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

OLD: roadwork delays, perceived rutting problem, noise and spray issues. Two Part Installation
~ Positive Textured Hot Rolled Asphalt (HRA) Asphalt + Rolled in Coated Chippings

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)
Historic Case #1: Bitumen and Friction

Fig. 89. Brems spur bei verändertem Material in der Gleitphase (Aufnahme im Gegenlicht).
Fig. 90. Diagramm der Bremsmomente (zu Fig. 89). Reibungskennziffer = 0,35.
Fig. 91. Gleichstrom. Das Bindemittel zwischen den Splittkörnern ist erwärmt und verflüssigt worden.
Fig. 92. Diagramm der Bremsmomente (zu Fig. 91). Reibungskennziffer = 0,50.

“...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.


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

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

Conference on Data Mining and Data Warehouses (SiKDD 2008) 17/10/2008, Ljubljana, Slovenia
A road more Slippery in the Dry than in the Wet

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

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


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.
“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**

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 $\mu$ were NOTHING to do with the circumstances of the crashes
Bituplaning was occurring....
\( \mu_{\text{dry}} \approx 0.5? \). This IS NOT a ‘typical’ value for dry road friction.
But … Highway Engineers have not really ever measured DRY road friction!

We Brits measured the dry friction of roads in 1936 with our motorbike wet skid tester and the dry friction was pretty good we didn’t really try again…

…[ until the 1970’s when it was still really jolly good (measured using another device) so we stopped looking (again) ]
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 $\mu$ & 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**
$$ F = m\mu g $$

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Devon & Cornwall Constabulary Testing at Westpoint Skidpan

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**Critical Speed**

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

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

$$ v = \sqrt{gr (\mu + \tan(\phi)) / (1 - \mu \tan(\phi))} $$

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*Derbyshire Constabulary Road Policing Support Unit (2005) Equations Sheet.*
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

Skidman Decellerometer Tests on DRY NEW HRA

Westpoint Skidpan ABS / NOABS Comparison
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

1 - Field Work
- Import Time series CSV/ASCII DATA from SKIDMAN device using SIMRET DOS application
- Record the Braking System (ABS/NoABS, surface type (NTS/PTS/Other) and surface condition (Wet/Dry))

2 - Database Preparation
- Combine CSV data into row tabulated data in MS-Excel using VB script
- Annotate MS-Excel data rows with Braking System, surface type and surface condition info
- Manually Identify key points in time series using VB application in MS-Excel to generate tabulated data for Statistical Analysis

3 - Database Analysis
- Extracted Point Datasets (ABS/NoABS Wet/Dry NTS/PTS sites only) imported into SPSS & MiniTab
- Output: Statistical Analysis of Peak and Average deceleration for ABS/NoABS Wet/Dry NTS/PTS sites
Between Force Variation with Common Trends
Findings to date:

- 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!

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