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DEADLY WHEN WET – A SERIES OF CASE STUDIES

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ABSTRACT

On Australia Day, 2001, five people died in a single incident on the South Gippsland Highway, Koo Wee Rup when an unladen articulated vehicle crossed to the incorrect side of the road and collided with two cars travelling in the opposite direction. The incident occurred on a pavement which was flushed and wet. It was one of a number of incidents occurring on the same section of road under the same sort of weather conditions. It need not have happened.

Over the eighteen years the author has been in private practice with a steadily increasing involvement in the transport industry the relationship between low friction pavements and heavy vehicle collisions has become increasingly significant in the analysis of these incidents.

This paper will look at two case studies where pavement condition was determined to be the main cause of the collision as a result of the measurement of pavement friction values and the effect that friction value had on the vehicle dynamics in situations where there should have been no adverse effect on the vehicle.

INTRODUCTION

Unless supported by an appropriate reference the comments made in this paper are based on the author's experience and reflect his opinions and his as yet unpublished findings.

Pavement friction values are a significant factor in the reconstruction of vehicle behaviour in collision sequences. Whether it is the determination of speed from skid marks, speed from yaw marks or any of the other circumstances in which friction values play a part one of the most common practices for the analyst is a determination of a friction value from the pavement surface involved. This is usually accomplished by

- the use of a vehicle mounted accelerometer and skidding the test vehicle to a stop
- use of SCRIM data
- a pendulum tester
- a commercially made or "home made" drag sled – crude but efficient
- reference to tables compiled from testing [e.g. Fricke, 1990] or
- by estimate from the investigator's experience

Most references to measured friction values in collision reconstruction texts refer to car tyres and the investigator has to be aware of this as when dealing with heavy vehicles the friction value for a given surface will be lower than that obtained with car tyres. This difference is usually in the order of 25%; i.e. the truck tyre will only return a value around 75% of a test on the same surface with a car tyre [Fricke 1990]. Similar but unpublished results as to the variation have been obtained by the author in testing instrumented trucks and light vehicles on the same pavement surfaces in both wet and dry conditions as part of routine investigations.

For the purposes of this paper a heavy vehicle is one defined as a bus with a gross vehicle mass over 5 tonnes or other vehicle with a gross vehicle mass over 12 tonnes.

It is well established that bituminous seals diminish in "skid resistance" as they age and that values are usually lower when the surface is wet. References to publications such as Fricke [1990] cite variations of between 30 and 40 percent between dry bituminous seals and wet ones.

The subject of this paper is the difference experienced between a flushed or bleeding surface when wet compared to its value when dry and the implications for vehicle behaviour.

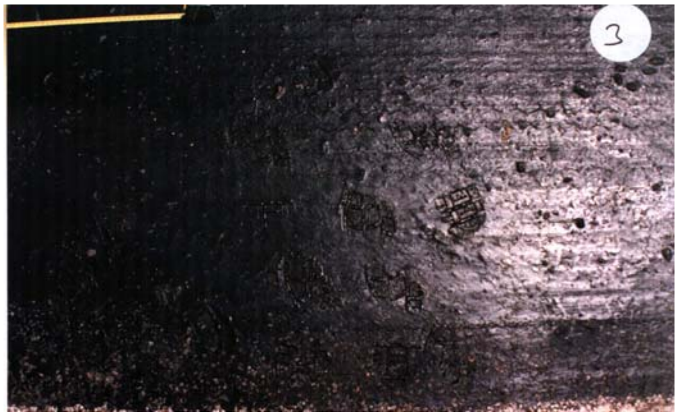

Figure 1: A dry flushed surface – soft with the heat of the day and with the stone totally subsumed into the binder

The surface in Figure 1 illustrates the wide variation in friction values possible with flushing. It is from a large radius horizontal curve in New South Wales in which, in an eight hour period over a cool wet night three articulated trucks, a four wheel drive and a sedan left the road within the curve. In the condition shown a skid test conducted in a light commercial vehicle fitted with an accelerometer returned a value of f = 0.67 and tore furrows in the soft road surface. A section was removed and tested in laboratory conditions using a pendulum tester fitted with a truck tyre compound slider made from a new tyre in the client's stock, the temperature in the test room adjusted to the recorded overnight temperature at the site [21C] and with the section sprayed with water. The sample returned a calculated friction value of 0.15 when converted using Oliver [1982] as a guide in the conversion.

Brown and Cenek [2002] have established a reliable relationship between SCRIM data and locked wheel skid testing to an accuracy of plus or minus 0.04 allowing confident use of SCRIM data by the investigator where other testing is not possible.

Figure 2: The D'Aguilar Highway, Queensland. Dry, as shown, 0.7. Wet 0.16

The following is extracted from SCRIM testing and across a surface varying from a travelled but satisfactory condition in terms of friction values to one which was flushed and dangerous. It graphically illustrates the rapid change which can confront drivers on a day to day basis.

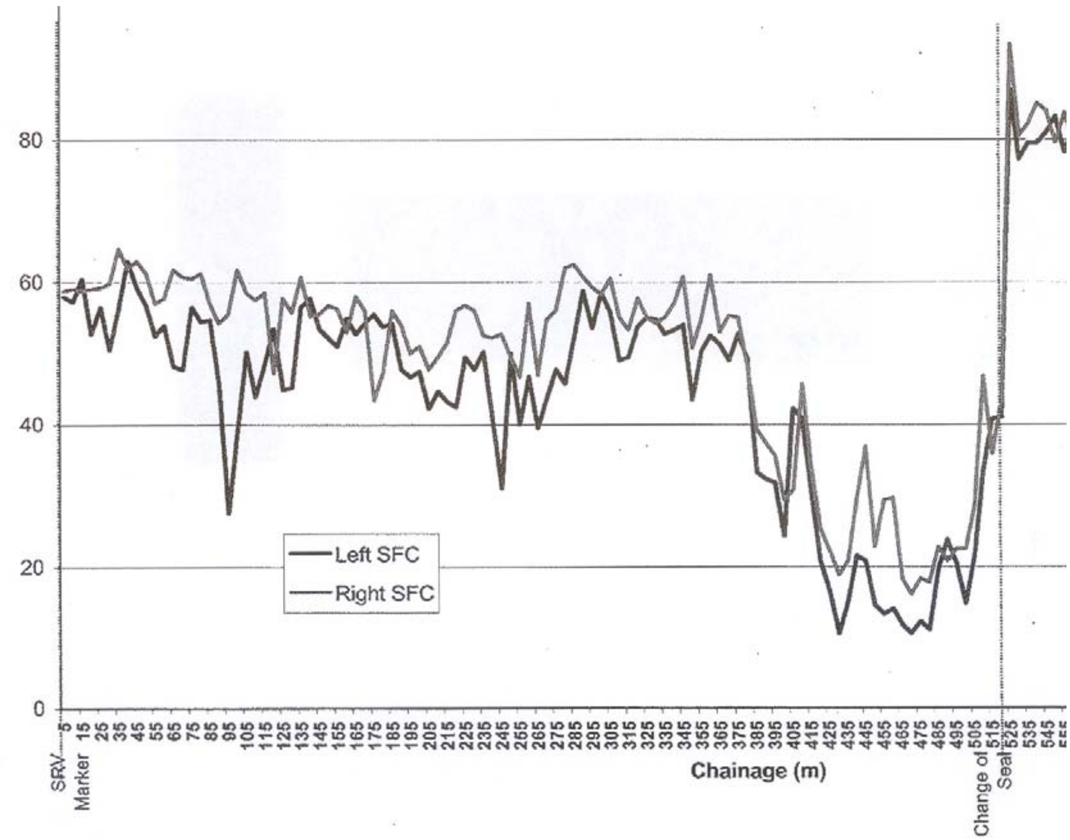

Figure 3: SCRIM Data from a collision site

The readings on the left of the graph are on a straight section with a right hand horizontal curve commencing around chainage 365. Skid testing with an instrumented vehicle was also undertaken on identified sites on this roadway with only minor variations in skid resistance from those shown in the table.

Over a period of nineteen years testing flushed surfaces using vehicles skidding to a stop from known speeds or fitted with an accelerometer or using a commercial drag sled the author has consistently recorded friction values in the range of 0.14 to 0.34 for truck tyres.

CASE STUDIES

The following case studies are incidents investigated by the author over a period of years and are representative of a significant number of similar occurrences investigated. One of the cases cited below will not have the location identified as the statute of limitations in respect to time for the instigation of civil action has not been reached although Coroner's findings have been handed down.

Case Study 1

On Australia Day, 2001, five people died when an empty articulated petrol tanker crossed to the wrong side of the South Gippsland Highway and collided with two vehicles travelling in the opposite direction. The loss of control occurred immediately after a short sharp rain storm and the as the tanker straightened up from a normal lane change manoeuvre.

The tanker had passed other slower moving traffic and commenced a normal lane change back into the left hand lane and straightened up within the lane at which time the driver lifted his foot from the accelerator and the engine brake activated. The prime mover changed direction clockwise approximately 30 degrees and crossed to the incorrect side of the road at which time the collisions with the oncoming vehicles occurred.

Figure 4: The section of road involved. Note the change in surface and the difference between the left and right lanes beyond the change.

The site was sealed off and became a crime scene.

Skid testing was undertaken on the wet road by the Victoria Police Major Collision Investigation Unit and the result for the left lane obtained in a Commodore sedan with standard tyres was f = 0.34 and when adjusted for a truck tyre f = 0.255.

This collision received enormous publicity and resulted in a transport operator coming forward and providing a number of instances in which his vehicles had lost traction on the same piece of road. The owner of a 4 x 4 utility came forward, with photographs, to show what had happened to him at the same location.

Figure 5: Rutting and flushing in the left hand lane

The emphasis from the authorities was on the driver being at fault. The Road Authority denied any responsibility.

The sudden change of direction led to the hypothesis that there was a real possibility of the vehicle having experienced wheel slip at the drive axles and the slight angle of articulation in the lane change led to the clockwise rotation of the prime mover.

An exemplar vehicle was provided by the transport company and it was duly instrumented by Roaduser Systems and a series of tests performed at the Anglesea Testing Ground. One purpose of the testing was to determine the friction demand at the drive axles when the engine brake was activated.

Given the total mass of the exemplar vehicle was 13.59 tonnes and the deceleration produced by the engine brake was 0.12g that equates to a retarding force of 16.0kN acting through the drive axles. As the drive axle group was 5.06 tonnes the minimum friction demand at the drive tyres was calculated to be 0.32. Allowance also needs to be made for two effects which will tend to increase the friction demand [above the average for the axle group] at an individual axle or wheel position. They are dynamic peaks in the retardation and dynamic variations in axle loads and some inequality in load-sharing between the axles. Roaduser Systems allowed an estimated factor of 1.3 for the former and 1.2 for the latter. This resulted in the calculated drive tyre friction demand due to engine braking being in the range 0.32 to 0.50.

Table 1: Results of test track manoeuvres

Manoeuvre	Results	Comment
Releasing accelerator from steady speed of 100 km/h [no engine brake.	Average deceleration of 0.075g. Calculated friction demand at drive tyres of 0.20 to 0.31	This is significant, although not all of this creates friction demand at the drive tyres [due to aerodynamic losses etc]. However, the engine deceleration by itself will create significant friction demand.
Releasing accelerator from steady speed of 100 km/h with engine brake engaged.	Average deceleration of 0.12g. Calculated friction demand at drive tyres of 0.32 to 0.5	Minimum tyre-road friction needed to sustain engine braking from 100 km/h, without traction loss

This range sits above the measured and calculated friction values at the site and what should have been a normal lane change manoeuvre turned into a tragedy.

The coroner exonerated the driver and laid the responsibility on the condition of the road. For a heavy vehicle this piece of road was indeed deadly when wet.

Less than a month later a small tourist bus returning from Phillip Island went out of control and capsized at the same location. Fortunately injuries were minor however it caused such a political storm that remedial treatment of the road was immediately put in place.

Case Study 2

This collision involved two articulated vehicles colliding head on within a horizontal curve with a radius of 488 metres. The vehicle travelling through the right hand arc crossed to the incorrect side of the road to collide with the other vehicle with both vehicles then leaving the pavement on the inside of the curve. The driver of the second vehicle was killed instantly. It was raining heavily at the time of the incident and witnesses on site immediately after the collision reported that the road surface was slippery underfoot.

A witness following the “loss of control” vehicle gave the speed of the vehicle as 100 km/h with a slowing in the curve to an estimated 95 km/h without any brake lights coming on. From that it can reasonably be inferred that the engine brake was operating. The damage to the prime mover precluded conformation of that due to the condition of the cab and control panel.

Fitting a replica vehicle to the path of travel through the right hand curve gave an angle of articulation of just under 2 degrees. Not much but certainly sufficient to influence a rotation of the prime mover as it experienced a loss of traction at the drive wheels under retardation.

Figure 6: The highway in question looking back along the approach path of the errant vehicle

Figure 7: The collision scene.

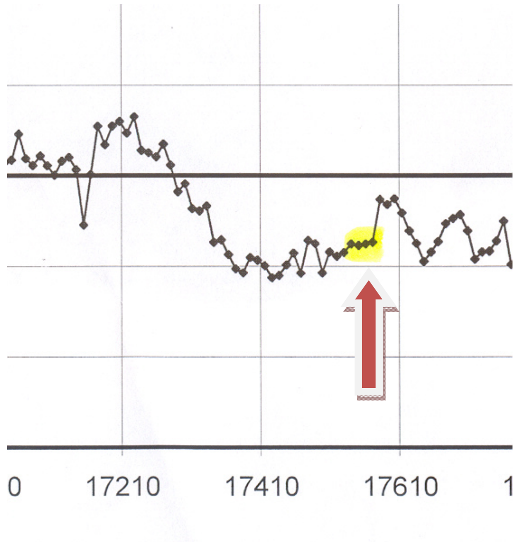

Figure 8: Friction testing at site.

Figure 8 is the result of friction testing approaching and through the curve with the highlight being in the curve and where the truck lost traction. The dark horizontal line represents a friction value of 0.45 with the other horizontal lines at 0.10 increments or decrements. For a car tyre the effective friction value within the curve was 0.37 and adjusted for truck tyres 0.28. Damage to the "loss of control" vehicle precluded obtaining or calculating axle weights to determine a range of friction demands at the drive axles under normal engine retardation and with engine braking. In either case from the information that was available it was expected that the results would lie under or around the minimum friction demand expected.

The angle of first contact between the two vehicles was determined from the physical evidence left by their post impact directions of travel compared to their pre impact directions. The rapid change of direction of the "loss of control" vehicle was calculated to be approximately 45 degrees indicating a very rapid rotation clockwise of the prime mover. Neither driver had the time or distance to avoid a collision.

The only reasonable conclusion to be drawn was that the truck had lost traction on the flushed pavement due to the friction demand at the drive tyres exceeding what the flushed surface could provide.

CONCLUSIONS AND RECOMMENDATIONS

The examples above are two of sixteen collisions investigated in detail where the author could identify a wet flushed pavement as the cause of the loss of control of a heavy vehicle. As a proportion [25.4%] of 63 similar incidents investigated in detail over the last 19 years the number causes concern that this type of surface may be a greater hazard to vehicles, particularly heavy vehicles, than may be realised.

Kennedy et al [2005] proposed a method of determining investigatory levels on the basis of risk analysis and the proposal is solid. It is a method leading into such a process that the author believes requires more serious appraisal and urgent attention. As a start the term Investigatory Level could well be replaced with Intervention Level as it denotes a more urgent requirement to consider any site identified and places an obligation on the Road Authority to "do something".

Sub-standard road conditions may be identified by;

- routine testing by the relevant Highway Authority,
- random observation by road crews,

- notification by Police either from random observation during the course of patrols or the occurrence of a collision,
- notification by a member of the community expressing concern regarding a particular area of roadway.

Where sites are identified as being hazardous then some immediate action is required.

- In identifying a site as hazardous the emphasis should be on friction levels relating to heavy vehicles rather than light vehicles.
- Economic constraints may preclude the immediate resurfacing of an area or treating it by water blasting however signage is cheap and can be installed immediately.
- Slippery When Wet and regulatory rather than advisory speed signs should be a minimum initial treatment.

Flushed/bleeding surfaces are a problem which should be treated with urgency as they are indeed "Deadly When Wet"

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AUTHOR BIOGRAPHY

David Axup holds a Bachelor of Arts [Police Studies] from Monash University and a Graduate Diploma in Highway and Traffic Engineering from Caulfield Institute of Technology. He was a member of the Victoria Police for 34 years retiring in 1992 as the Chief Superintendent commanding the Traffic Support Group. Since then he has been the principal in a small consulting firm specialising in the detailed analysis [reconstruction] of vehicle collisions with a large part of that work being within the heavy transport industry.