Signs of Change in Wet Weather Conditions

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Biography

Graham Brisbane has been working in the area of ITS and Dynamic Warning systems for over 15 years. In 1998 he was awarded a Ph.D. for his work on driver behaviour in restricted visibility conditions on the Sydney - Wollongong F6 Freeway. He has been involved in a number of real time advisory warning projects including ice, rain and queue detection advice as well as the concept development of Sydney's bus lane monitoring systems.

He is currently employed as the Roads and Traffic Authority's Manager Road Environment and Light Vehicle Standards. Graham was previously the Road Safety and Traffic Manager for the RTA's Southern Region, Roads Engineer for the Queens Road reconstruction in Fiji and undertaken a wide range of roles for the DMR across NSW.

Abstract

For many years throughout the world, a number of systems have been introduced which provide dynamic advice to motorists on the real time status of the road network. The most common of this real-time information has been congestion related, allowing motorists to take alternate routes to reduce travel time.

However in the RTA's Southern Region, a number of systems have been developed to provide real-time information which can improve road safety by allowing drivers to in some way modify their speed behaviour based on advice on approaching changed road conditions. Such systems combine hazard detection, which continually monitor road conditions and obtain information to display on changing message signs. Changeable message signs have also been provided at several locations, which are connected to presence detectors to advise drivers when queues build up at sites with restricted sight distances. These displays revert to a different message when queues are not present.

In August 2001 in association with a suite of road improvements for wet weather conditions, a changeable sign was installed at a sub-standard curve location where wet weather conditions significantly increases the hazard to motorists. In wet weather and when the pavement is wet, the advisory warning provided to motorists changes to reflect the increased risk at the site.

This paper examines how the available technology has been adapted to the wet weather problem. It examines the effect the sign has had on changing driving speeds based on the changed advice for different conditions as motorists travel through the curve and the associated before and after accident pattern at the site. The total effect of the wet weather treatments is also examined.

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INTRODUCTION

Changes in technology affect the road users in many ways. Cars come equipped with devices that tell you where they are and how to get where they are going. Drivers can check the Internet before leaving work to see how long it will take to get home and send a message to tell the oven when to start cooking the meal. Cameras can detect when an accident occurs and make a recording of the event.

The Road Environment is no exception to this use of modern gadgets and can provide drivers with real time information on hazards as they occur on the roadway. This can be done using Variable Message Signs (VMS) that advise of problems due to accidents or congestion or Changeable Message Signs (CMS) that reflect immediate hazards such as queues ahead as and when they occur (Brisbane 1999).

An extension of this process of providing real time information to drivers through the use of a Dynamic CMS was undertaken by the RTA's Southern Region on a notorious section of curves. The results of this work is presented in this paper. The paper also looks at the accident reduction effects of a suite of other treatments carried out in association with the dynamic warning sign.

OTHER RESEARCH

Research into vehicle-activated signs have been in use since the late 1970s. Early research in the UK examined the use of signs to warn of close following behaviour (Helliar-Symons & Wheeler 1984). However their use was quickly used for more site specific problems ranging from mobile signs at worksites (Garber & Patel) to more permanent use of Variable Message Signs to warn motorists of speeding (Brisbane 1994) or hazardous conditions (Brisbane 1996).

Although offering the benefits of time specific warning relating directly to the time the hazard exists, the cost of such solutions is significantly higher than a permanent static sign. As potential uses real time signs have been identified it has been essential to quantify the effectiveness of the solution adopted. In the UK a recent large scale evaluation was carried out on the use of fibre-optic or LED signs used for speed enforcement or hazard warning (Winnett & Wheeler 2002). The results showed the signs to be effective in reducing speeds and accidents although the effect varied with different situations.

BACKGROUND

On the Princes Highway immediately south of the Kiama by-pass is a 2.3 km section of 4 lane road which is built on a winding alignment developed in the first half of the last century. The speed limit is 80 km/hr. An accident study showed that in the 3 year period from 1996 to 1998, 65 accidents occurred within the section of which 58 (89%) were in wet weather conditions. (This compared with 65% of accidents occurring in wet weather in the next homogeneous section of the Princes Highway immediately to the south.)

55 of the accidents were loss of control accidents suggesting excessive speed on the curves despite the provision of advisory speed warning signs throughout the section

In order to address this accident problem, a number of treatments were undertaken throughout the site. This consisted of the installation of median drainage, provision of a New Jersey kerb through most of the site and the resheeting of selected sections of the road with a high friction surface.

However it was noted that 17 of the accidents occurred at one particular bend with 10 of those occurring in the northbound direction. This section was treated with a steel slag surface treatment to provide increased skid resistance to the bend. However, in addition to the traditional engineering works outlined above, it was decided to install a Vaisala rain and surface moisture detection system which would detect the hazardous conditions and to use this information to provide motorists advice on safer behaviour during these periods.

The complete package of works was installed over a three year period from 1999 to 2001 at a cost in the order of $1M.

SIGN SITE DETAILS

The selected site for the warning sign contains a right hand curve on a 4 lane section of the Princes Highway separated by a New Jersey kerb. Annual rainfall is in the order of 120 cm. There is an AADT in excess of 13000 vehicles per day. The existing curve warning sign was located in the approach to the curve with an advisory speed of 65 km/hr.

FIG 1: Selected Site

In establishing the trial site the sign was converted to a three way sign with displays as shown in Fig 2. The different displays were activated by the moisture detection device that detected weather conditions and the amount of precipitation when raining as well as the pavement conditions in terms of dry/moist/wet. (The equipment is also capable of detecting other conditions such as frost, snow and chemical spills although these were not relevant as a part of the trial.)

Condition 2 provided a lower advisory speed to reflect the wet surface conditions and would be expected to occur at a time when windscreen wipers were used. Condition 3 was assessed as the most dangerous situation as without rain falling motorists would not be required to use windscreen wipers and would not always be aware of the wet nature of the road surface, particularly during periods of low ambient light (eg at night). A visual examination of the data also shows that the pavement sometimes remains wet or moist in some cases for several hours after the rain has ceased. There is also evidence that dew is responsible for considerable periods of moist pavement, particularly in winter. For Condition 3 a red background was provided and flashing lights attached to the sign were used.

Wet Road - No Rain (Condition3) – Red Background/Flashing Lights

FIG 2: Variable Sign Arrangement

Details of the display logic for the triggers are shown in Table 2.

Condition1		Condition2		Condition3	
Weather	Surface	Weather	Surface	Weather	Surface
Clear	Dry	Rain	Dry	Clear	Moist
Cloudy			Moist	Cloudy	Wet
			Wet		

TABLE 2: Display Logic

In order to assess the effectiveness of the system, speed detection loops were place in both lanes as shown in Fig 3. The combination of equipment allowed speeds to be measured during different conditions, lane (fast or slow), time of day (to assess day and night effects), rainfall and pavement surface conditions. No changes were made to signposting for southbound traffic.

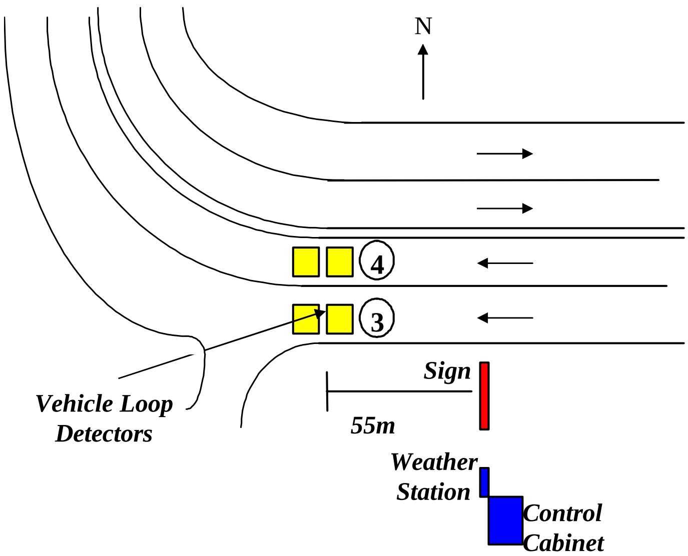

Fig 3: Site Arrangements

The equipment was commissioned on 30th May 2001 and speed measurements were taken for a period before the sign was activated to assess the effects of traditional signposting. These measurements were continued until a behaviour pattern for the pre-existing signposting had been established in wet as well as dry conditions. Following the obtaining of "before" data the sign was commissioned to provide advice to motorists in accordance with Table 2 on 22nd August 2001.

During the course of the trial it was considered that any reduction in speeds could be due to the speed displayed rather than any other display. A trial was therefore also undertaken to assess the effect of a speed display of 55 during Condition 1. The results of this display are included in the analysis of results.

RESULTS

Detailed results were obtained for all conditions before and after the installation of the sign. The data was separated into different time of day periods (dawn, daytime, dusk and night) when varying ambient light conditions might be expected to result in differing driving behaviour. For analysis purposes results for dawn and dusk periods were not used as the crossover in light conditions vary considerably at these times. For Condition1 (clear and dry) a full week's data was obtained on days when no rainfall occurred providing 53,916 data sets. For Condition2 and Condition3 22,094 and 32,155 were obtained for the "before" data whilst 57,368 and 32,185 samples respectively were used for analysis of the "after" data. When the dry conditions using a 55 advisory display were analysed, 65,308 data sets were used.

Analysis was made using the Cumulative Distribution Frequencies (CDF) for each case with significance testing undertaken using the Kolmogorov-Smirnov Test. In all cases the results were shown to be significant at the 1% level.

Dry Conditions. 65km/hr vs 55km/hr

As indicated previously, this analysis was undertaken to determine whether any speed reduction could just be attributed to the speed display. As shown in Fig4 the speed reduction for vehicles entering the bend at the recommended speed is minimal.

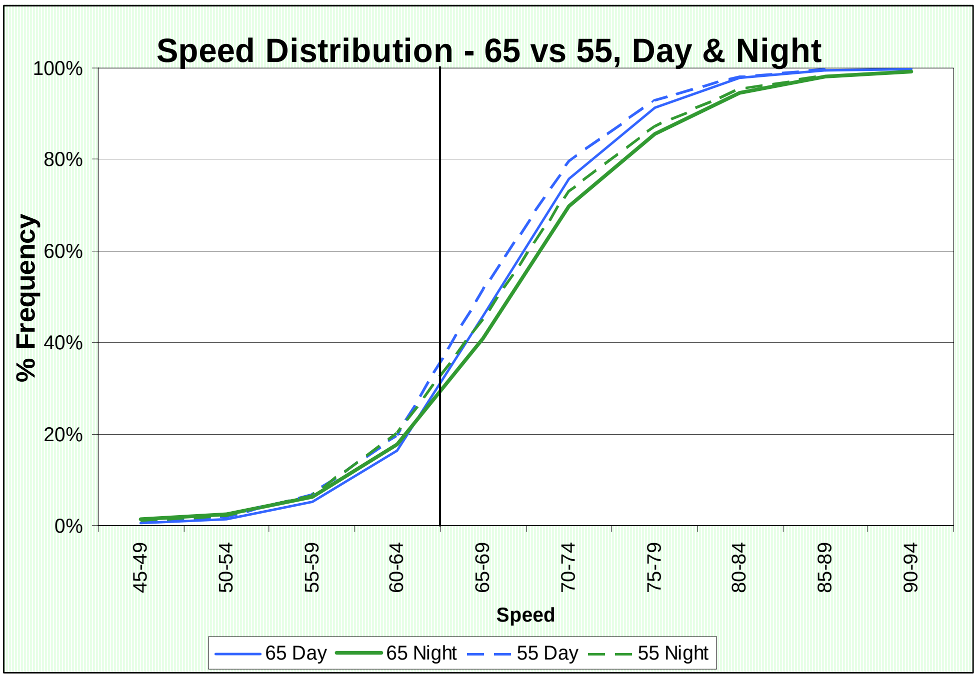

Fig 4: Speed Distribution – 65 vs 55 display in dry conditions, Day & Night

Wet weather behaviour before intervention

This analysis was undertaken to assess the normal difference in behaviour of drivers during clear and wet weather periods. Fig 5 shows the behaviour in the 3 different conditions to be assessed before the changeable sign was introduced.

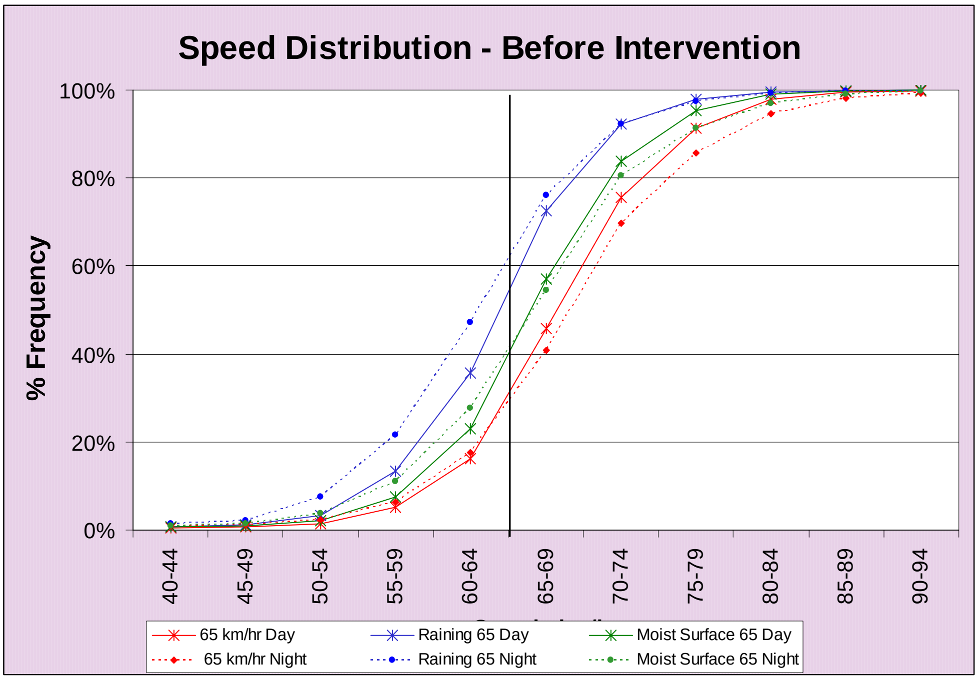

Fig 5: Before Intervention

The figures show that drivers reduce speed during rain and when the pavement is wet. However, there is a clear increase in speed that occurs when the rain stops even though the pavement remains wet.

Wet Weather Conditions

Condition 2 (Rain falling)

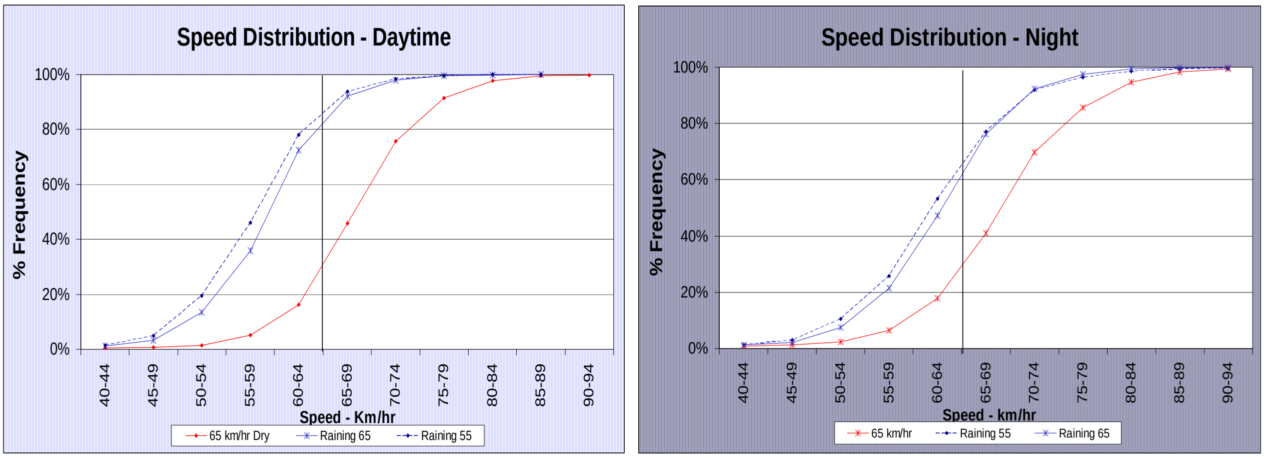

Fig 6: During rain conditions

The display of a lower speed produces a small reduction in speed during both daytime and night time conditions. However the change is small when compared to the normal reduction that occurs when rain is falling.

Condition 3 (Wet Pavement with no rain falling)

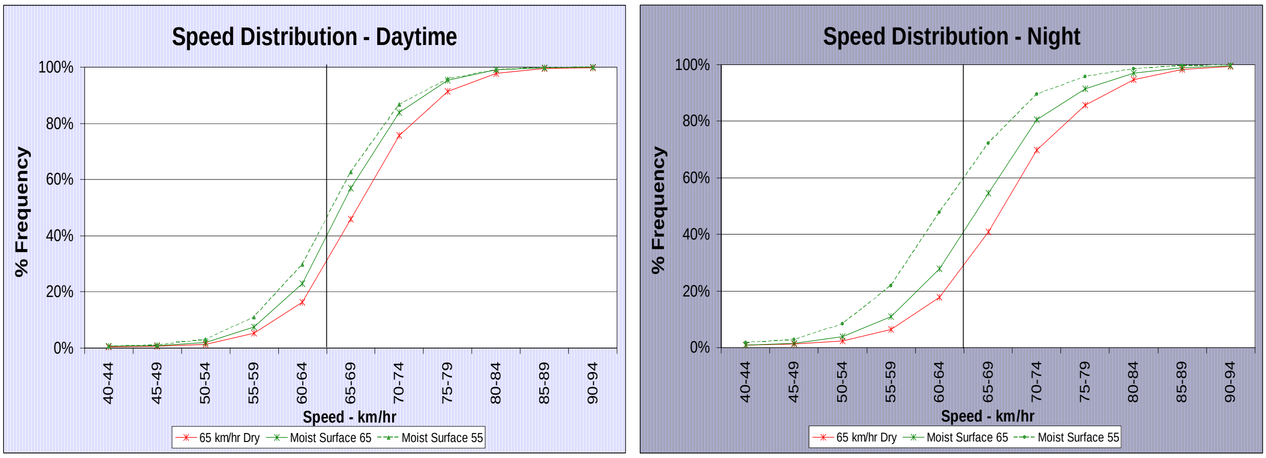

Fig 7: Wet pavement with no rain falling

Condition3 represents the worst scenario for motorists as during this period drivers increase their speeds above that for when rain is falling even though the pavement surface remains wet. The results show a reasonable reduction in speed due to the signage during daylight with a large increase at night. It should be noted that the signage associated with Condition3 also utilised flashing lights attached to the display. These are likely to be more effective during night conditions and may have been responsible for much of the speed reduction in excess of that achieved for Condition2 at night.

Excessive Speeds

A further analysis was carried out to see the percentage travelling in excess of the original advisory speed of 65km/hr as shown in Table 3.

	Day			Night		
	Before	After	Reduction (Absolute)	Before	After	Reduction (Absolute)
Condition1 (65)	84			82		
Condition 1 (55)	80			80		
Condition2	64	54	10	53	47	6
Condition3	77	70	7	72	52	20

Table 3: Percentage of motorists exceeding 65km/hr

These figures show the sign is effective at all times but has an increased effect at night when the pavement is wet but the rain has stopped, previously identified as the most dangerous period.

ACCIDENTS

Table 4 shows the accidents before and after the introduction of the suite of works in comparison with a control site immediately to the south. The combination of treatments can be seen to have had a major effect on the accident problem within the Kiama bends which show a large reduction in the annual accident rate, both at the worst curve and throughout the site. The results also show a large reduction in the wet weather accidents from 89% to 25% which is likely to be directly related to the treatments provided as may be expected from engineering works designed to remove surface moisture and improve skid resistance.

This accident reduction pattern compares with a control site immediately to the south which shows an increase in the accident rate and in the percentage of wet weather accidents.

		Before – 3 years			After – 19 months		
	Length	Accidents	Accidents /year	% Wet weather	Accidents*	Accidents/ year*	% Wet Weather
Kiama Bends	2.3km	109	36	89	16	12	25
Control Section	10.8km	43	14	26	34	21	29
At curve (N/B)	220m	10	3.3	100	1	0.8	0

* Adjusted to take into account periods when the sign was not working due to failures and/or adjustments in equipment.

COMMENTS

The reduction in wet weather accidents at the site of the changeable sign cannot be shown to be attributed to the provision of the sign due to the other treatments provided. Nevertheless the speed profile of motorists does show an improvement in behaviour, particularly during night conditions after rain periods when the pavement is still wet. The speed reductions are in line with those achieved in UK evaluations who also demonstrated that substantial accident reductions can be achieved by reducing excessive speeds. (Winnett & Wheeton 2002).

SUMMARY

The results of this and other tests of similar signage that interacts directly with the motorists (Brisbane 1994) demonstrates that motorist speed behaviour can be modified to improve safety at times of higher risk, particularly in the immediate vicinity of the hazard. However, care needs to be taken that the use of the sign is related to proven effectiveness.

References

BRISBANE G.J.B. (1994) Speed Modification – Intelligent signs for the future?*. Proceedings 17th ARRB Conference. Part 5*. *(Australian Road Research Board, Gold Coast).*

BRISBANE G.J.B. (1996) Driving In Fog - Putting Research Into Practice*. Proceedings 18th ARRB Conference. Part 5. (Australian Road Research Board. Christchurch, New Zealand).*

BRISBANE G.J.B. (1999) ITS - Not Just For Cities *Proceedings ITSA '99 (Intelligent Transport Systems Australia, Adelaide).*

BRISBANE G.J.B. & VASILIOU A (2001) Signs Of Rain *Proceedings ITSA '99 (Intelligent Transport Systems Australia, Sydney).*

GARBER N.J & PATEL S.T (1995) Control of Variable Speeds in Temporary Traffic Control Zones (Work Zones) using Changeable Message Signs with Radar. *74th Annual Meeting Transportation Research Board (US).*

HELLIAR-SYMONS R.D. & WHEELER A.H. (1984) Automatic speed warning sign – Hampshire trials. *Laboratory Report LR 1095, TRL.*

WIMMETT M.A. & WHEELER A.H. (2002) Vehicle-activated signs – a large scale evaluation. *TRL Report 548, TRL.*

Keywords

Rain, Wet Weather, Dynamic Signage, Speed, Intelligent Transport Systems (ITS)