Effectiveness of Transverse Road Markings on reducing vehicle speeds

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 (called speed perceptual countermeasures) are desired. One such device identified in overseas trials and studies are transverse road markings.

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. 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. The purpose of this report, 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.

A review of available national and international literature identified 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 a variety of different transverse road marking arrangements. In addition, some studies found a reduction in accident levels at the hazard itself.

No specific mention of transverse road marking was found in New Zealand legislation, design guidelines or standards, and no transverse road marking arrangement has been formally applied in New Zealand prior to this project. However, marking arrangements trialled within driving simulators have shown promise for applications in high-speed rural environments. In the United Kingdom (UK), the primary user of this device, a logarithmically decreasing arrangement has been applied to some motorway roundabouts and off-ramp slips. Transverse markings have also been assessed in Australia on approaches to rural intersections through field trials and driving simulators. This research found that constantly spaced arrangements could display similar speed reduction properties to those of their UK counterparts. 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, including those leading up to bridges and intersections.

A methodology for two field trials was developed. It was determined that providing continuity between the field trial methodology and previous New Zealand research would be beneficial. A modified marking arrangement (figure ES1) was adopted:

- **Line arrangement:** 100mm transverse bars extending at a 60° angle over 1.0m from the edgeline and centreline
- **Line spacing:** Transverse bars placed at an even 3m spacing for approximately 300m, ending 110m prior to the hazard
- **Line colours:** White reflectorised road marking in accordance with NZ Transport Agency specifications

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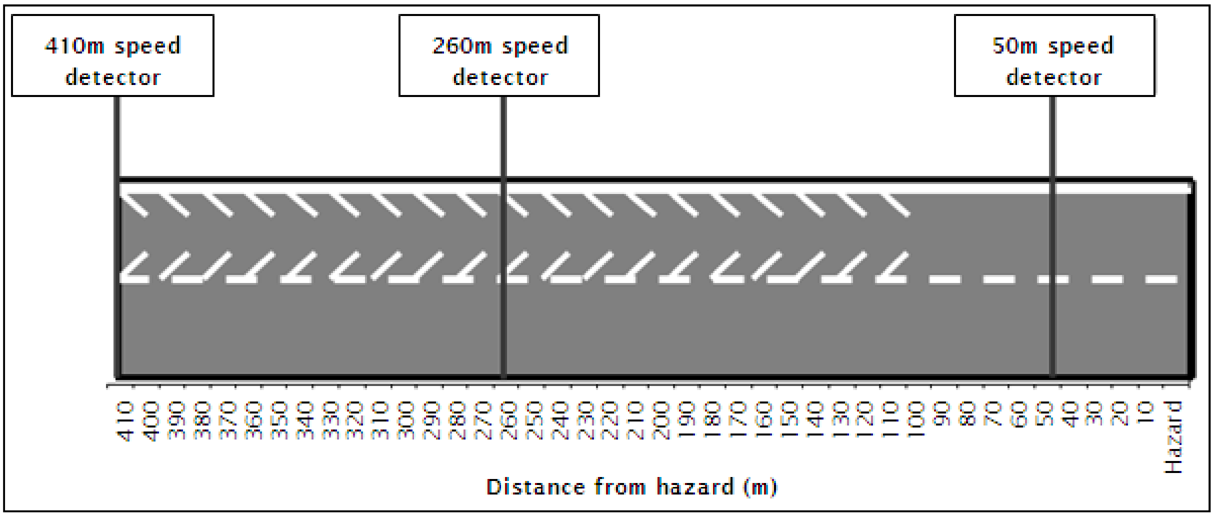
- **Assessment:** A before-and-after assessment of vehicle operating speeds travelling towards each trial site hazard using a four-second headway. Speeds assessed at three locations (410m, 260m and 50m prior to the hazard) within the hazard approach for seven continuous days two weeks prior to, two weeks after and six months after the installation of the marking treatment

Figure ES1 Visual concept of adopted layout and speed detector locations



Two transverse road marking trial sites were established in high-speed rural environments, where a reduction in speed is required to safely negotiate the following hazards:

1. the southbound approach to the Kimberley/Arapaepae Road intersection on State Highway 57 (SH 57) as shown in photo 1 below.

Photo 1: Trial Site 1: State Highway 57

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2. the eastbound approach to the Waihenga River Bridge on State Highway 53 (SH53) as shown in photo 2 below.

Photo 2: Trial Site 1: State Highway 53

Figure 1 and 2 illustrate the short and and long-term vehicle speed results, the detailed figures are include in Table ES1, Appendix A.

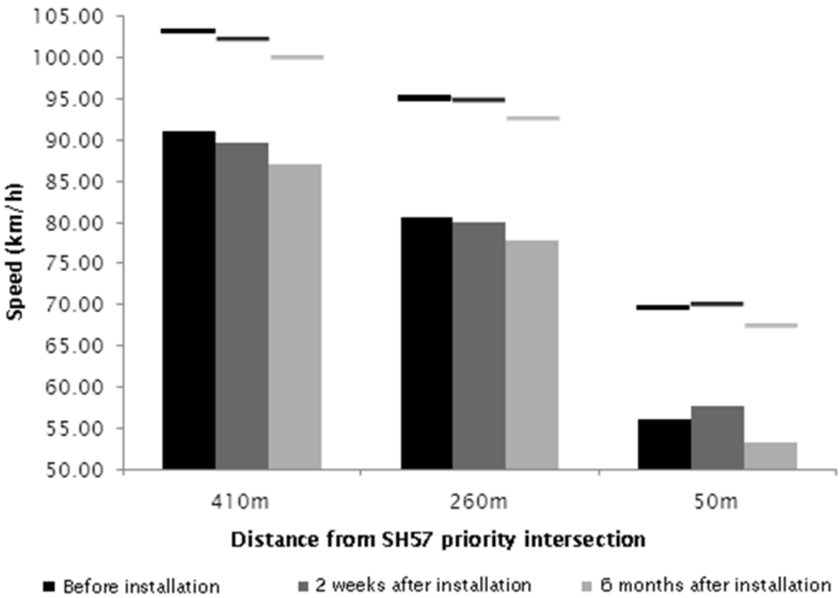

Figure ES2: Short and long term result for SH 57

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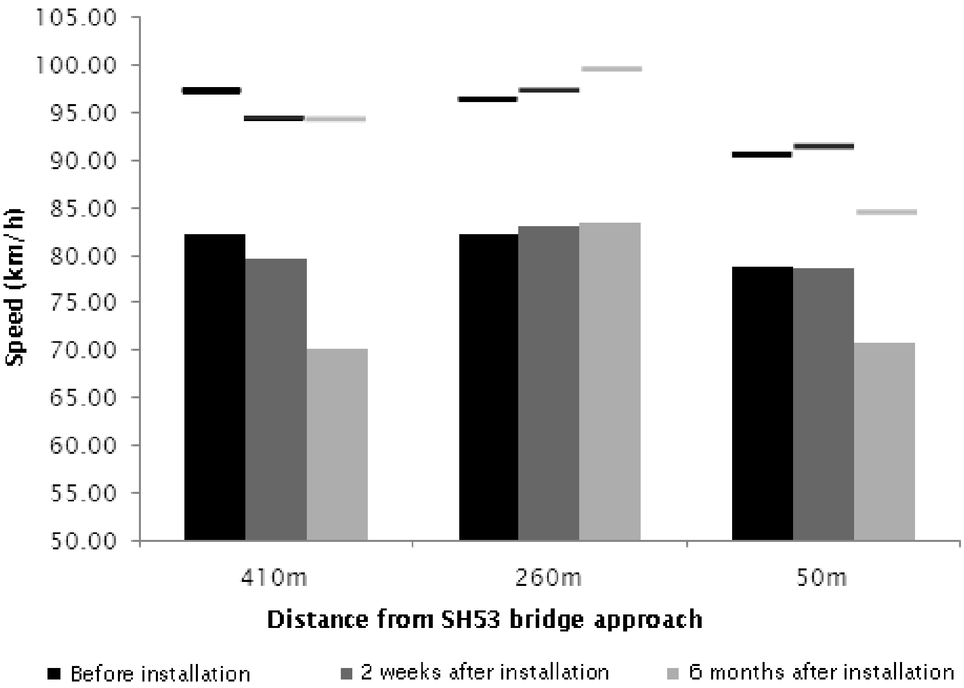

Figure ES3: Short and long term result for SH 53

The mean and 85th percentile speeds decreased at both treatment sites as vehicles approached either the bridge or intersection hazard. This occurred whether the transverse lines were installed or not. Regardless of the variation between the short- and long-term speed changes, **the main effects of the markings were 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. Excluding the long-term result found at SH57, vehicle speeds in the short- and long-term were at levels similar to those recorded pre-installation at the midpoint of both marking treatments. 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. Based on the long-term speed data, 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 varied 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.

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.

Consequently, it is recommended that further trials be conducted to allow for more accurate and empirical evidence to be collected. This will allow a standardised procedure for transverse road marking in New Zealand to be formalised. If these trials are undertaken, consideration should be given to methodological improvements, such as:

- a reduction of the treatment length,
- a reduction of the distance between the start and finish of the markings prior to the hazard.
- More visually pronounced lines may also increase the size of the speed reduction. This could be achieved by increasing the widths of the transverse bars to around 500mm and by increasing the spacing gap.

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' effect on safety through a reduced accident history will be a more telling statistic to judge their overall effectiveness by.

Appendix A

Table ES1 Overall speed 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 [1]

[1] The significance of the mean speed changes was assessed using a full-factorial univariate analysis of variance (ANOVA) with a 95% confidence interval.

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