Speeding Through Roadworks: Understanding Driver Speed Profiles and Ways to Reduce Speeding

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Abstract

Poor compliance with speed limits is a serious safety concern at roadworks. While considerable research has been undertaken worldwide to understand drivers' speeding behaviour at roadworks and to identify treatments for improving compliance with speed limits, little is known about the speeding behaviour of drivers at Australian roadworks and how their compliance rates with speed limits could be improved. This paper presents findings from two Queensland studies targeted at 1) examining drivers' speed profiles at three long-term roadwork sites, and 2) understanding the effectiveness of speed control treatments at roadworks. The first study analysed driver speeds at various locations in the sites using a Tobit regression model. Results show that the probability of speeding was higher for light vehicles and their followers, for leaders of platoons with larger front gaps, during late afternoon and early morning, when higher proportions of surrounding vehicles were speeding, and at the upstream of work areas. The second study provided a comprehensive understanding of the effectiveness of various speed control treatments used at roadworks by undertaking a critical review of the literature. Results showed that enforcement has the greatest effects on reducing speeds among all treatments, while the roadwork signage and information-related treatments have small to moderate effects on speed reduction. Findings from the studies have potential for designing programs to effectively improve speed limit compliance at Australian roadworks.

Introduction

Poor compliance with speed limits is a serious safety concern at roadworks (Allpress & Leland Jr, 2010; Brewer, Pesti, & Schneider, 2006; Debnath, Blackman, & Haworth, 2015). Despite numerous studies on understanding speeding behaviour at roadworks (Allpress & Leland Jr, 2010; Brewer, et al., 2006; Daniel, Dixon, & Jared, 2000; Hajbabaie, Ramezani, & Benekohal, 2011; Haworth, Symmons, & Mulvihill, 2002), little is known about the speeding behaviour of drivers at Australian roadworks and how their compliance rates with speed limits could be improved. This paper presents findings from two Queensland studies targeted at 1) examining drivers' speed profiles at roadwork sites, and 2) understanding the effectiveness of speed control treatments at roadworks.

Method

The first study measured driver speeds at four points within three long-term work zones (referred to hereafter as Sites 1 - 3) in Queensland. Schematic diagrams of the work zones showing the posted speed limits and the location of the four speed measurement points are presented in Appendix A. Site 1 was an undivided sealed two lane road (one lane each way) with pre-work speed limits of 100 km/h (southern end) and 80 km/h (northern end). Work (resurfacing) involved full closure of one lane within the activity area, with the open lane alternating (southbound/northbound) as required. At Site 2, work involved the addition of an extra lane in each direction to the existing two lanes (one each way). The pre-work speed limits were 90 km/h at the southern end of the work zone and 80 km/h at the northern end.

Site 3 comprised two lanes in each direction, divided by a 15 meter wide median, with 100 km/h pre-work speed limit. Work involved construction of a new westbound slip lane exiting a fuel station, with no traffic interruptions in the eastbound lanes. Speed data were collected from all sites using pneumatic tubes over a continuous period of seven days.

The speed data was analysed descriptively to obtain the mean speeds and the proportions of vehicles speeding at each speed measurement point in the sites. In addition, a Tobit model (see Debnath, Blackman, & Haworth, 2014 for a detailed description of the model) was applied to examine how different characteristics of vehicles and their surrounding traffic affect driver speeds. The model estimated the probability of speeding and the extent of speeding (i.e., the difference between the observed speed and the posted speed limit) for different vehicular and traffic characteristics.

The second study involved a review of the literature to understand the effectiveness of various speed control treatments. The treatments were categorised into four groups: Informational, Physical, Enforcement, and Educational treatments.

Results

Driver speed profiles in roadwork zones

The descriptive statistics of the speed profiles and magnitude of compliance with posted limits for the three work zones (Sites 1-3) are presented in Appendix B. The average speeds at Point 1 (after the first speed reduction sign) were higher than the posted speed limits in all sites. In addition, the percentages of vehicles speeding were higher at Point 1 than at other points, indicating that motorists generally speed more in the upstream work zone areas.

Before the activity area at Site 3, there were two speed limit reductions: first to 80 km/h from 100 km/h at Point 1, and then to 60 km/h (day hours) or to 70 km/h (night hours) at Point 2. The almost equal average speeds under the different speed limits and their corresponding rates of speeding (83% at point 1 and 97% at point 2) suggest that the speed reduction signage in upstream work zone areas may have very limited effects on travel speeds.

At the start of the activity area (Point 3), the average speeds were higher than the posted speed limits at Sites 2 and 3, with 89% and 72% of vehicles speeding, respectively. At the end of the activity areas (Point 4), the average speed was higher than the posted speed limit at Site 3, but was lower at Site 1 and about equal at Site 2 (still about half of the vehicles violated the posted speed limit, but mostly by small margins). The night-time speeds were significantly higher than the daytime speeds at Site 1 (4.4 km/h) and Site 2 (5.4 km/h).

The average speed measured at a location downstream of a stop/slow traffic controller (Point 2) at Site 1 was lower than the posted limit of 60 km/h with higher mean speed during night hours than during daytime. These findings might imply that motorists drive at lower speeds when passing a traffic controller standing on road, particularly during the day hours.

The estimates of the Tobit model (Appendix C) showed that relative to the 3-6pm hours, a lower percentage of vehicles were speeding during the other daytime hours (6am-3pm) at both Site 1 and Site 2. A driver had 7.3% and 3.5% higher probability of being non-compliant at Site 3 and Site 1 work zones respectively during the early morning hours (10am-3am).

The probability that a driver will be non-compliant was highest at Point 1 (after first speed reduction sign), for Site 1 (12.5%) and Site 2 (13.2%), with corresponding increases of 0.95 and 2.50 km/h in the excess speeds (i.e., amount of speed over the posted limit). At the beginning of the activity areas (Point 3), the probabilities of exceeding speed limits were 2.6% (Site 1), 11.2% (Site 2), and 1.1% (Site 3) higher than those at the end of activity area. The findings suggest that relative to the end of the activity area (Point 4), the magnitudes of speeding at the other locations (i.e., start and upstream of activity area) were likely to be significantly higher.

Compared to light vehicles, all work zones observed lower magnitudes and probabilities of non-compliance for medium vehicles. Similar results were found for the effects of types of lead vehicles on the following vehicle's speeds. Relative to the vehicles with a small gap to the vehicles in front (<= 2 seconds), vehicles with larger gaps were more likely to travel at higher speeds and to exceed the posted speed limits. Relative to the leaders of platoons, the follower vehicles had lower magnitudes and probabilities of non-compliance. The vehicles in a platoon with 2nd to 5th rank (considering the leader of the platoon as ranked 1st) and those in the tails of platoons (ranks 6th and beyond) had lower probabilities of being non-compliant. On the other hand, vehicles not in a platoon had higher probabilities of being non-compliant than the leaders of platoons. These results demonstrate that the speed of a particular vehicle and the probability of it exceeding the posted limits not only depend on its type but also on the type of vehicle it is following.

An increase in the proportion of vehicles in surrounding traffic that were exceeding posted speed limits was associated with the increase in speeds and probabilities of exceeding speed limits of other vehicles. Similar results were obtained for an increase in the proportion of vehicles which exceeded the posted limits by a large margin (at least by 20 km/h). These results indicate that a driver's speed at a particular point is significantly influenced by the speed profiles of other drivers travelling through the same point in a short time interval.

Effectiveness of speed control measures

Informational treatments

Regulatory speed limit signs were found to reduce speeds in general, but they do not bring the speed down to the posted limits (Haworth, et al., 2002). In a Victorian survey (VicRoads, 1990), only 43% of drivers reported adjusting their speeds according to speed limits. About 14% and 30% chose their speeds based on their perception of suitable speed and road conditions, respectively, without regard to the posted limits. The remaining 13% reported that they failed to notice the speed limit signs or felt that the signage was inadequate. The advance warning signs, on the other hand, seemed to have less effect on speeds than regulatory speed limit signs (Huebschman, Garcia, Bullock, & Abraham, 2003; VicRoads, 1990).

Variable message signs (VMS) produce larger speed reductions than the traditional static signage. Brewer, et al. (2006) and Bai, Finger, and Li (2010) showed VMS to be more effective than the traditional signage in reducing the number of speeding vehicles. Fontaine, Carlson, and Hawkins Jr. (2000) found VMS in combination with speed feedback systems reduced speeds by up to 16 km/h, whereas VMS alone resulted in about a 3 km/h speed reduction. Some researchers argued that the effects of VMS and speed feedback systems are temporary. Meyer (2004) found that radar-activated VMS had only a "novelty effect" which was not sustained over time but other research (Wang, Dixon, & Jared, 2003) found effects three weeks after installation. Innovative and attention-grabbing messages were tested by

Wang, et al. (2003) and found immediate speed reductions of 0.3-2.9 km/h in daylight conditions in one worksite, but another site showed little effect. Huebschman, et al., (2003) displayed the number of traffic fines issued to date, but found this ineffective.

Physical treatments

Inconsistent findings were obtained on the effectiveness of rumble strips in reducing speeds. Meyer (2000) reported speed reductions for both cars and trucks. Fontaine and Carlson (2001) observed 2 mph smaller speed reductions for cars in comparison with trucks. However, Horowitz and Notbohm (2005) reported that speed reductions due to rumble strips were not constantly present in a Missouri study. Considering the factors related to deployment of rumble strips (e.g., time to lay the strips, workers exposed to traffic), rumble strips might not be suitable for transient and moving sites. Optical speed bars were found to have relatively small but statistically significant reductions in speeds (Meyer, 2004).

Enforcement and educational treatments

Enforcement measures were the most effective means to reduce speeds but these measures often demand allocation of significant resources (Ross & Pietz, 2011). The presence of a speed camera (Benekohal, Hajbabaie, Medina, Wang, & Chitturi, 2010; Huebschman, et al., 2003; Joerger, 2010) or a police car with flashing lights showed significant effects on improving speed limit compliance, but the downstream effects were limited (Benekohal, et al., 2010). Imposing higher fines for violating speed limits showed little effect on speed reduction (Ross & Pietz, 2011; Ullman, Carlson, & Trout, 2000). Haworth, et al. (2002) argued that considerations need to be taken on increasing the likelihood of speeding drivers being detected, instead of only increasing the amount of fines.

Educational measures have the potential to improve public awareness of the risks involved at roadworks, but reliable evaluations are lacking regarding their effectiveness in terms of objective measures of speed reductions (Haworth, et al., 2002; Ross & Pietz, 2011). However, it is noteworthy that deployment of safety measures at roadworks without proper public awareness of the associated risks is unlikely to be effective.

Conclusions

This paper presents findings from two Queensland studies to examine the speed profiles of drivers at various locations in roadwork zones and to understand the effectiveness of speed control measures used at roadworks. Results from the analysis of driver speed profiles showed that the probability of speeding was higher for light vehicles and their followers, for leaders of platoons with larger front gaps, during late afternoon and early morning, when higher proportions of surrounding vehicles were speeding, and at the upstream of work areas. A review of the literature on the effectiveness of speed control measures showed that enforcement has the greatest effects on reducing speeds among all treatments, while the roadwork signage and information-related treatments have small to moderate effects on speed reduction.

References

Allpress, J. A., & Leland Jr, L. S. (2010). Reducing traffic speed within roadwork sites using obtrusive perceptual countermeasures. *Accident Analysis & Prevention, 42*(2), 377-383.

Bai, Y., Finger, K., & Li, Y. (2010). Analyzing motorists' responses to temporary signage in highway work zones. *Safety Science, 48*(2), 215-221.

Benekohal, R. F., Hajbabaie, A., Medina, J. C., Wang, M., & Chitturi, M. V. (2010). *Speed photo-radar enforcement evaluation in Illinois work zones*. Urbana: Illinois Center for Transportation.

Brewer, M. A., Pesti, G., & Schneider, W. (2006). Improving compliance with work zone speed limits: Effectiveness of selected devices. *Transportation Research Record, 1948*, 67-76.

Daniel, J., Dixon, K., & Jared, D. (2000). Analysis of fatal crashes in Georgia work zone. *Transportation Research Record, 1715*, 18-23.

Debnath, A. K., Blackman, R., & Haworth, N. (2014). A Tobit model for analyzing speed limit compliance in work zones. *Safety Science, 70*, 367-377.

Debnath, A. K., Blackman, R., & Haworth, N. (2015). Common hazards and their mitigating measures in work zones: A qualitative study of worker perceptions. *Safety Science, 72*, 293-301.

Fontaine, M. D., & Carlson, P. J. (2001). Evaluation of speed displays and rumble strips at rural maintenance zones *Transportation Research Record, 1745*(1), 27-38.

Fontaine, M. D., Carlson, P. J., & Hawkins Jr., H. G. (2000). *Evaluation of traffic control devices for rural high-speed maintenance work zones: second year activities and final recommendations*. Texas: Texas Transportation Institute.

Hajbabaie, A., Ramezani, H., & Benekohal, R. F. (2011). *Speed Photo Enforcement Effects on Headways in Work Zones*. Paper presented at Transportation and Development Institute Congress 2011.

Haworth, N., Symmons, M., & Mulvihill, C. (2002). *Safety of small workgroups on roadways*. Melbourne: Monash University Accident Research Centre.

Horowitz, A., & Notbohm, T. (2005). *Testing Temporary Work Zone Rumble Strips. Research Report*. Milwaukee, WI: University of Wisconsin.

Huebschman, C. R., Garcia, C., Bullock, D. M., & Abraham, D. M. (2003). *Construction work zone safety*. West Lafeyette, IN: Purdue University.

Joerger, M. (2010). *Photo radar speed enforcement in a State highway work zone: Demonstration project Yeon Avenue*. Salem: Oregon Department of Transportation.

Maze, T., Kamyab, A., & Schrock, S. (2000). *Evaluation of work zone speed reduction measures*. Ames: Centre for Transportation Research and Education.

Meyer, E. (2004). *Evaluation of data from test application of optical speed bars to highway work zones*. Lawrence: University of Kansas.

MVA Consultancy. (2006). *Roadworkers' safety research - Phase two: A report to the Highways Agency by MVA*. London: Highways Agency Great Britain.

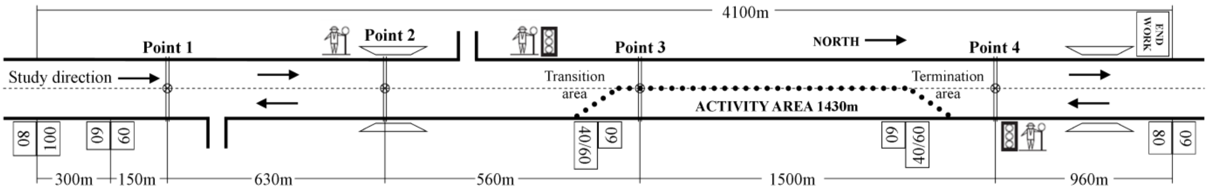
Ross, J. H., & Pietz, A. J. (2011). *Maximizing investments in work zone safety in Oregon: Final report*. Salem: Oregon Department of Transportation.

Ullman, G. L., Carlson, P. J., & Trout, N. D. (2000). Effect of the work zone double-fine law in Texas. *Transportation Research Record* (1715), 24-29. VicRoads. (1990). *Influencing road user behaviour through roadworks*. Melbourne: VicRoads.

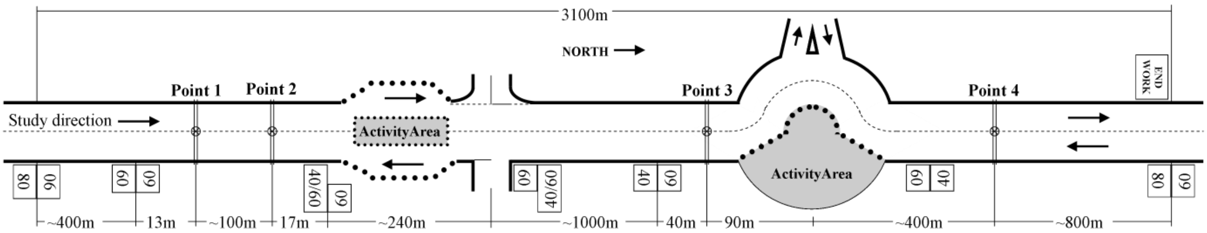
Wang, C., Dixon, K. K., & Jared, D. (2003). *Evaluation of Speed Reduction Strategies for Highway Work Zones.* Paper presented at 82nd Annual Meeting of the Transportation Research Board, Washington, D.C.

Appendices

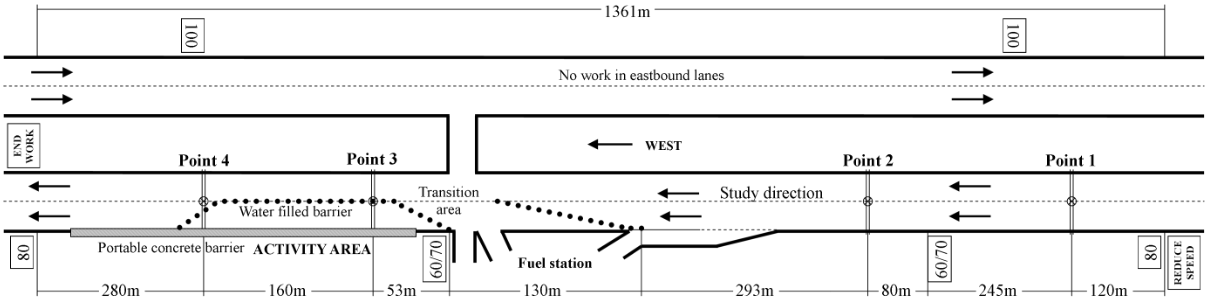
Appendix A Schematic diagrams of roadwork zones



Site 1 work zone plan



Site 2 work zone plan



Site 3 work zone plan

Appendix B Descriptive statistics of speed profiles and speed limit compliance

Work zone	Point	No of obs.	Posted speed limit	Mean Speed (km/h)	S.D.	% vehicles speeding	% speeding by at least 5 km/h	% speeding by at least 20 km/h	Mean speed difference (Night-Day)[a]	Mean speed difference (99% CI)
Site 1	1	23906	60	68.4	14.2	76.6	61.6	18.9	**8.5**	(8.0, 9.0)
Site 1	2	22141	60	50.1	11.7	19.4	11.4	1.7	**13.3**	(12.9, 13.7)
Site 1	*3	11725	40	43.5	8.2	66.4	44.2	1.7	**-3.6**	(-4.8, -2.5)
Site 1	*3	6302	60	44.7	10.9	8.8	2.9	0.1	**-8.5**	(-9.2, -7.9)
Site 1	4	19082	60	49.2	7.7	6.8	1.8	0.1	**4.4**	(4.1, 4.7)
Site 2	1	53085	60	74.7	8.6	95.5	88.2	25.4	**5.6**	(5.3, 5.8)
Site 2	3	58858	40	49.1	7.6	89.2	73.5	6.1	**4.7**	(4.5, 4.9)
Site 2	4	57881	60	59.4	7.4	48.4	18.5	0.5	**5.4**	(5.1, 5.6)
Site 3	1	79149	80	89.4	10.3	83.2	67.4	14.5	**0.5**	(0.3, 0.7)
Site 3	*2	48612	60	86.3	13.0	97.6	95.3	72.5	-	-
Site 3	*2	14796	70	89.0	11.2	96.9	90.4	44.7	**-1.1**	(-1.9, -0.3)
Site 3	*3	62199	60	67.7	14.2	72.7	59.8	18.6	-	-
Site 3	*3	18108	70	76.3	14.2	71.9	55.8	15.4	0.6	(-0.4, 1.6)
Site 3	*4	58532	60	70.9	12.2	84.4	70.9	21.2	-	-
Site 3	*4	17054	70	79.2	11.2	79.6	62.4	16.9	0.4	(-0.4, 1.2)

* Points with different speed limits during day and night periods, - No observation during night-time, **Bold values:** significant at 99% confidence level, [a] H_0: diff (mean night - mean day) = 0 with H_a: diff>0 (if diff is positive) or H_a: diff<0 (if diff is negative)

Appendix C Tobit model estimation results

Explanatory variables	Site 1		Site 2		Site 3	
	Expected value sensitivity[c]	Zero sensitivity (%)[d]	Expected value sensitivity[c]	Zero sensitivit y (%)[d]	Expected value sensitivity[c]	Zero sensitivit y (%)[d]
Time of day						
00:01 - 03:00	0.27	3.52	0.39	1.65	0.29	7.32
03:01 - 06:00	0.12	1.65	-0.06	-0.28	0.03	0.08
06:01 - 09:00	-0.15	-1.95	-0.32	-1.56	0.08	0.20
09:01 - 12:00	-0.15	-1.94	-0.35	-1.68	-0.09	-0.24
12:01 - 15:00	-0.10	-1.33	-0.09	-0.44	-0.06	-0.17
15:01 - 18:00	a		a		a	
18:01 - 21:00	-0.05	-0.70	-0.38	-1.85	-0.07	-0.19
21:01 - 24:00	0.02	0.27	-0.28	-1.36	0.00	0.01
Speed measurement point						
1	0.95	12.53	2.50	13.23	0.07	0.20
2	0.52	6.99	NA		0.30	0.81
3	0.19	2.57	1.92	11.18	0.43	1.13
4	a		a		a	
Posted speed limit	-2.09	-25.69	b		b	
Type of vehicle						
Light vehicle	a		a		a	
Medium vehicle	-0.63	-8.42	-0.54	-2.81	-0.38	-1.03
Heavy vehicle	-0.82	-10.94	-1.26	-7.45	-0.57	-1.58
Gap (from front vehicle)						
<=2 seconds	a		a		a	
2.1 - 4 seconds	0.13	1.74	1.27	6.34	1.66	4.50
4.1 - 8 seconds	0.35	4.63	1.26	6.30	1.15	3.30
8.1 - 14 seconds	0.94	12.44	1.58	7.52	0.98	2.86
>14 seconds	1.07	14.04	0.70	3.85	1.16	3.30
Type of vehicle in front						
Light vehicle	a		a		a	
Medium vehicle	-0.29	-3.88	-0.35	-1.75	-0.20	-0.55
Heavy vehicle	-0.25	-3.27	-1.10	-6.38	-0.24	-0.64
Order of vehicle in platoon						
No platoon	0.61	8.01	1.33	5.22	0.82	2.10
Platoon leader	a		a		a	
2nd-5th in platoon	-0.30	-4.03	-0.60	-3.27	-0.41	-1.22
6th and beyond	-0.65	-8.69	-2.17	-15.98	-2.20	-8.03
Traffic volume	0.01	0.07	0.00	0.01	0.01	0.02
Proportion of medium vehicles	-		-0.01	-0.04	-	
Proportion of heavy vehicles	-		-		-	
Proportion of vehicles speeding	0.07	0.88	0.10	0.50	0.16	0.43
Proportion of vehicles speeding by 20 km/h	0.05	0.61	0.12	0.59	0.16	0.44
Lane	NA		NA		0.16	0.42

[a] Reference category, [b] Removed due to correlation, NA Not Applicable, - Not significant at 95% confidence level, [c] Change in the expected value of excess speed (observed speed – posted speed limit), [d] Change in the probability of exceeding posted speed limits.