Effectiveness of Transverse Road Markings on Reducing Vehicle Speeds

Andrew Martindale BE (Hons), GIPENZ
Transport Engineer
Opus International Consultants
Andrew.Martindale@opus.co.nz

Cherie Mason BSc, Grad Cert. Road Safety (NSW)
Senior Road Safety / Transportation Specialist
Opus International Consultants
Cherie.Mason@opus.co.nz

Abstract

Transverse road markings as a speed mitigation device may be a cost-effective method of reducing fatal and serious injury crashes as a consequence of speeding on high-speed hazard approaches. As no established marking layouts have been formally applied in New Zealand, investigations into the use and application of transverse road markings were conducted over 2008–2010. The culmination of this research was to develop and undertake two field trials on the New Zealand State Highway network.

Field trials assessed vehicle speed in a before-and-after study. Vehicle speed was recorded two weeks prior to, two weeks after and six months after installation of a 300m long transverse bar arrangement, starting at a distance of 410m from a high-speed rural hazard. It was found that the markings reduce vehicle speeds, particularly on the entrance into the marking treatment. This trend occurred both in the short and long term. Based on these results, it was recommended that further trials be conducted with a slightly modified marking arrangement and a larger assessment period. The results of the trials conducted as part of this research will contribute to the formalisation of a standardised procedure for transverse road marking in a New Zealand roading environment.

Introduction

Speeding is a significant cause of safety problems on New Zealand roads. As speed mitigation measures, road signs and markings are the most cost-effective and widely implemented, but the abundance of signs being used has created a clutter effect, reducing their effectiveness. Alternative devices, whereby the road layout and its associated features can subconsciously inform a driver of the upcoming road conditions, are desired. One such device identified in overseas trials and studies is the speed perceptual countermeasure, transverse road marking.

Transverse road markings can be defined as a series of marked (either flat or raised) transverse bars placed across the road in the direction of traffic flow as shown by the example in Figure 1. They are used to assist in raising driver awareness of risk through perceptual optical effects, thus encouraging drivers to reduce their speed in anticipation of an upcoming hazard.

Figure 1: An example of Transverse Road Markings

The purpose of this NZ Transport Agency (NZTA) funded research project, undertaken in 2008-2010, was to establish an understanding of how transverse road markings affect driver behaviour and speeds in varying environments, and how they can be applied to reduce risk from speeding on hazard approaches in a New Zealand context. This was achieved by undertaking a literature review, and developing and applying a transverse road marking arrangement at two New Zealand field trial sites. In this way, the research presented has the potential to contribute to the “Safer Journeys” New Zealand Road Safety Strategy 2010–2020, which endeavours to ‘significantly reduce the impact of speed on crashes by reducing the number of crashes attributed to speeding and driving too fast for the conditions’ (MoT 2010).

Literature Review

A review of available national and international literature was undertaken to assess the ability of transverse road markings to act as a speed mitigation device. With reference to previously completed research trials, the literature review would help identify existing applications and driver behaviour trends known to be associated with the markings.

No specific mention of transverse road marking was found in New Zealand legislation, design guidelines or standards. Additionally, no documented transverse road marking arrangement was found to have been formally applied in New Zealand prior to this research project. However, marking arrangements were trialled in driving simulators by TERNZ Ltd and the University of Waikato. The New Zealand based simulator research had shown promise for applications of different transverse road marking arrangements in high-speed rural environments (Charlton 2003).

Internationally it was found that the United Kingdom (UK) was the primary user of this speed mitigation device. In accordance with the DfT Standard TD6/79 (Department for Transport 1986), a logarithmically decreasing arrangement has been applied to some motorway roundabouts and off-ramp slips as shown in Figure 2. A variety of different transverse markings have also been assessed in Australia on approaches to rural intersections through field trials (Jarvis and Jordan 1990) and driving simulators (Godley et al. 2000). The Australian research found that constantly spaced arrangements could display similar speed reduction properties to those of their UK counterparts.

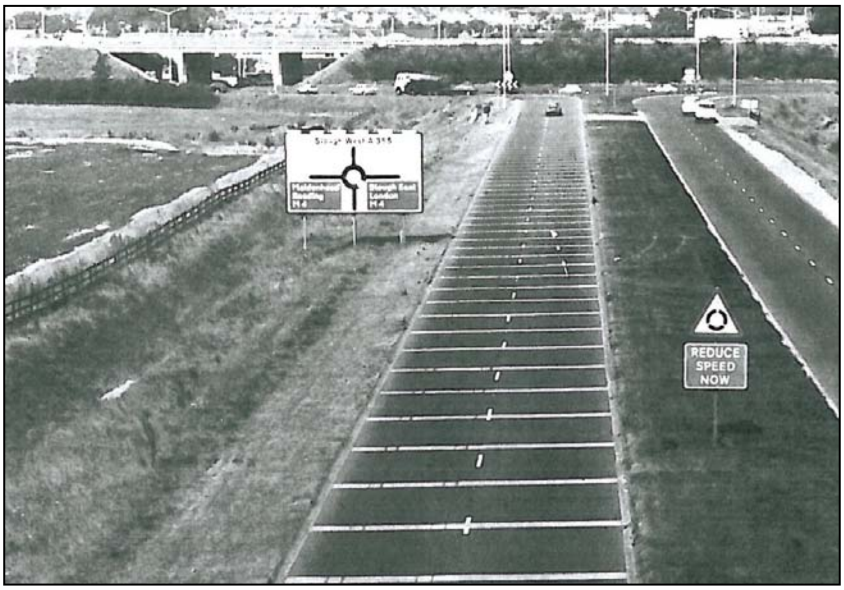

Figure 2: Yellow bar markings in the UK on approach to a roundabout (Helliar-Symons 1981)

Regardless of the application or the marking arrangement adopted in New Zealand and internationally, research has consistently demonstrated that transverse road markings could be beneficial as a speed mitigation device. Reductions in mean and 85th percentile vehicle speeds were typically observed on hazard approaches after the implementation of transverse road marking treatments. Some studies also found a reduction in accident levels was possible at the hazard itself (Helliar-Symons 1981).

As New Zealand's infrastructure typically lacks the large-scale motorway facilities seen in the UK, transverse markings appear to present a greater opportunity to reduce fatal and serious injury crashes caused by speeding on rural hazard approaches in a New Zealand roading environment. Such hazard approaches include those leading up to bridges and intersections.

Field Trial Methodology

Following the literature review, a methodology for the implementation of transverse road markings at two New Zealand field trial sites was developed. It was decided that providing continuity between the field trial methodology and previous New Zealand based simulator research would be beneficial. For these reasons the field trials utilised the transverse road marking arrangement shown in Figure 3 with the following characteristics and assessment procedure:

- Line arrangement: 100mm transverse bars extending at a 60° angle, 1.0m from the edgeline and centreline;
- Line spacing: Transverse bars placed at 3m spacing over a 300m treatment length. The treatment starts approximately 410m prior to the hazard and ends 110m from the hazard;
- Line colours: White reflectorised road marking in accordance with NZTA specifications;
- Assessment: A before-and-after assessment of vehicle operating speeds travelling towards each trial site hazard using a four-second headway. Speeds were assessed at three locations (410m, 260m and 50m prior to the hazard) within the hazard approach for seven continuous days two weeks prior to, two weeks after and six months after the installation of the marking treatment. Metro-count® roadside units were used as the speed detectors.

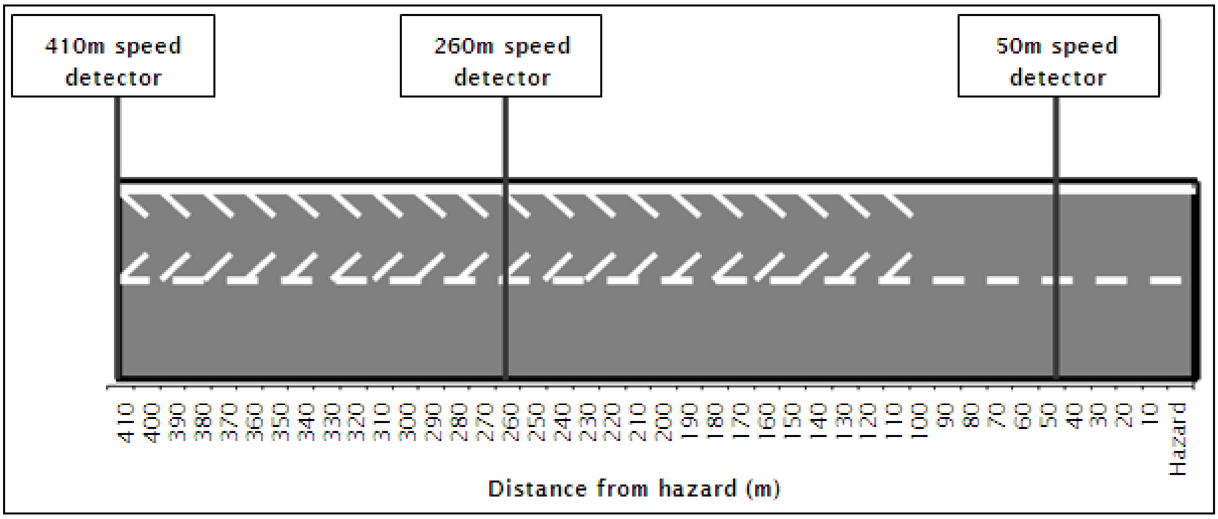

Figure 3: Visual Concept of adopted layout and speed detector locations

With the assistance of NZTA, two transverse road marking trial sites were established as per the adopted methodology. At both trial sites a speed reduction is required to safely negotiate the following hazards which are located in high-speed, rural State Highway environments:

1. **Southbound approach to the Kimberley/Arapaepae Road intersection on SH57;**

   The priority cross-roads intersection is located near Levin on SH57 (route position 0/2.083), approximately 2km to the east of SH1. The intersection is arranged as an out-of-context curve, with SH57 traffic having priority from west to north (and vice versa) as shown in Figure 4. The southbound SH57 approach to the intersection is approximately 500m in length and has a posted speed limit of 100km/h. On the approach to the intersection, a major speed reduction is required by southbound traffic to negotiate the intersection safely. A review of the NZTA crash database noted that 15 crashes occurred at the intersection between 2004 and 2008. Six of the 15 crashes were caused by drivers travelling too fast on the southbound intersection approach, losing control when making the right-hand turn. One crash was attributed to losing control at excessive speed on the southbound approach when making a left-hand turn. An image of the established SH57 treatment site is shown in Figure 5.

Figure 4: Southbound approach to the SH57 trial site (50m from the intersection)

Figure 5: Established SH57 trial site (410m from the intersection)

2. Eastbound approach to the Waihenga River Bridge on SH53

The Waihenga River Bridge is located on SH53 (route position 0/14.755) between Featherston and Martinborough. The bridge is situated approximately 575m to the east of the Jenkins Dip Floodway bypass. The eastbound bridge approach is characterised by a straight section approximately 580m in length prior to a right-hand horizontal curve leading up the bridge abutment as can be seen Figure 6. The approach operates with a 100km/h posted speed limit and requires a reduction in speed to drive over the bridge safely. Although the NZTA crash database showed only one minor injury crash at the bridge over the five-year period between 2004 and 2008, the bridge is regularly used by oversized farming vehicles which can become a hazard because of the lack of forward visibility. An image of the established SH53 treatment site is shown in Figure 7.

Figure 6: Eastbound approach to the SH53 trial site (50m from the bridge)

Figure 7: Established SH53 trial site (410m from the bridge hazard)

Results

Data recorded during the trial process was analysed to assess the speed reduction properties of the transverse road markings. A summary of the before, short and long term mean and 85th percentile speeds recorded across the three detectors at each trial site is provided in Table 1. The significance of the mean speed changes was assessed using a full-factorial univariate analysis of variance (ANOVA) with a 95% confidence interval.

Table 1: Overall speed change results for each trial site

Period	Statistic	Distance from hazard		
		410m	260m	50m
SH57 Arapaepae Road/Kimberley Road intersection				
Before installation	Mean speed (km/h)	91.0	80.6	56.0
	85th percentile (km/h)	103.3	95.0	69.4
2 weeks after	Mean speed (km/h)	89.7	80.0	57.6
	85th percentile (km/h)	102.2	94.7	69.9
Short-term speed change	**Marginal mean speed (km/h)**	**-1.3***	**-0.6**	**1.6***
	85th percentile (km/h)	**-0.8***	**-0.3**	**0.5***
6 months after	Mean speed (km/h	87.1	77.8	53.2
	85th percentile (km/h)	100.0	92.5	67.1
Long-term speed change	**Marginal mean speed (km/h)**	**-3.9***	**-2.7***	**-2.8***
	85th percentile (km/h)	**-3.3***	**-2.5***	**-2.3***
SH53 Waihenga River Bridge				
Before installation	Mean speed (km/h)	82.3	82.3	78.8
	85th percentile (km/h)	97.4	96.5	90.8
2 weeks after	Mean speed (km/h)	79.7	83.1	78.6
	85th percentile (km/h)	94.5	97.2	91.6
Short-term speed change	**Marginal mean speed (km/h)**	**-2.6***	**0.9**	**-0.2**
	85th percentile (km/h)	**-2.9***	**0.7**	**0.8**
6 months after	Mean speed (km/h	70.1	83.5	70.7
	85th percentile (km/h)	94.2	99.7	84.6
Long-term speed change	**Marginal mean speed (km/h)**	**-12.2***	**1.2**	**-8.1***
	85th percentile (km/h)	**-3.2***	**3.2**	**-6.2***

*speed change is statistically significant

At both sites lower mean and 85th percentile speeds were recorded as vehicles approached either the bridge or intersection hazard. This occurred whether the transverse lines were installed or not. The main effect of the markings was to reduce vehicle speed at the start of the treatment, 410m from the hazard. Consequently, one can assume that the transverse lines have created an alerting property; drivers have reacted to the markings as they are first observed and have entered into the marking treatment at a lower speed out of precaution.

Vehicle speeds at the midpoint of the marking treatment were at levels similar to those recorded pre-installation. This was true in both the short and long term. It is possible that during the first 150m of the treatment, drivers became accustomed to the presence of the lines and exhibited a habitual response.

In the long-term, 50m from each hazard, it was found that vehicles arrive at lower speeds than they did prior to the installation of the lines. One possible reason for this is that the heightened perception of risk induced upon entering the marking treatment better prepared drivers to identify the visual cues associated with either the bridge or intersection hazard.

In addition to the overall speed results, ANOVA was used to determine whether any variations in the speed change trends were present between the weekday/weekend periods. In this way, it would be possible to estimate if the markings were more influential on commuter (weekday) or occasional (weekend) drivers. The speed change trends were also reviewed for light and heavy vehicles to see if the markings had different effects on drivers of different vehicle classes. The analysis concluded that the change in mean vehicle speed was unrelated to either of the two factors. Transverse markings had the same effect on both commuter and occasional drivers travelling through the treatment. Likewise, the markings had the same effect on drivers of either light or heavy vehicles.

Conclusions

The literature review and field trials demonstrated that transverse road markings could be used as a practical speed mitigation device on high-speed, rural hazard approaches in New Zealand due to the fact that statistically significant mean speed reductions were determined at intervals within the transverse marking treatment. In this way, transverse markings have been shown the potential to be a cost-effective method for reducing fatal and serious injury crashes at locations where the speed on a hazard approach is a significant contributing factor.

Consequently, it is recommended that further trials be conducted to allow more accurate and empirical evidence to be collected. This will allow a standardised procedure for transverse road marking in New Zealand to be formalised. Based on the results of field trials completed in this research project, if further trials are undertaken, consideration should be given to the following methodological improvements:

- The distance between the between the hazard and the start/end point of the marking treatment should be reduced. A 150m marking treatment starting between 200–260m from the hazard should result in reduced vehicle approach speeds closer to the hazard;
- Increasing the width of the individual bars to at least 500mm will make the markings visually more pronounced. The distance between the bars should be increased from 3m to 10m to account for the increase in bar width;
- The long-term assessment period should be increased from 6 to 12 months after the marking arrangement is installed. In this way, a limited assessment of accident data can be made in addition to assessing the change in vehicle speed;
- Increasing the number of high-speed rural trial sites from two to five or more would be of benefit. This will help account for any variation between the individual trial sites as was found in this study.

In summary, the overall success or failure of transverse road markings as an accident prevention measure should not be purely based on the changes in vehicle speed. Because of the limited time available for this trial, the hypothesis that a positive relationship possibly exists between reduced travel speed and a reduction in speed-related crashes has been assumed. The markings' affect on safety through a reduced accident history will be a more telling statistic to judge their overall effectiveness by.

References

MARTINDALE, A and C, URLICH (2010). Effectiveness of transverse road markings on reducing vehicle speeds. NZ Transport Agency research report 423.

CHARLTON, S (2003) Development of a road safety engineering modelling tool. Hamilton: University of Waikato and TERNZ Limited.

DEPARTMENT for TRANSPORT (1986). Transverse yellow bar markings at roundabouts. Departmental standard TD 6/79. London: Department of Transport.

GODLEY, S, T TRIGGS and N FIDLES (2000) Speed reduction mechanisms of transverse lines. Melbourne: Monash University Accident Research Centre.

HELLIAR-SYMONS, R (1981) Yellow bar experimental carriageway markings – accident study. Road Research Laboratory report LR 1010. Crowthorne, UK: Transport Research Laboratory.

JARVIS, J and P JORDAN (1990) Yellow bar markings: their design and effect on driver behaviour. Proceedings 15th ARRB Conference, Darwin, Australia, 26–31 August 1990, Part 7: 1–22.

MINISTRY OF TRANSPORT (2010) Safer journeys. New Zealand’s road safety strategy 2010–2020.