

THE STATISTICAL INTERPRETATION OF SIMULATED EMERGENCY BRAKING EVENT TIME SERIES DATA

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The New Generation of Road Surfaces.. why we use them

<http://www.highwaysmaintenance.com/>



OLD: roadwork delays, perceived rutting problem, noise and spray issues. Two Part Installation

~Positive Textured Hot Rolled Asphalt (HRA)
Asphalt + Rolled in Coated Chippings

Conference on Data Mining and Data Warehouses
(SiKDD 2008) 17/10/2008, Ljubljana, Slovenia



NEW: Lower noise, lower spray, use for thin resurfacing/regulating, Less rutting(?), Single Stage Installation = less delay

~ Stone Mastic/Matrix Asphalt (SMA), a Negative Textured Surface (NTS)



INFORMATION SOCIETY 2008
11th International multiconference
13 - 17 October 2008
Jožef Stefan Institute, Jamova cesta 39, Ljubljana, Slovenia

Historic Case #1: Bitumen and Friction

Blickrichtung →



Fig. 89

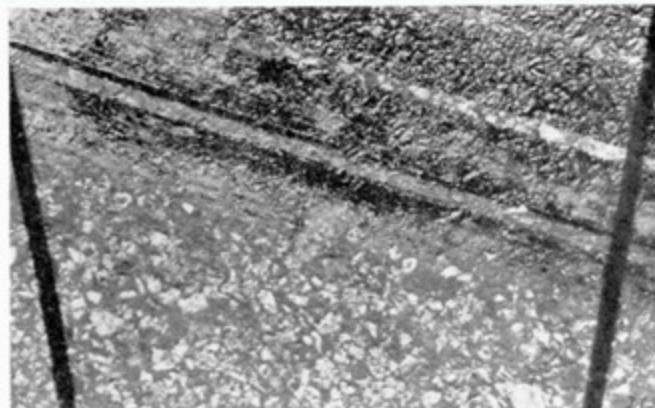


Fig. 91

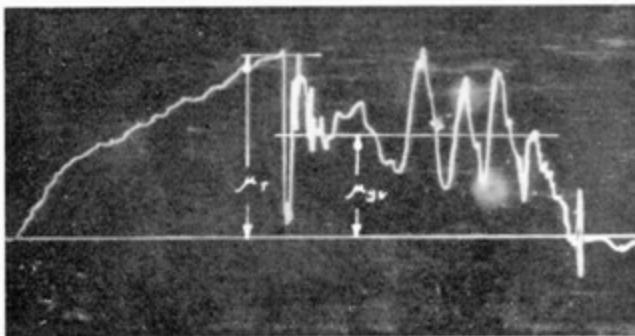


Fig. 90

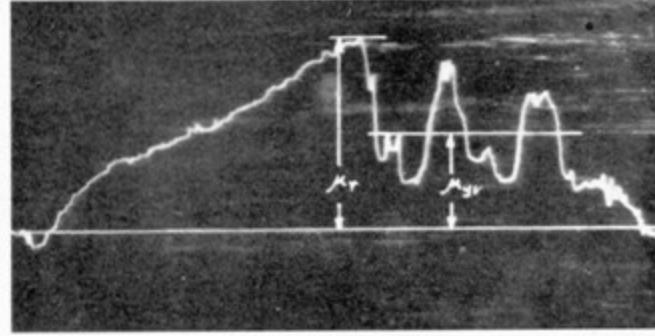


Fig. 92

Fig. 89. Bremsspur bei verändertem Material in der Gleitphase (Aufnahme im Gegenlicht).

Fig. 90. Diagramm der Bremsmomente (zu Fig. 89), Reibungskennziffer = 0,55.

Fig. 91. Gleitspur. Das Bindemittel zwischen den Splittkörnern ist erwärmt und verflüssigt worden.

Fig. 92. Diagramm der Bremsmomente (zu Fig. 91), Reibungskennziffer = 0,50.

ZIPKES, E. (1944) Die Reibungskennziffer als Kriterium zur Beurteilung von Strassenbelägen Eidgenössische. Verlag A.G. Gebr. Leeman and Co.

1944 E.Zipkes (Switzerland)



Fig. 1. Apparatur zur Messung der Bremsmomente nach der Methode Schindler.

ZIPKES, E. (1944) Die Reibungskennziffer als Kriterium zur Beurteilung von Strassenbelägen Eidgenössische Verlag A.G. Gebr. Leeman and Co.

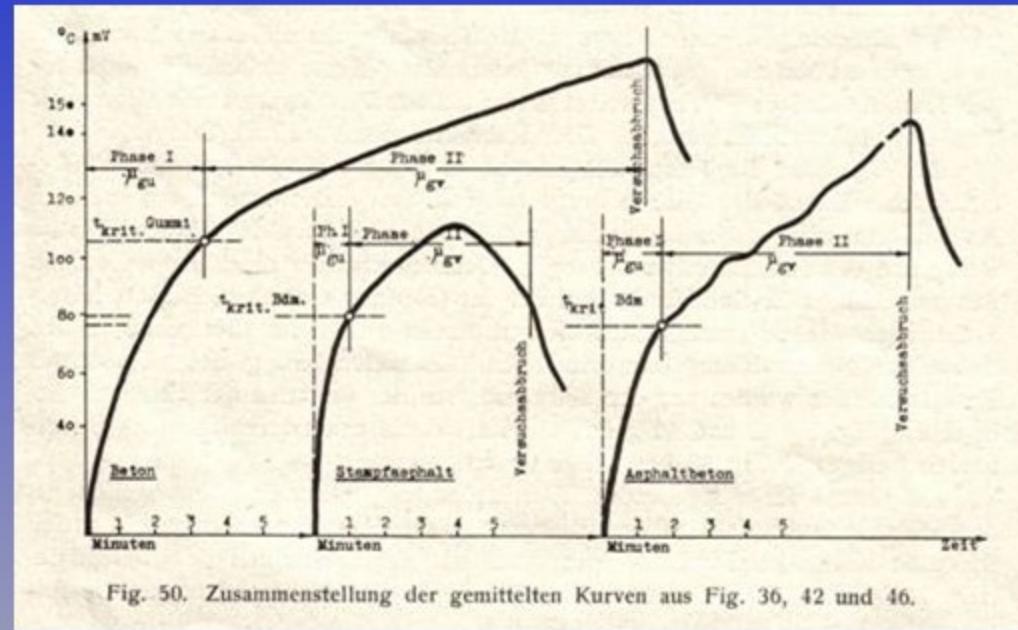


Fig. 50. Zusammenstellung der gemittelten Kurven aus Fig. 36, 42 und 46.

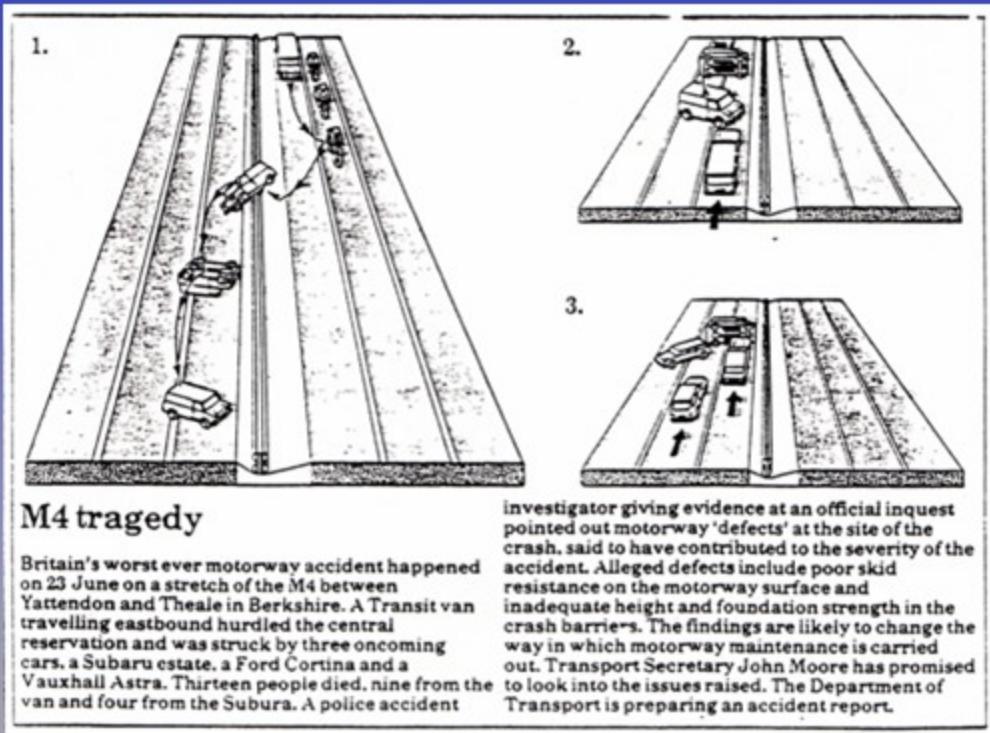
.....On some road surfaces, the melting point of the binder may be reached before that of the tread rubber, in which case the slipping coefficient will have a different value from that on which the rubber melts first”

Historic Case #2: 1985, The M4 Motorway (UK) 13 are dead...

13 dead owing to a combination of:

- Poor driving
- Substandard central barrier height
- Extended DRY braking distances [longer than in the WET] on a coated stone chippings with a thick layer of bitumen

“....some of the worst DRY skid resistance seen in 10 years” were measured by the Police Crash Investigator



ANON (1986) Low barriers conceded at M4 accident site. *New Civil Engineer*.

BYRD, T. & DADSON, J. (1986) Safety barrier review follows M4 carnage. *New Civil Engineer*. SHELSHEAR, G. (1986) Poor Skid Resistance cited at Crash Inquest. *New Civil Engineer*.

SHELSHEAR, G. (1986) Resume regarding "Poor Skid Resistance cited at Crash Inquest".

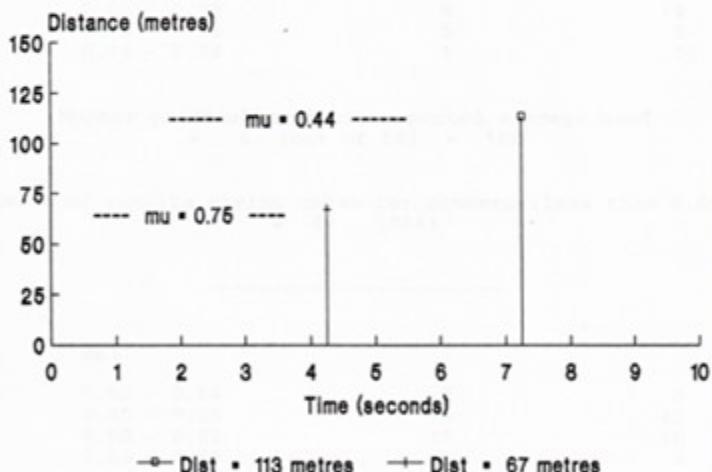
SHELSHEAR, G. (1986?) Statement by Mr D Simpson Concerning Safety Fences - M4 Berkshire Crossover Accident 23.6.86

SHELSHEAR, G. (1986?) Statement on Skidding resistance by Mr P E Nutt - M4 Berkshire Crossover Accident 23.6.86

...A road more Slippery in the Dry than in the Wet

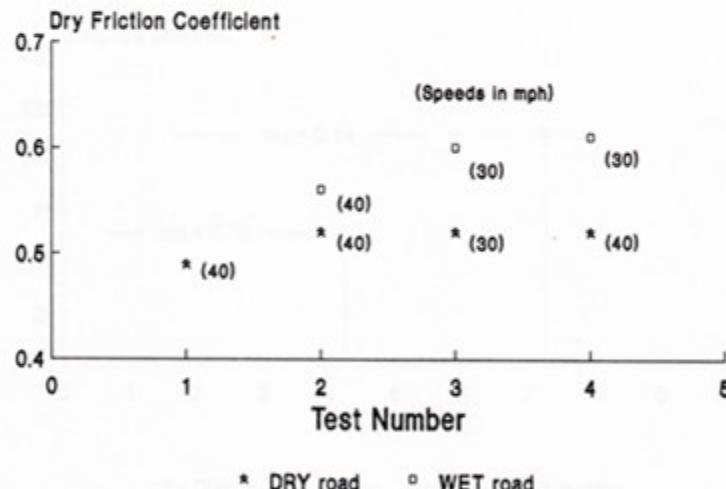
Braking Distance Comparison

μ of 0.44 - v - 0.75
(Vehicle speed = 70mph)



New Surface - Unopened

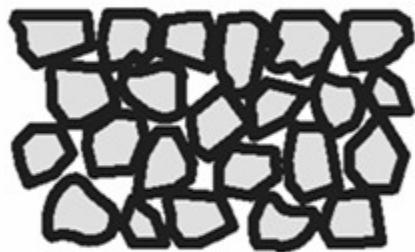
DRY - v - WET
(same location)



MANDERSON, J. & RUDRAM, D. (1993) The variation in tyre/road friction with time. IN JACOB, B. & BONTE, W. (Eds.) Vol 3: *Forensic criminalistics 1*. Dusseldorf; Germany, Berlin.

Historic Case #3: The Netherlands 1990's Crash Investigation: ABS v NOABS

Porous Asphalt



- 20% voids
- 13 micron film
- >2.0mm TD
- 3-4 dB (A) less noise



RICHARDSON, J. T. G. (1999) Stone Mastic asphalt in the UK.
SCI Lecture Series. Society of Chemical Industry.

FAFIÉ, J. (2004) Early Life Dry Skid Resistance. *Paper presented at "Surf 2004", 5th Symposium on Pavement Surface Characteristics*. Toronto, Ontario, Canada.

Porous Asphalt (P.A.) Negative Texture, low noise, low spray

NOABS on P.A.

ABS on ASPHALT

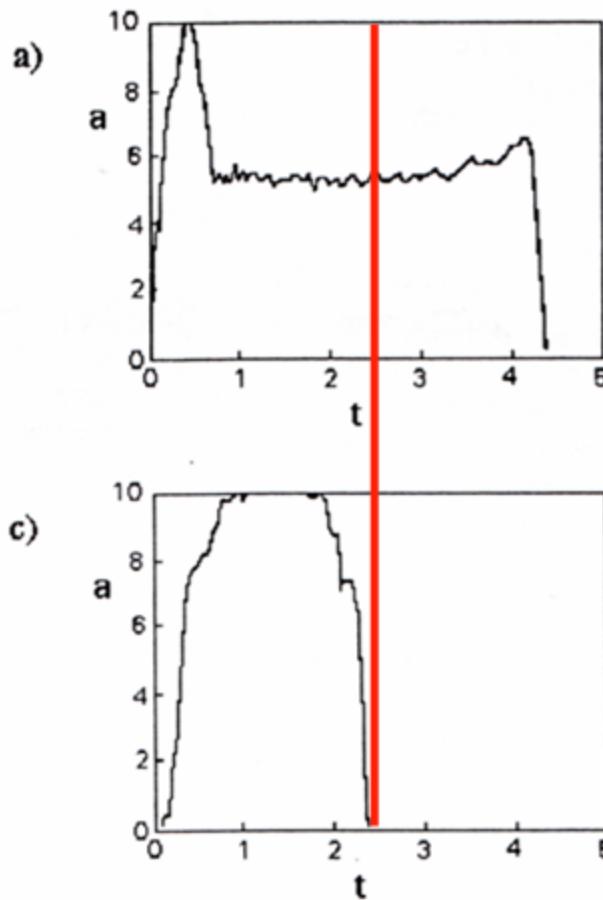


Figure 1. Deceleration during an emergency stop on a) new porous asphalt, b) dense asphalt and c) new porous asphalt with a car equipped with ABS.

ABS on P.A.



“The low skid resistance (was) caused by melting of the mortar” (the bitumen)”

The Porous Asphalt had a thick layer of bitumen on the chippings when new.. this doubled the stopping time when ABS was turned off!

Research published by D.W.W.
(NL) in 1997**

**JUTTE, R. H. & SISKENS, C. A. M. (1997) A Material Technological Approach to the Low Initial Skid Resistance of Porous Asphalt Roads. *European Conference on Porous Asphalt*, Madrid. Ministerio de Fomento, Direccion General de Carreteras, Spain.

Historic Case #4: UK 2001: Two fatal crashes on new(ish) S.M.A.

DRY $\mu=0.56, 0.48, 0.48, 0.49, 0.51$

Fatal Crash: Police NOABS Skid Testing →



DRY $\mu=0.52, 0.51$ Downhill 1:100

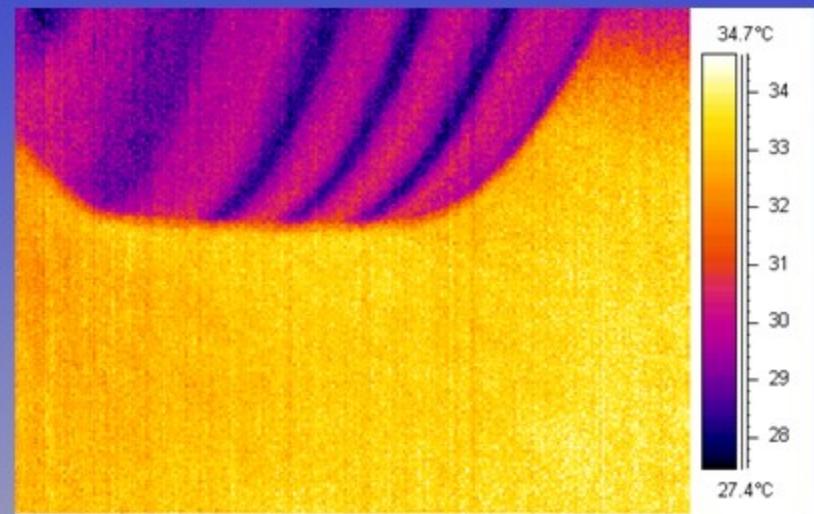
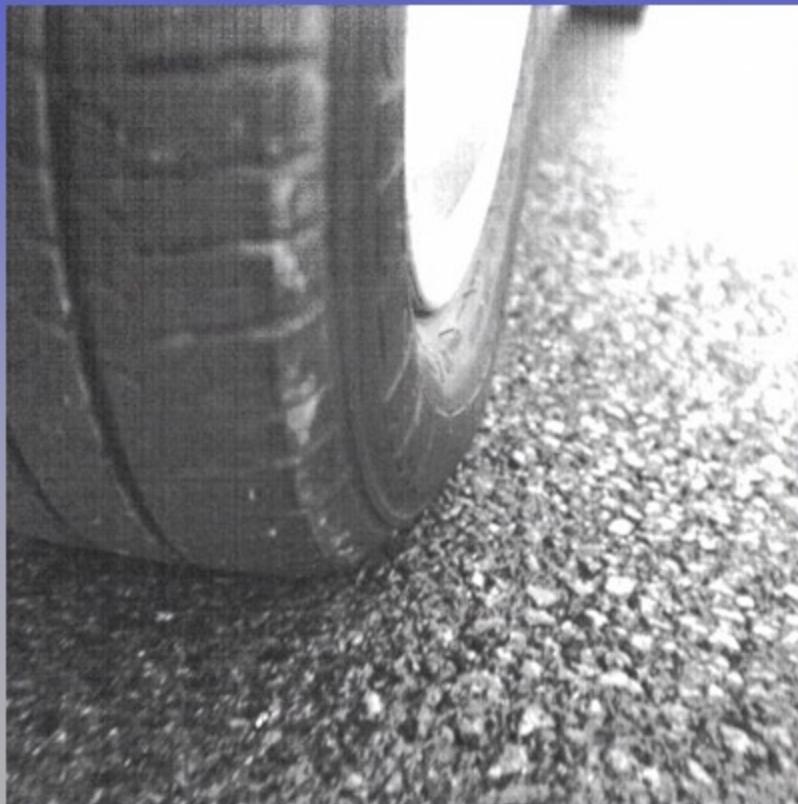
DRY $\mu=0.53, 0.55$ Uphill 1:25

← Fatal Crash: Police NOABS Skid Testing

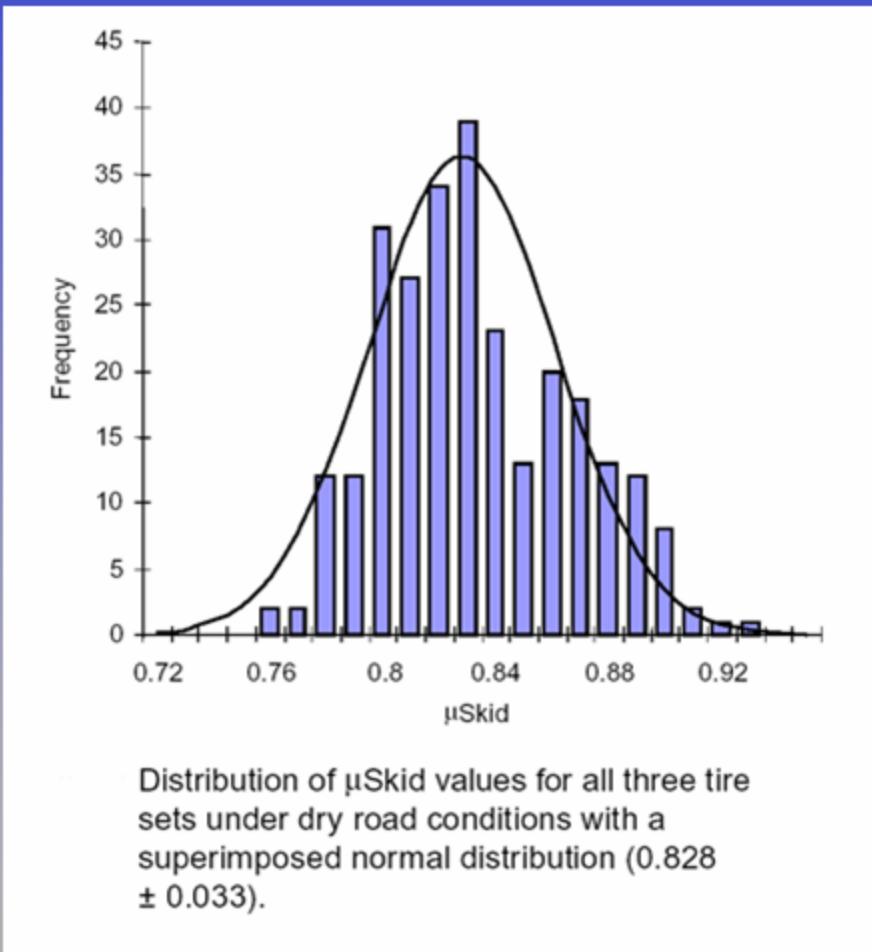
NB: Low values of Dry μ were NOTHING to do with the circumstances of the crashes

ALLEN, J. (2001) "Stone Mastic Asphalt": Presentation to the ACPO Senior Collision Investigators Conference, Hull.

Bituplanning was occurring....

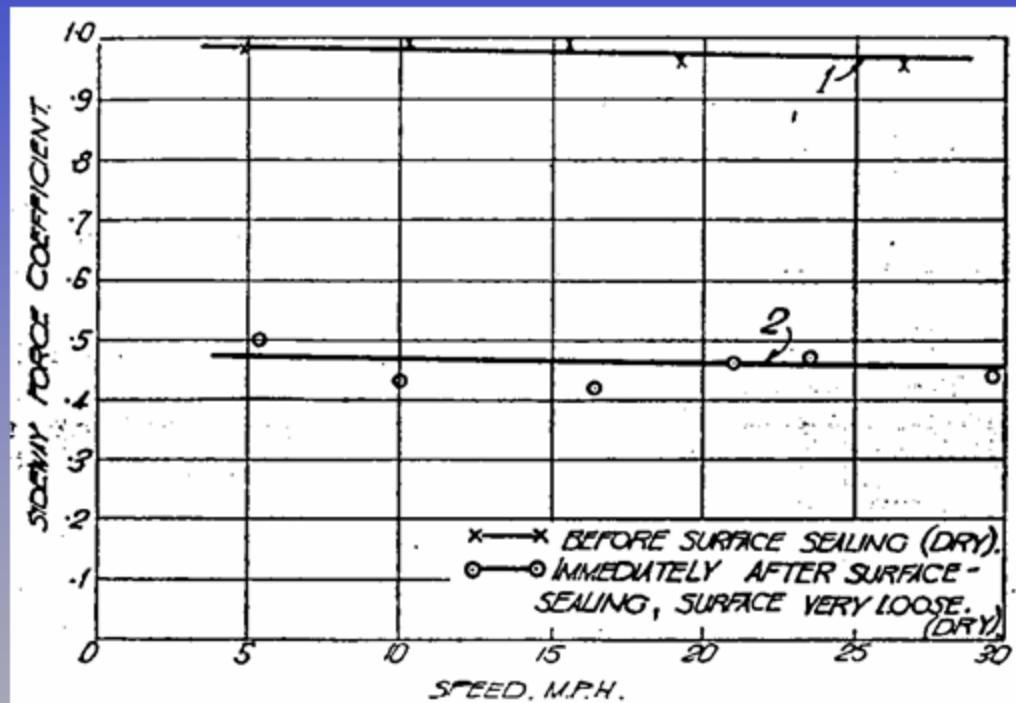


$\mu_{\text{dry}} \approx 0.5$?.. This IS NOT a ‘typical’ value for dry road friction



GOUDIE, D. W., BOWLER, J. J., BROWN, C. A., HEINRICH, B. E. & SIEGLUND, G. P. (2000) Tire Friction During Locked Wheel Braking. *Accident reconstruction: simulation and animation*. Detroit, MI, Society of Automotive Engineers.

But ... Highway Engineers have not really ever measured DRY road friction!



BIRD, G. & SCOTT, W. J. O. (1936) Studies in Road Friction: I. Road Surface Resistance to Skidding Department of Scientific and Industrial Research / Ministry of Transport.

HOSKING, J. R. & WOODFORD, G. C. (1976) Measurement of skidding resistance part i. guide to the use of SCRIM, Transport Research Laboratory Report LR737. Transport Research Laboratory.

Who does measure the dry friction of the highway?





Police Collision Investigators do

..... to estimate the braking speed and/or speed at inception of loss of control from skid marks at the scene of fatal or near-fatal crashes

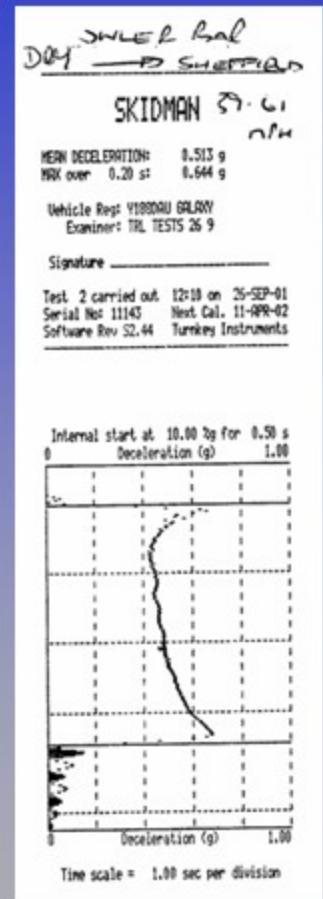
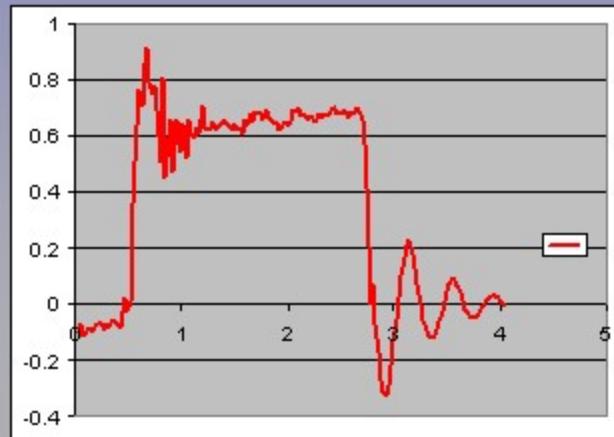


Dry Friction Tests using Decelerometers



SkidMan/Vericom
decelerometers and data
output from a skid test

hard copy [right] and
downloaded [below]





Skid tests to estimate μ & critical speed



Equations of Motion (adapted)

Skidding: $u = \sqrt{v^2 + 2\mu gs}$

Coefficient of Friction from Skid Tests: $\mu = \frac{u^2}{2gs}$

Coefficient of Friction from Drag Tests: $\mu = \frac{\text{pulled force}}{\text{actual weight}}$

Force $F = m\mu g$

Devon & Cornwall
Constabulary Testing at
Westpoint Skidpan

Critical Speed

$$r = \frac{c^2}{8M} + \frac{M}{2}$$

$$v = \sqrt{\mu gr}$$

$$v = \sqrt{\frac{gr(\mu + \tan(\theta))}{1 - \mu \tan(\theta)}}$$

DERBYSHIRE
CONSTABULARY ROAD
POLICING SUPPORT UNIT
(2005) Equations Sheet.



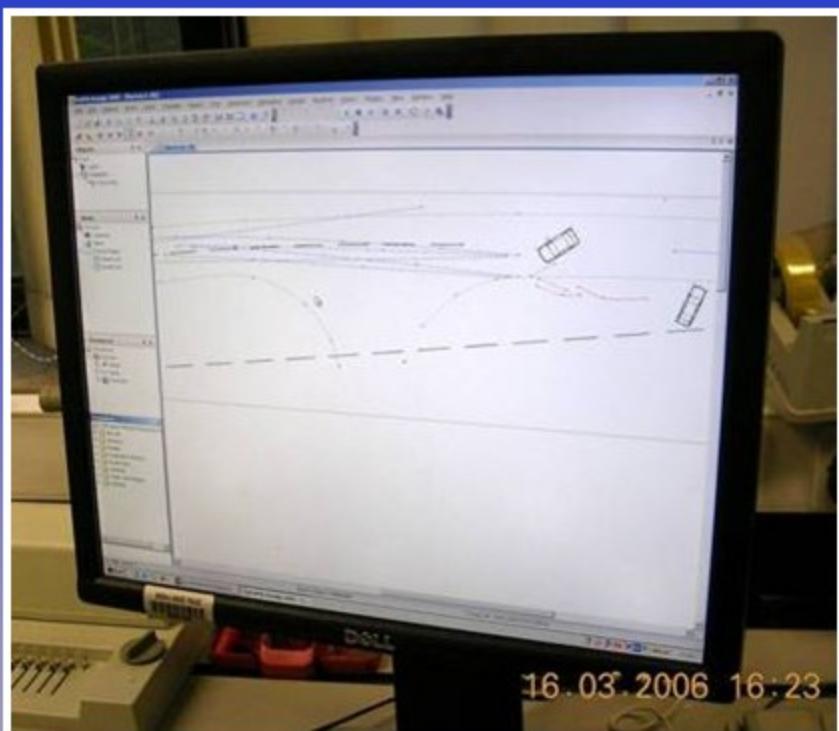
Derbyshire Constabulary
Road Policing Support Unit

v = Final velocity (m/s)
u = Initial velocity (m/s)
g = Acceleration
Due to Gravity (9.81 m/s²)
 μ = Coefficient of Friction
a = Acceleration (m/s²)

s = Displacement (m)
t = Time (seconds)
r = Radius
c = Chord length (m)
M = Mid-ordinate (m)
 θ = Camber/Angle (°)

m = Mass
h = Height of Centre of Mass (m)
l = Length of wheelbase (m)
w = Weight (proportion)
b = Braking (proportion)

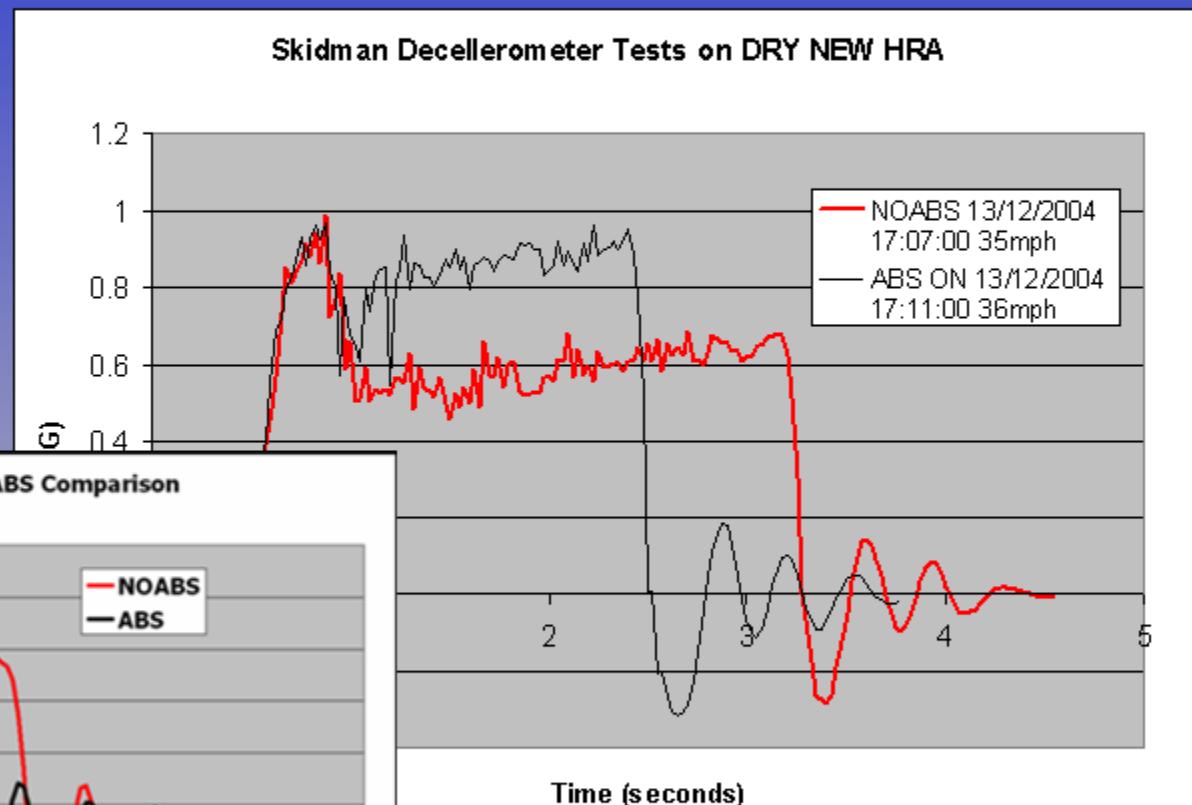
Dry “Mu” is used in reconstruction of the crash scene by combining survey data and skid test results to estimate “critical speed” from the tyre marks’ curve radii



NO ABS v ABS on a DRY road: extended stopping time & distance for a NEW binder rich surface

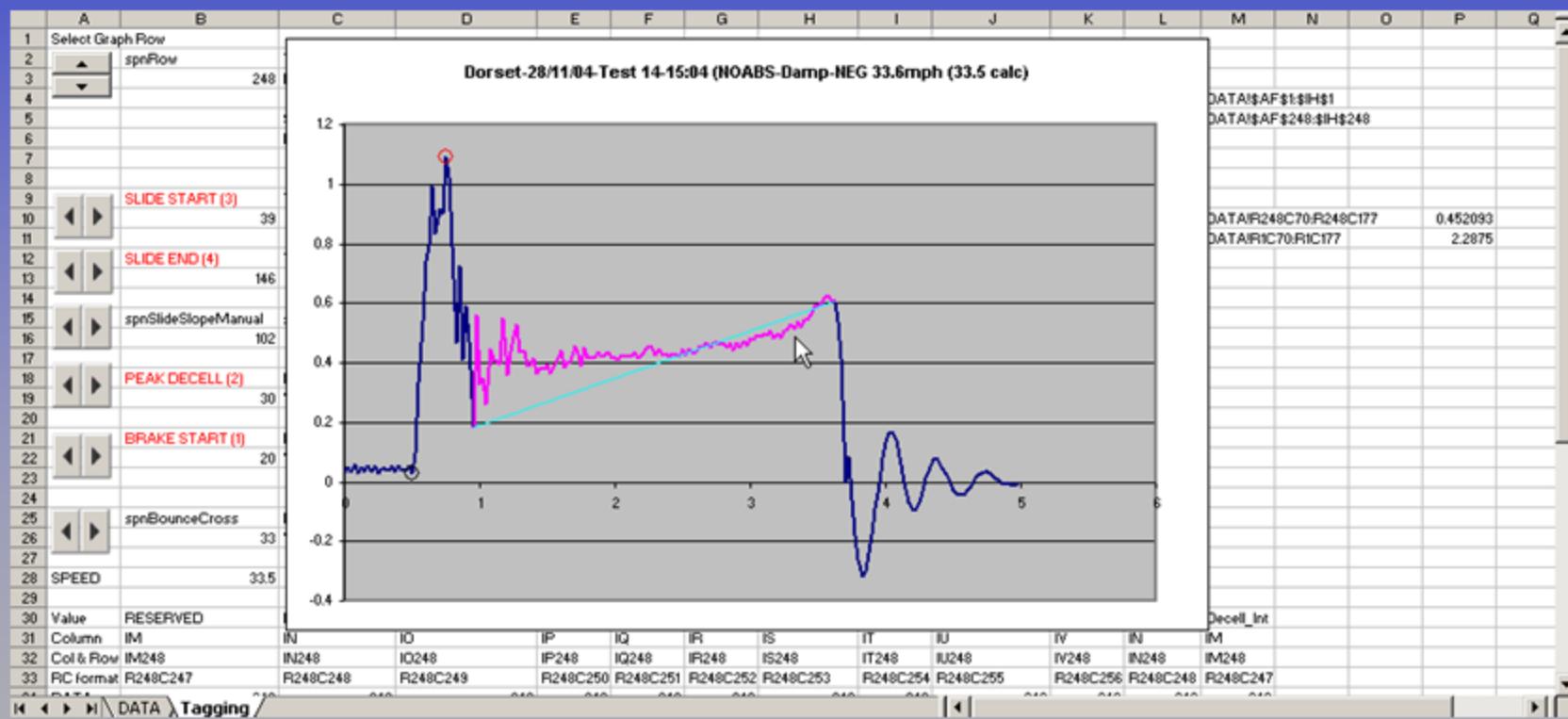
Hampshire Constabulary Testing at Winnall Waste Processing Facility

Devon & Cornwall Constabulary Testing at Westpoint Skidpan

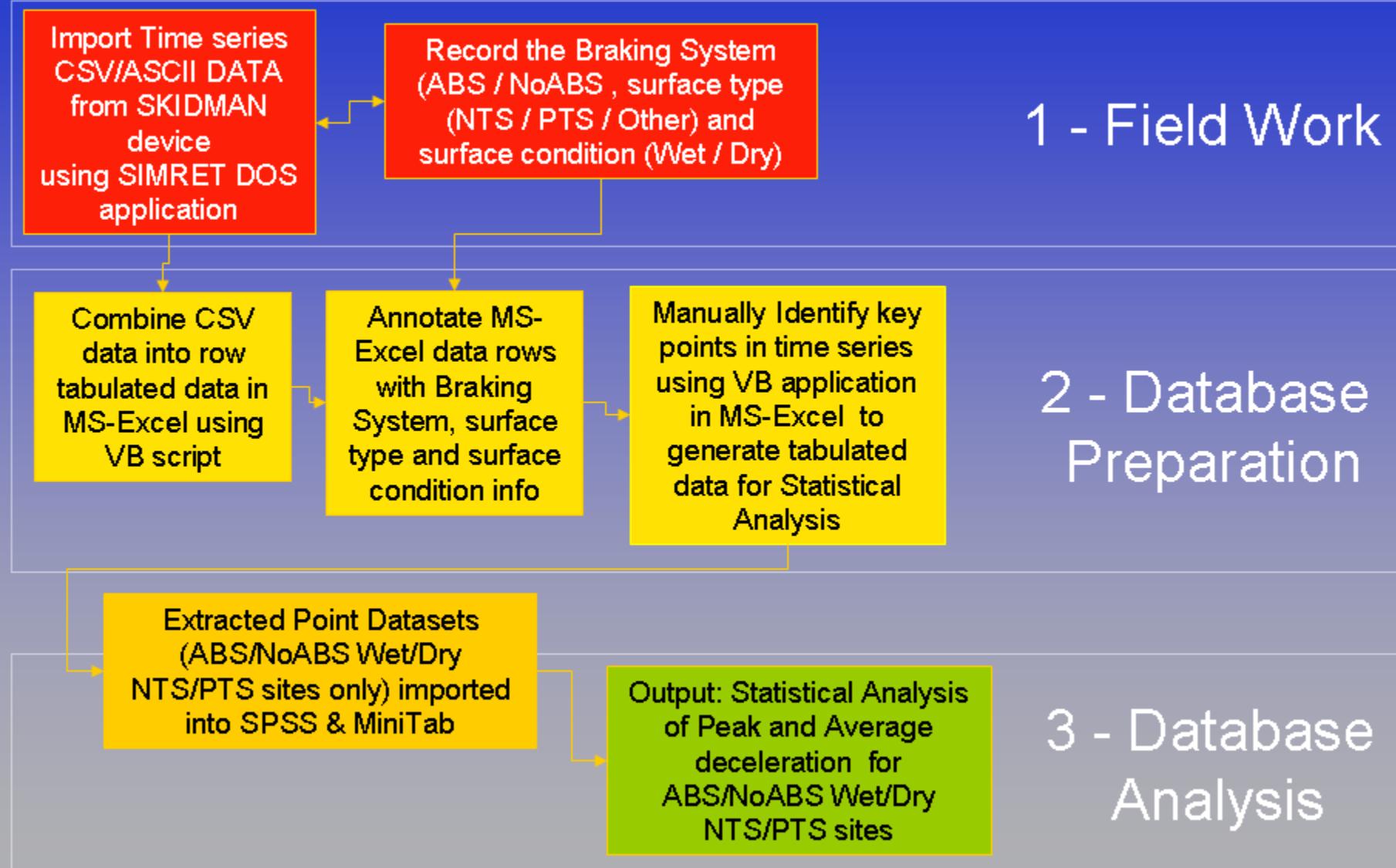


The Devil is in the detail.....

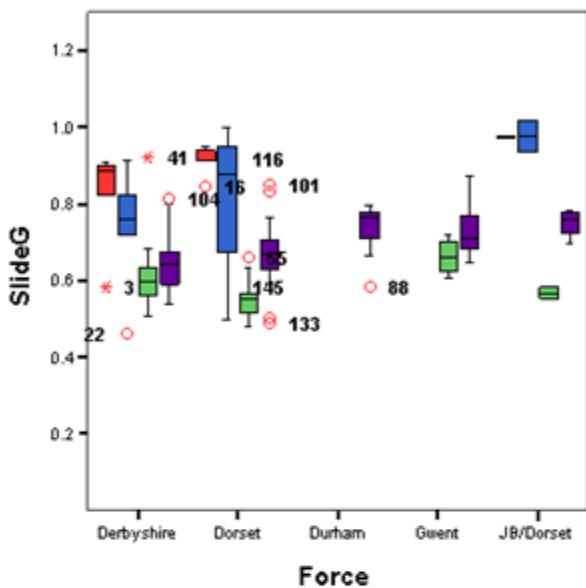
- Tabulation and visual classification of key phases within each simulated emergency braking event for a 300+ event database



Raw Time Series Data to Data Analysis

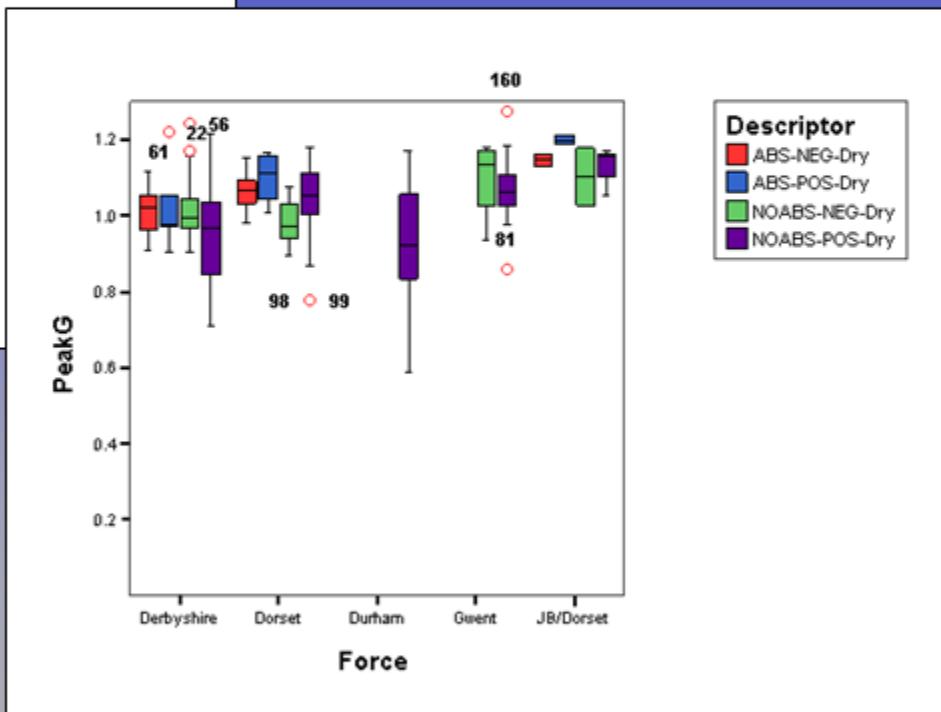


Between Force Variation with Common Trends



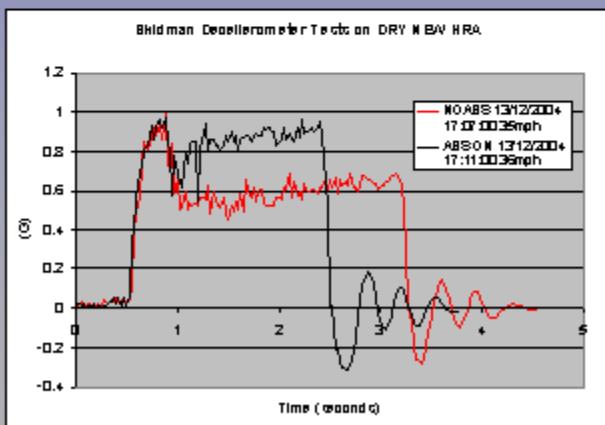
Descriptor

- ABS-NEG-Dry
- ABS-POS-Dry
- NOABS-NEG-Dry
- NOABS-POS-Dry



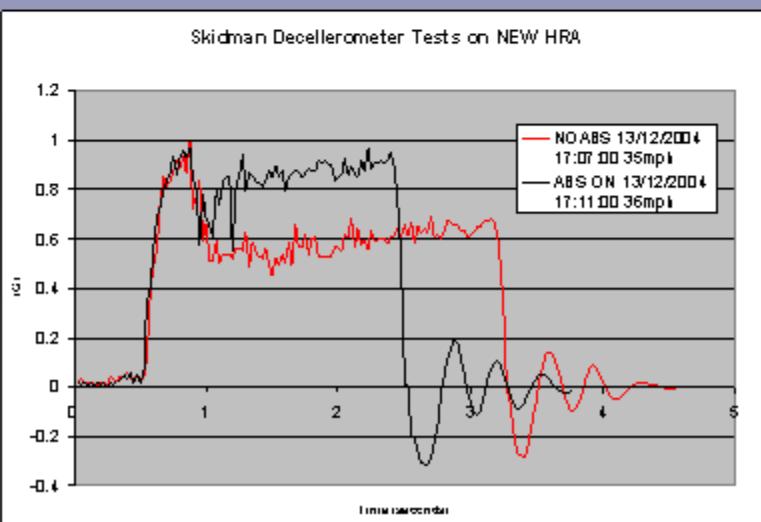
Descriptor

- ABS-NEG-Dry
- ABS-POS-Dry
- NOABS-NEG-Dry
- NOABS-POS-Dry



Findings to date:

ARE THE LEVELS OF SLIDING DECELERATION SIGNIFICANTLY DIFFERENT BETWEEN....?	Significance Levels (MiniTab 14)
#1 (FOR THE SAME BRAKING SYSTEMS / SURFACE STATES BETWEEN THE "TEXTURES")	
NOABS Negative v Positive DRY	<1%
ABS Negative v Positive WET	12.8%
ABS Negative v Positive DRY	25.7%
NOABS Negative v Positive WET	80.2 %
#2 (FOR THE SAME SURFACE /SURFACE STATES BETWEEN THE BRAKING SYSTEMS)	
ABS v NOABS Negative DRY	<1%
ABS v NOABS Negative WET	5.5%
ABS v NOABS Positive DRY	5.6%
ABS v NOABS Positive WET	9.2%



- The Low Dry Friction ('bituplaning') phenomenon is easy to reproduce on 'new' bituminous surfaces of both texture types with retained binder films
- The 'bituplaning' deceleration characteristics observed are almost identical to those reported on in NL on PA.
- The 'bituplaning' phenomenon is NOT just a high speed event (just need 50kph+)
- ABS braking can lead to momentary low dry friction with "dash like" skidmarks now more commonly left by ABS braked vehicles

Thank you for listening!

**THE STATISTICAL INTERPRETATION OF SIMULATED
EMERGENCY BRAKING EVENT TIME SERIES DATA**

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ABSTRACT

Over three hundred five-second / skid time series datasets from simulated emergency braking manoeuvres at English first accident sites and field trials (see Fig 1) were classified using key characteristics of the braking sequences events and their outcomes. These characteristics were tested for significant differences between road surface types and braking system types. One key metric, average deceleration, was also compared against existing benchmark 'typical' values for acceptable performance as found in the literature.

The views expressed in this Paper are those of the Author.

1 INTRODUCTION

During the course of the investigation of a fatal or near-fatal road traffic accident (RTA) occurring in the UK, tests may be undertaken by qualified Police collision investigators to quantify the frictional properties of the road surface at the scene. The fundamental physics behind the test methodology was first tested in court in the 1940's [1].

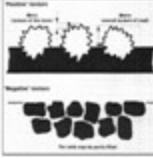
Fig 1. The diverse range of vehicles contributing to the database of deceleration / 'skid' tests

Fig 2. Idealized negative and positive textures [2]

These tests are commonly carried out using equivalent vehicles if those involved in the collision cannot be used. The vehicle's acceleration and deceleration rates and the vehicle during a simulated emergency braking manoeuvre ('skid test') undertaken at the scene are recorded using a device equipped with an accelerometer and a timing circuit.

As tests were more commonly undertaken on DRY surfaces, the great majority of tests fortunately fell within the group of DRY tests required for the PhD study.

It should be noted that road surface frictional conditions, i.e. are caused by ice or snow etc were not a



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