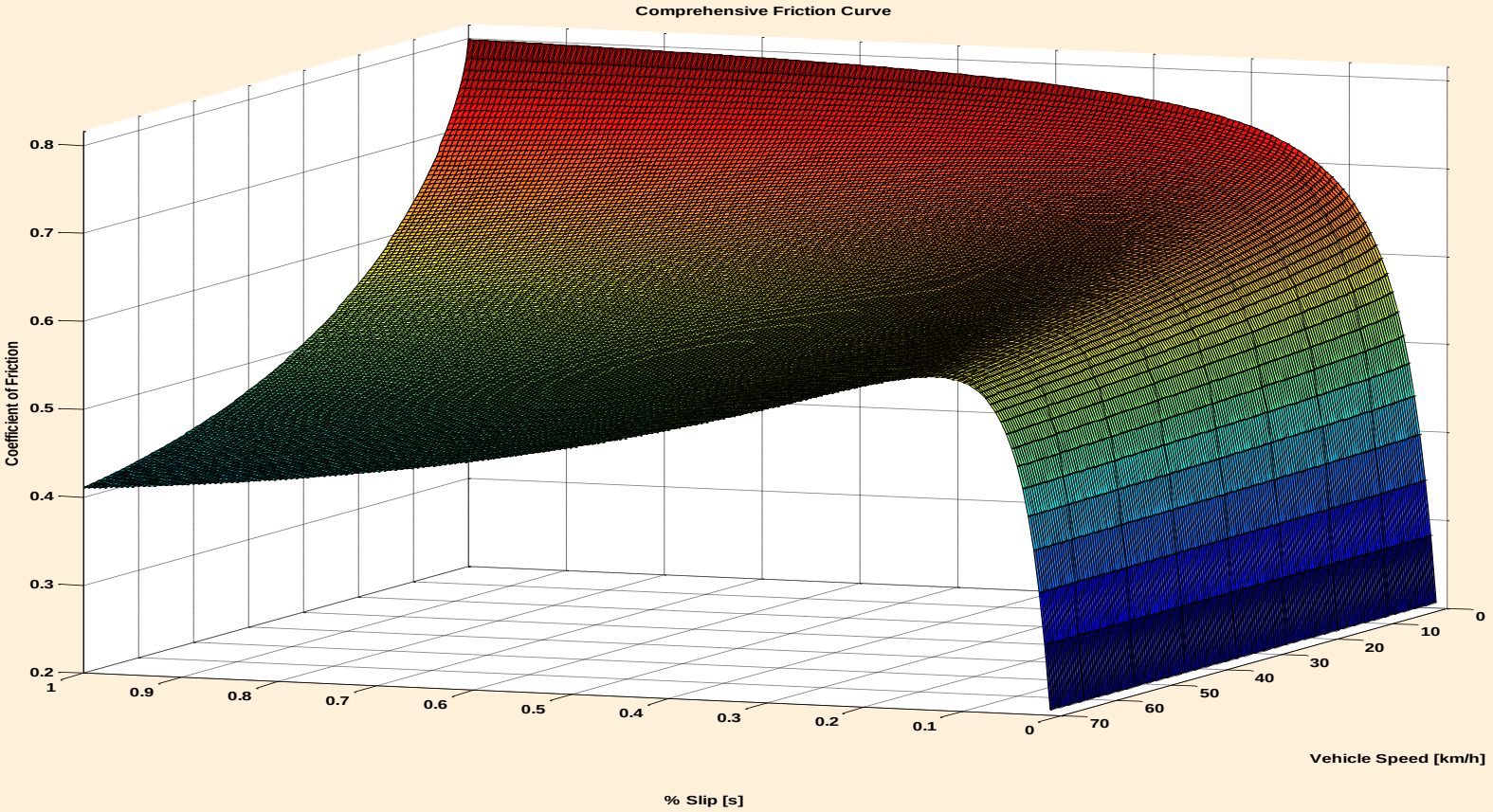
Effect of Speed and Slip on Braking and Side Friction



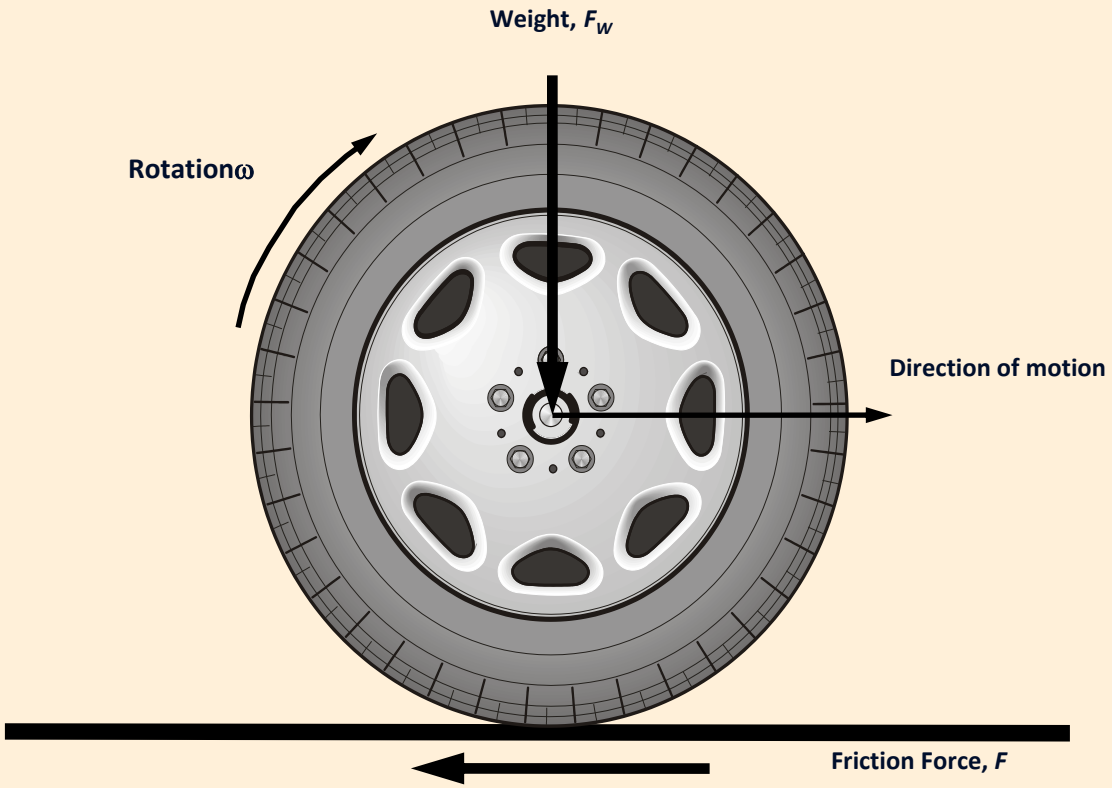
Where tire and pavement mainly affect friction verses slip speed

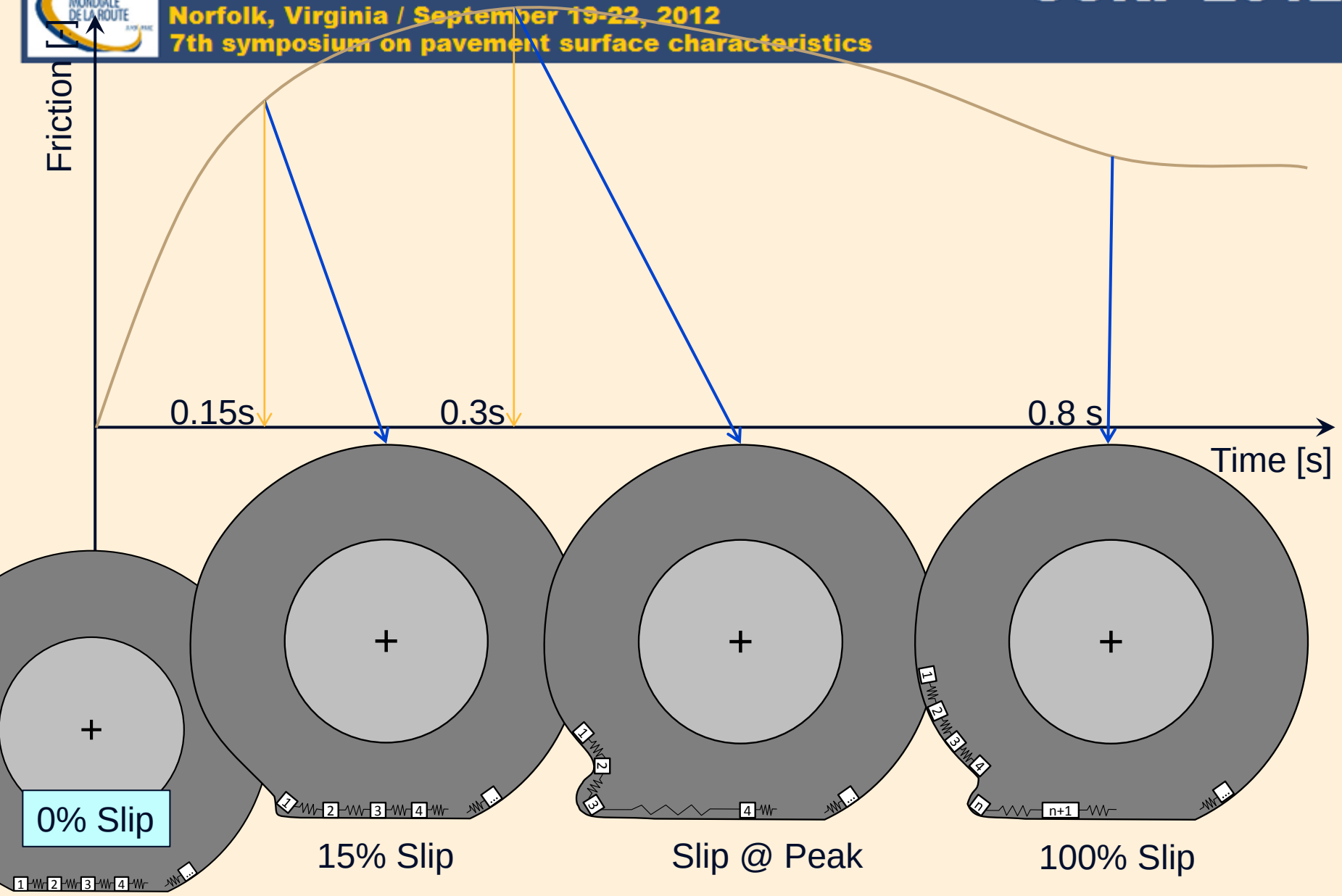


A Comprehensive Friction Model

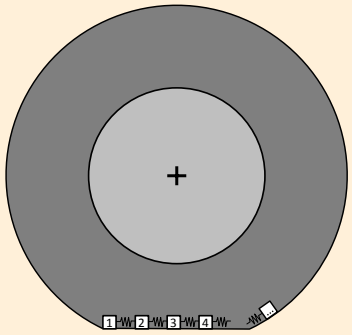


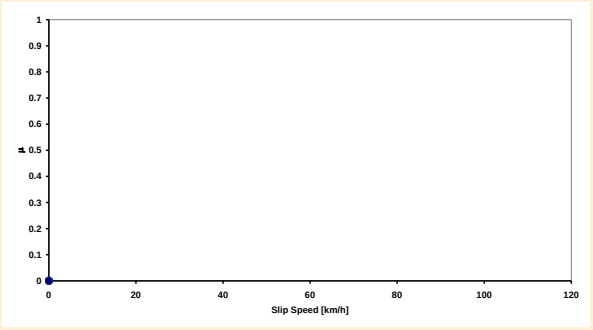
Tire/Road Friction



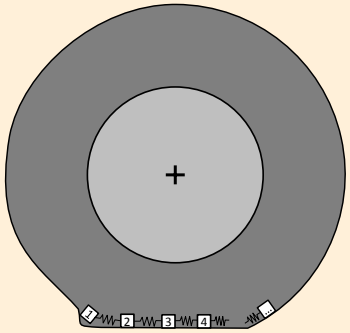

Friction [-]
0.15s
0.3s
0.8 s
Time [s]
0% Slip
15% Slip
Slip @ Peak
100% Slip

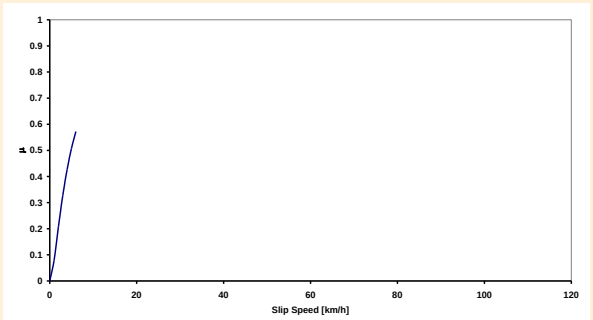
Pavement Surface Characteristics and tire friction





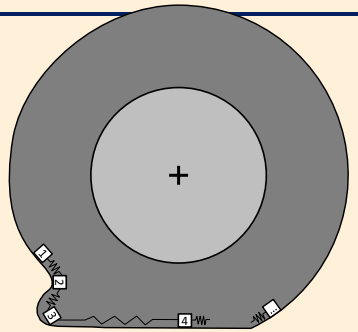
Free rolling

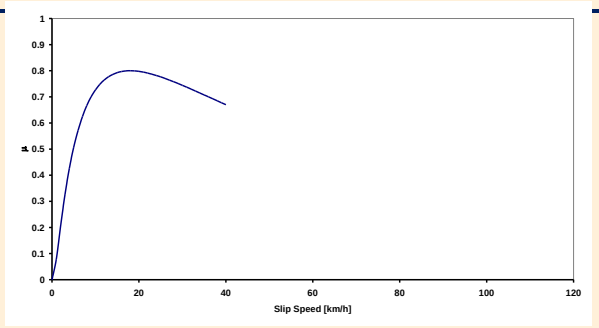




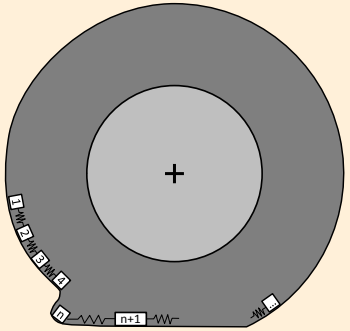
Low slip %

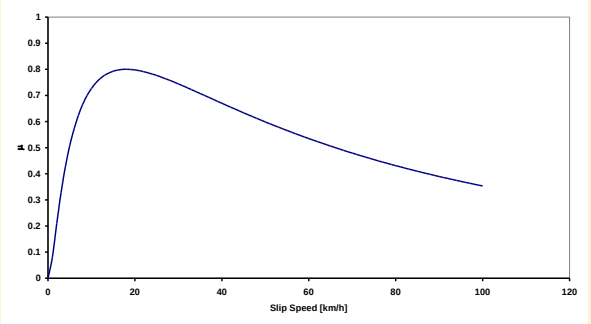
Pavement Surface Characteristics and tire friction



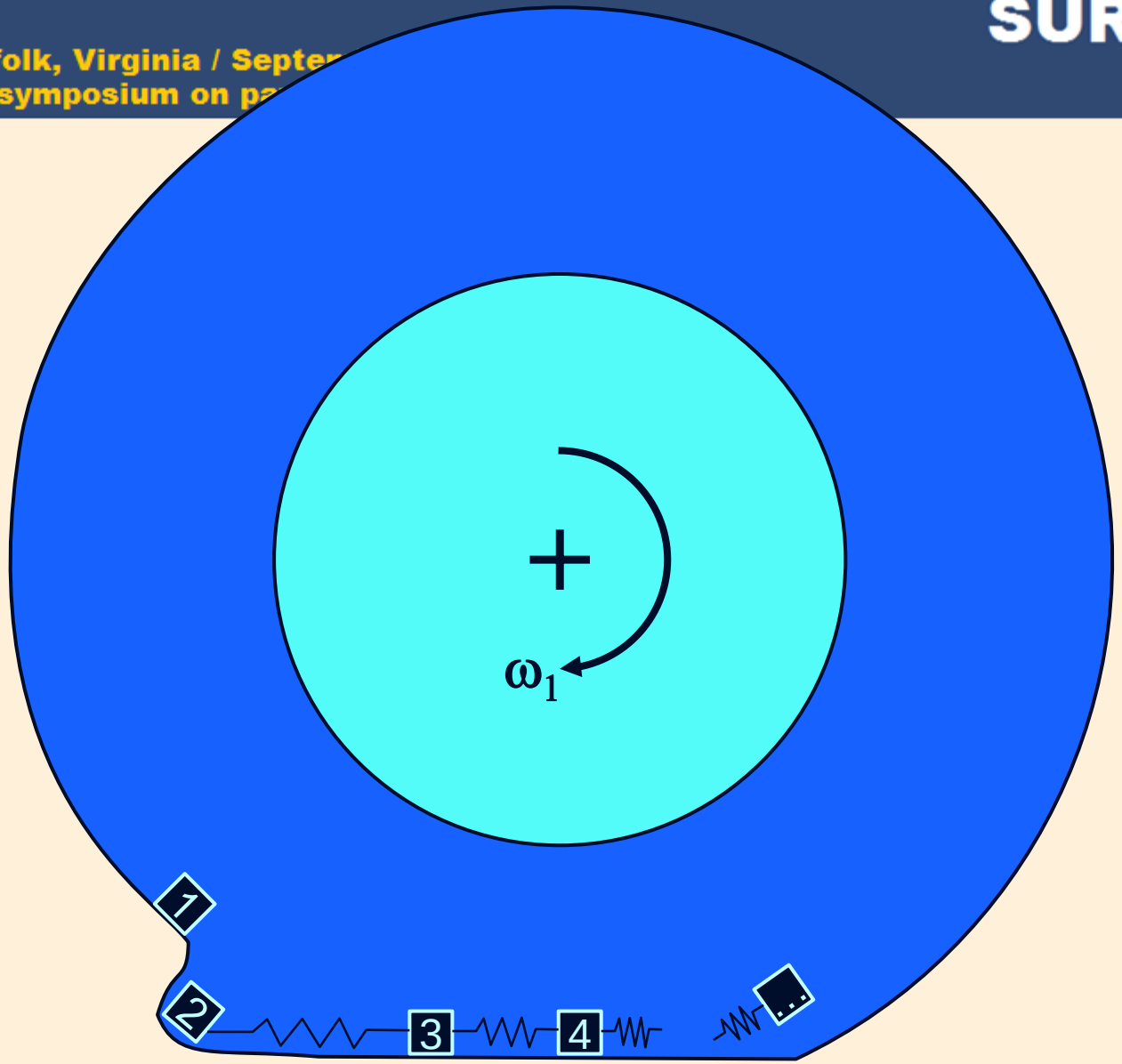


High slip %

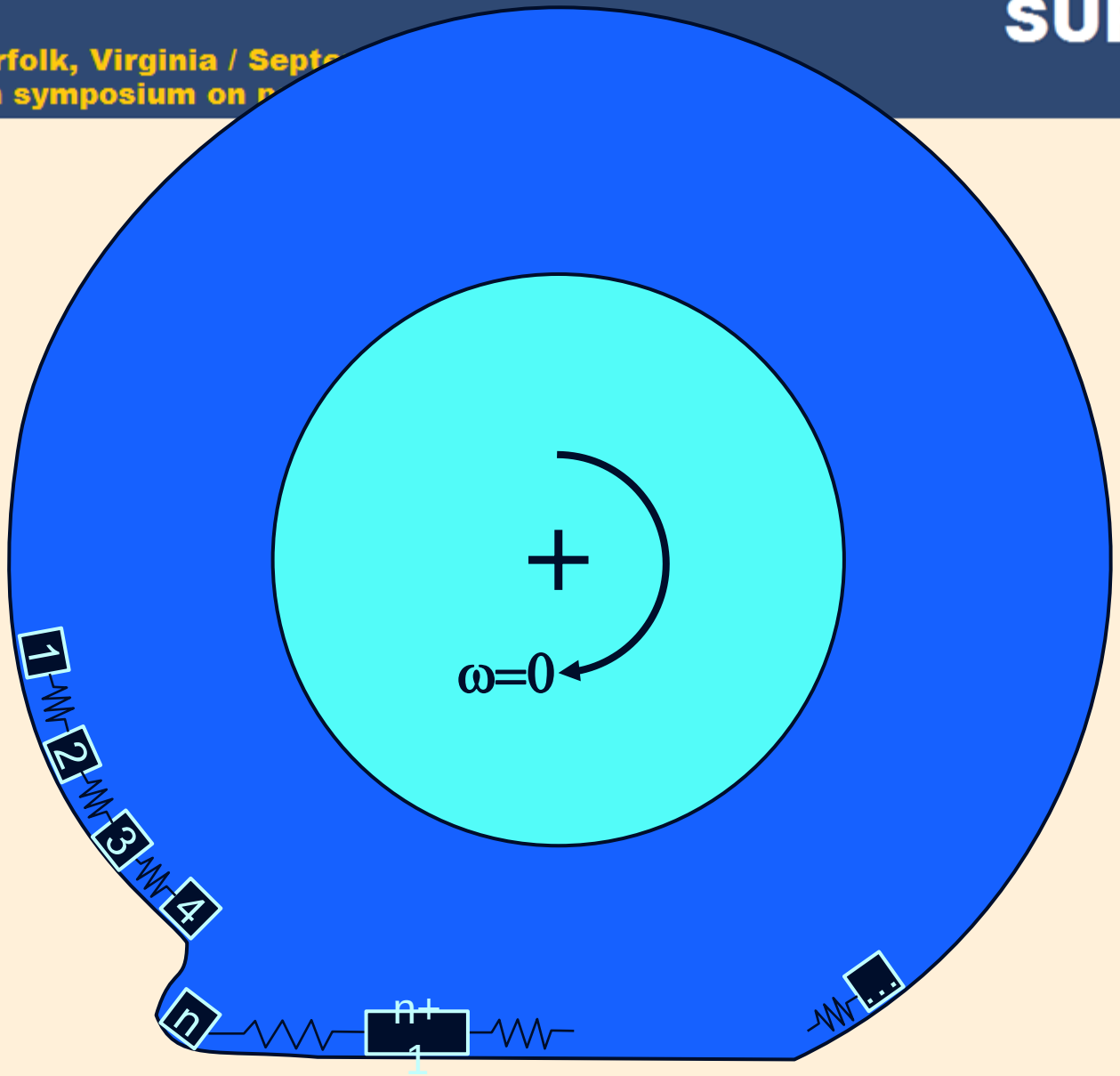




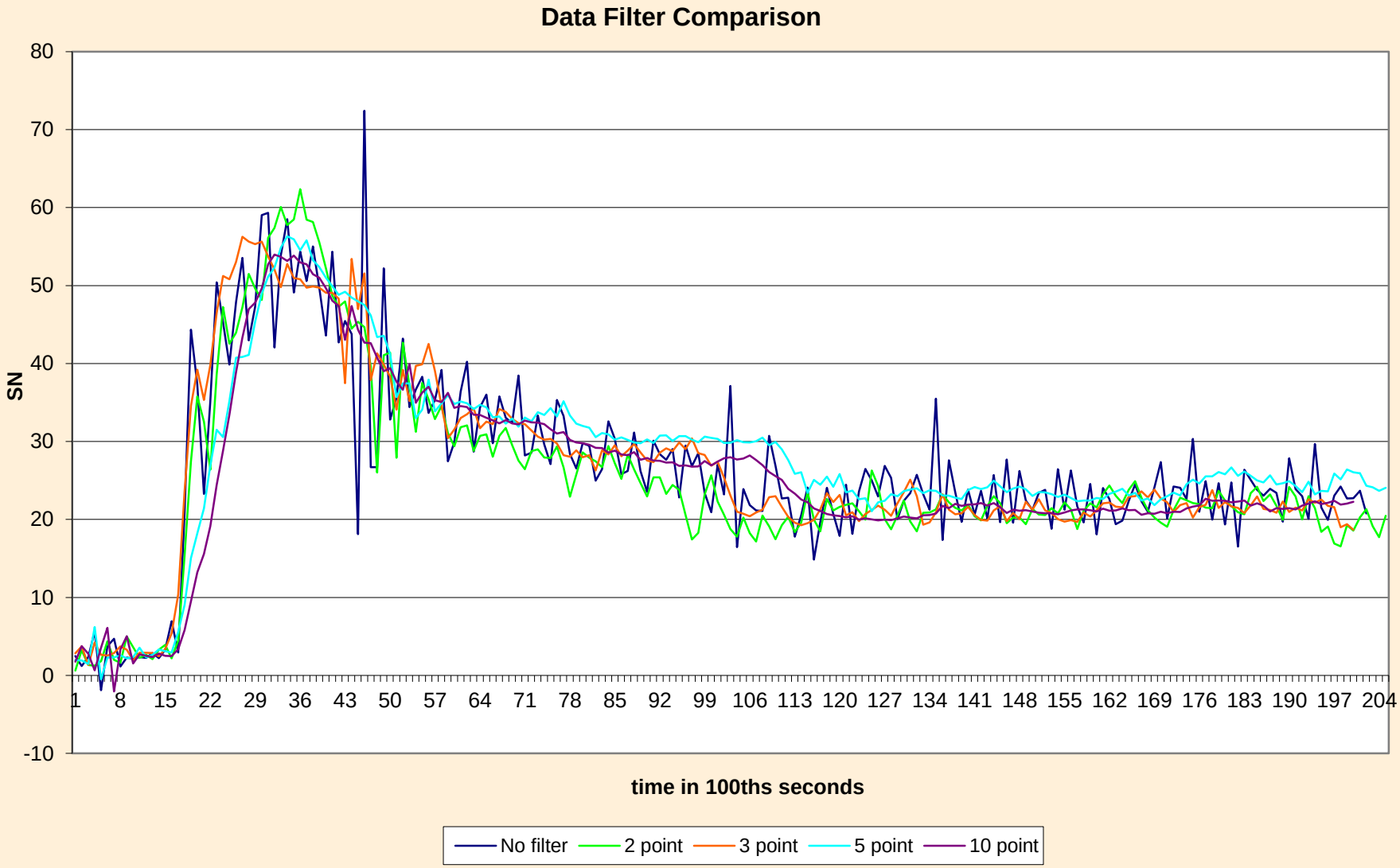
100% slip



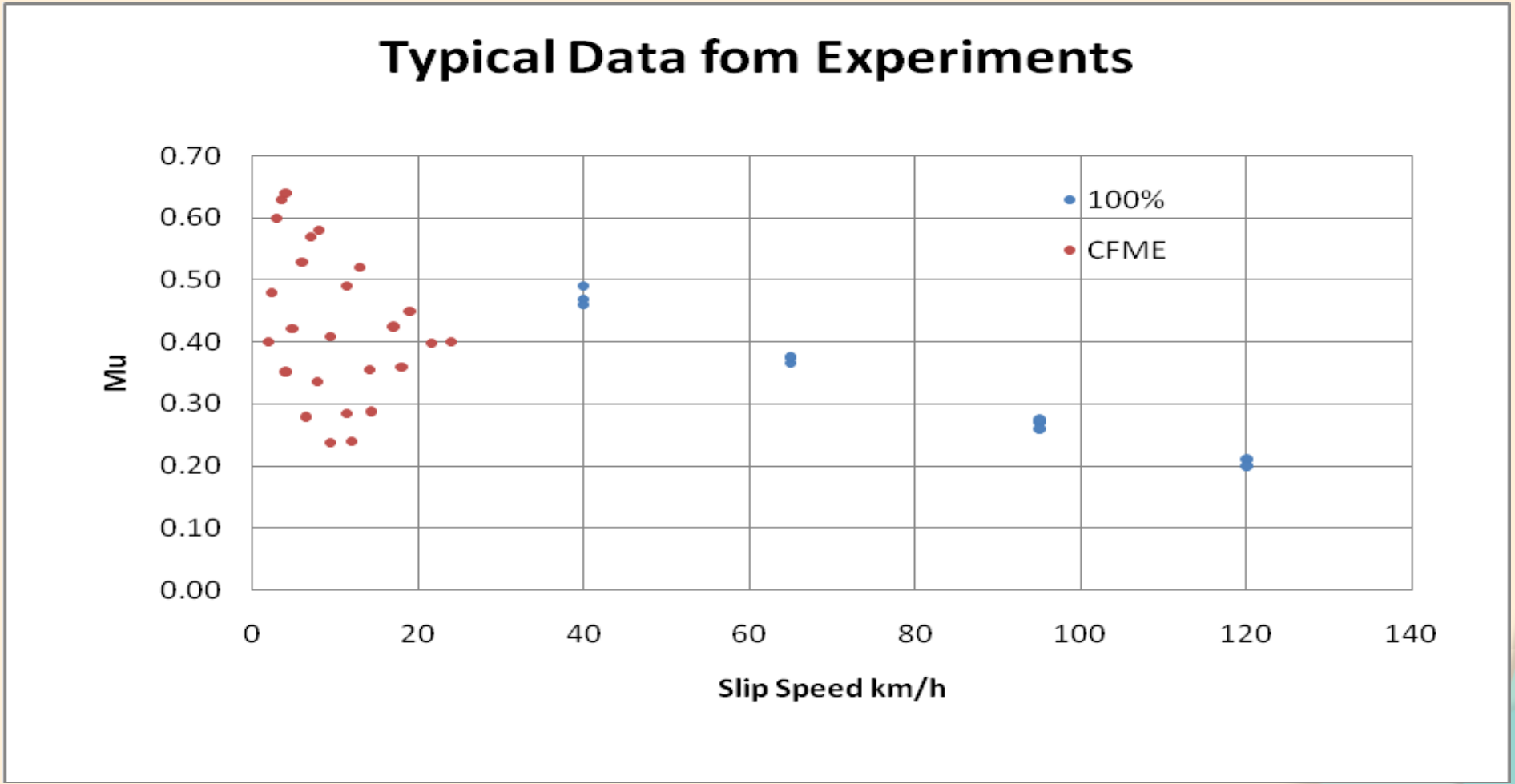
15% Slip



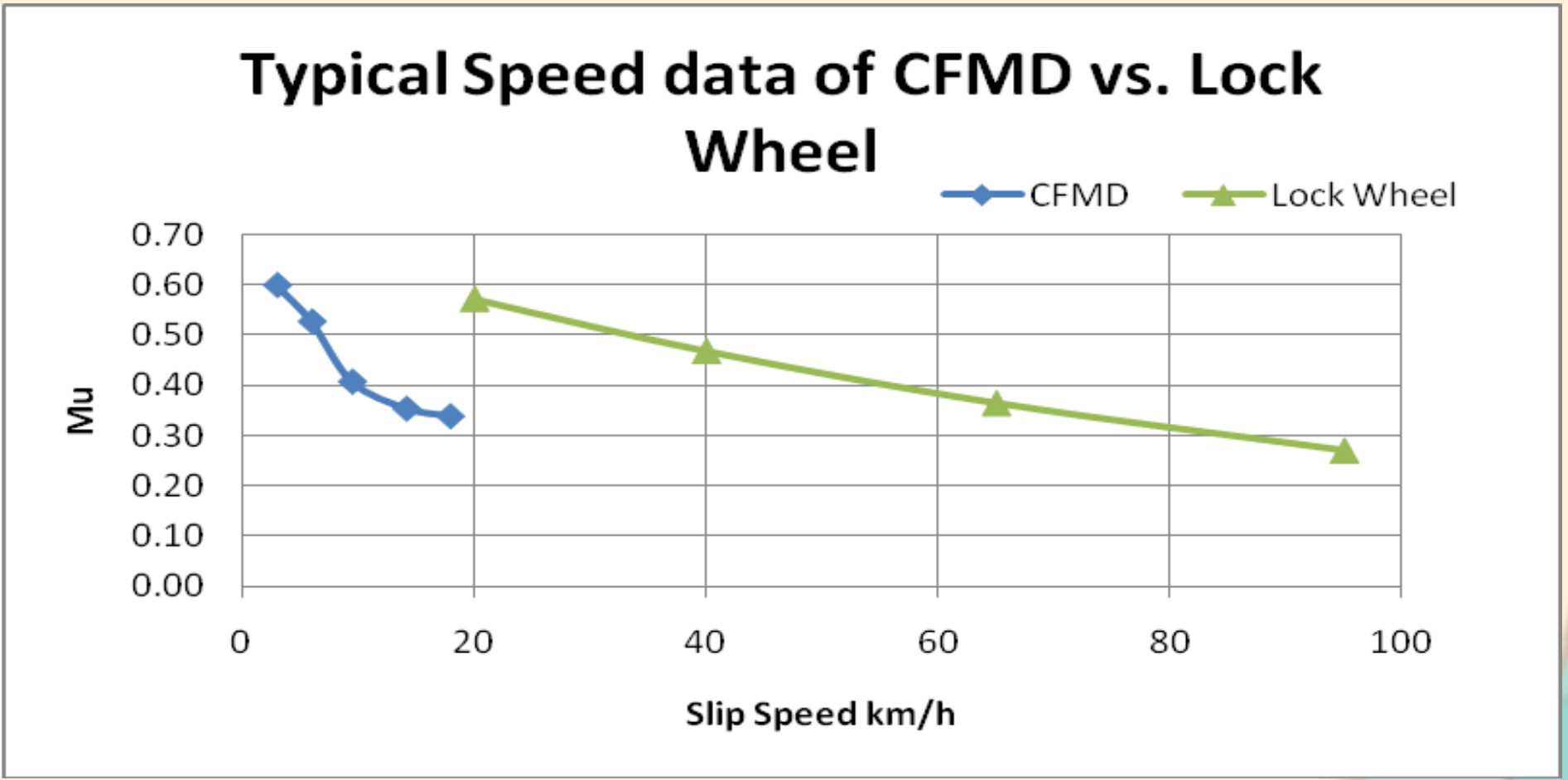
100% Slip

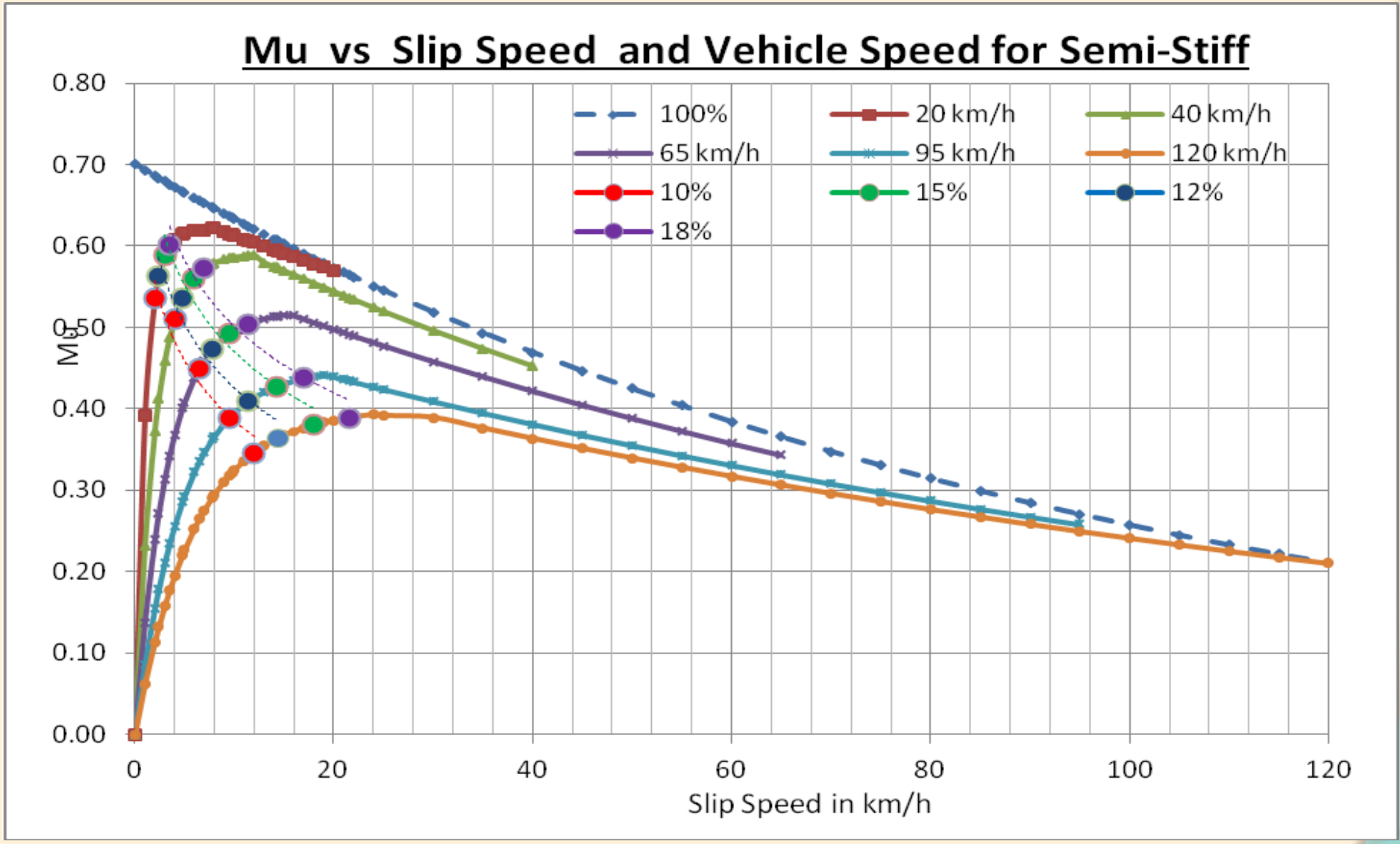

Data Filter Comparison
SN
80
70
60
50
40
30
20
10
0
-10
1
8
15
22
29
36
43
50
57
64
71
78
85
92
99
106
113
120
127
134
141
148
155
162
169
176
183
190
197
204
time in 100ths seconds
No filter
2 point
3 point
5 point
10 point

Typical Speed Data for CFMEs and Locked Wheel Testers

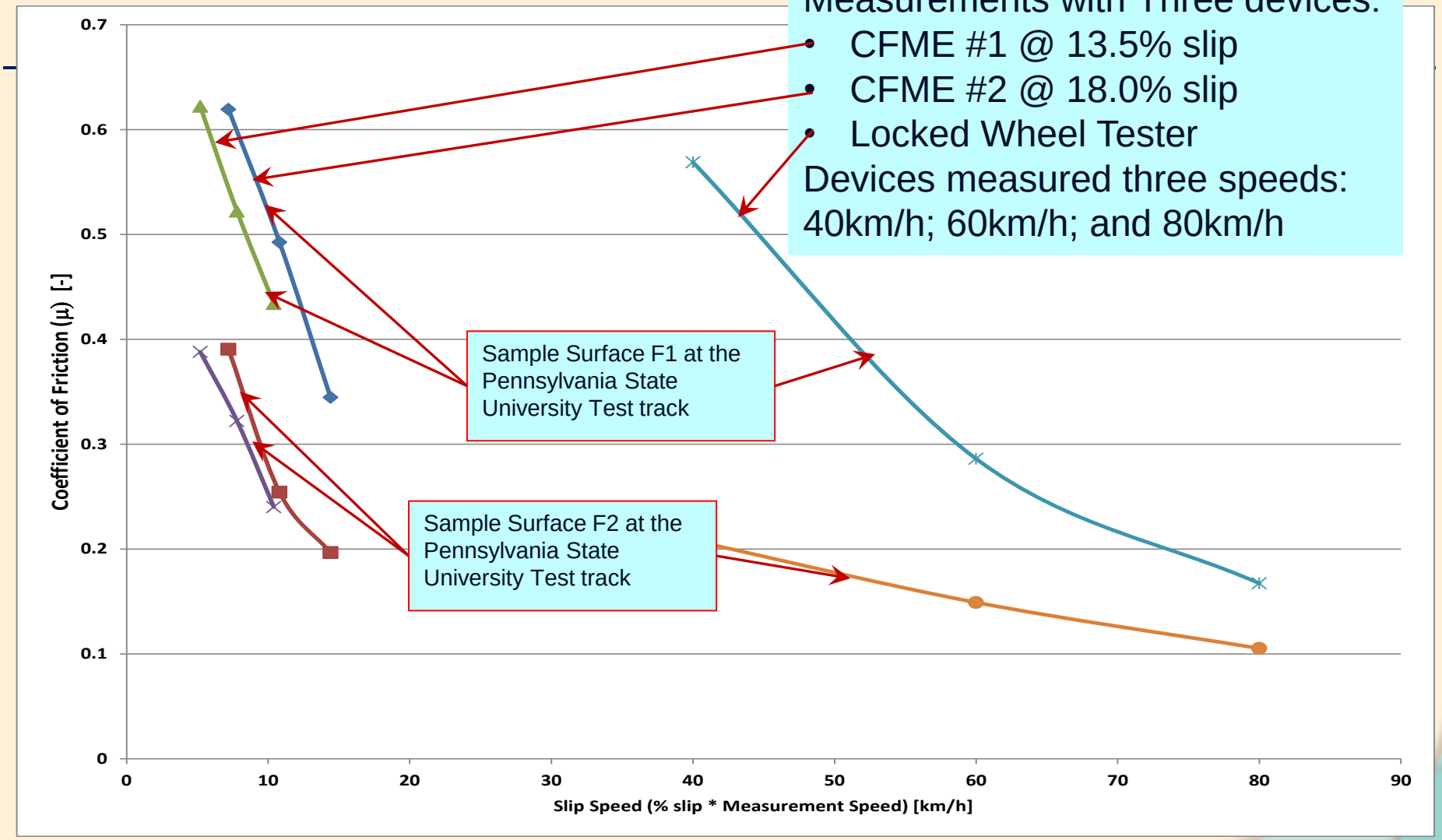


Typical Speed Data for one CFME and one Locked Wheel Tested




Mu vs Slip Speed and Vehicle Speed for Semi-Stiff
100%
20 km/h
40 km/h
65 km/h
95 km/h
120 km/h
10%
15%
12%
18%
Mu
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
20
40
60
80
100
120
Slip Speed in km/h

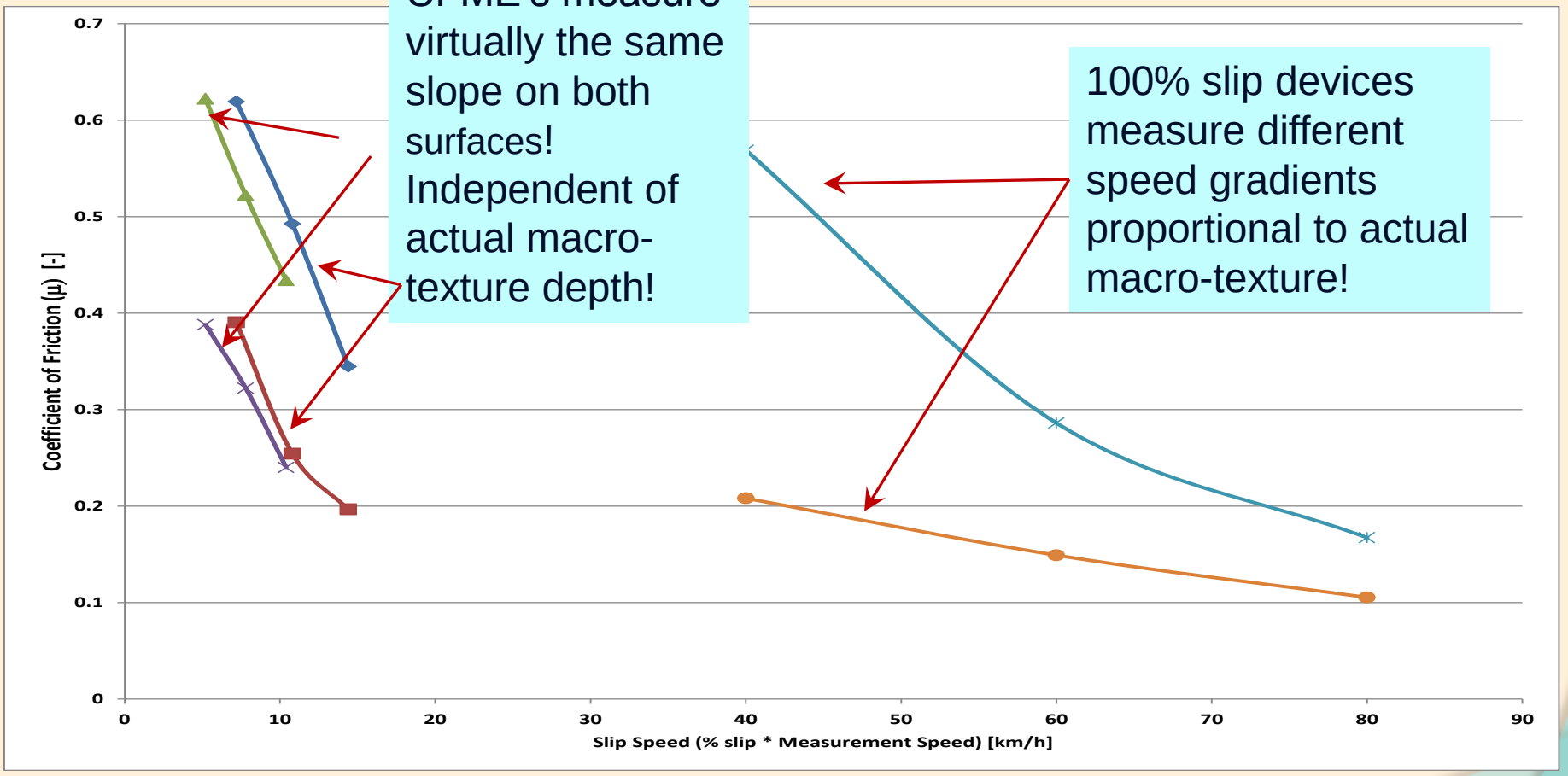
Graphs from Historical Data



Graphs from Historical Data

CFME's measure virtually the same slope on both surfaces! Independent of actual macro-texture depth!

100% slip devices measure different speed gradients proportional to actual macro-texture!



CORRELATIONS OF CFMEs

Both the PIARC and FEHRL experiments were conducted to correlate or harmonize different friction devices. Similarly the NASA Runway Friction Workshops and then the continuation Friction Workshops at Penn State were conducted to look into how to harmonize devices. The 2010 and 2011 workshops at Penn State found that the water flow rates and distributions varied significantly. Thus, water distribution and different slip ratios as well as tire differences all affect the friction reading of CFMEs

It is recommended that

1. CFMEs should not be run at several speeds to determine speed gradient, but should be run at a single speed and use macro-texture measurements to obtain the pavement speed gradient.

It is recommended that

2. The data from the HERMES project should be revisited with this in mind to revise the EFI. To a lesser extent the PIARC data could be revised; however, the locked wheel data did dominate the golden values and thus is not as critical.