LAND transport safety AUTHORITY

Treatment at Bends Using Chevrons

September 1996

Executive Summary

Loss of control crashes and head-on crashes are frequent crash types occurring at bends. Quite often, treatment for crashes occurring at bends includes installing chevrons, traffic signs, rrpms, edge marker posts, and guard rails.

There were 213 bends in total where recommendations were implemented. From these initially selected bends, the most common treatment implemented was installation of chevrons (103 bends). Data from the 103 bends was used for analysis, and those results are reported in this paper.

At 9 bends only chevrons were installed with no other actions being implemented. At 57 (55 %) of the 103 selected bends, installing traffic signs in addition to installing chevrons along with other actions was recommended. Installing rrpms was the next most common treatment (29 out of 103 bends (28 %), in combination with other actions). The combination of installing chevrons, traffic signs, and rrpms occurred at 15 (15 %) of the 103 bends.

Reduction in crashes was calculated for the 103 bends where chevrons were installed. Other works may have been implemented in addition to installing chevrons at those bends.

The selected bends were in both urban and open road speed limit areas. The data used for analysis are from the Land Transport Safety Authority Crash Investigation Monitoring System.

At bends where chevrons were installed (along with other works):

- crashes overall reduced **49 %**
  - daytime crashes reduced **38 %**
  - nighttime crashes reduced **67 %**

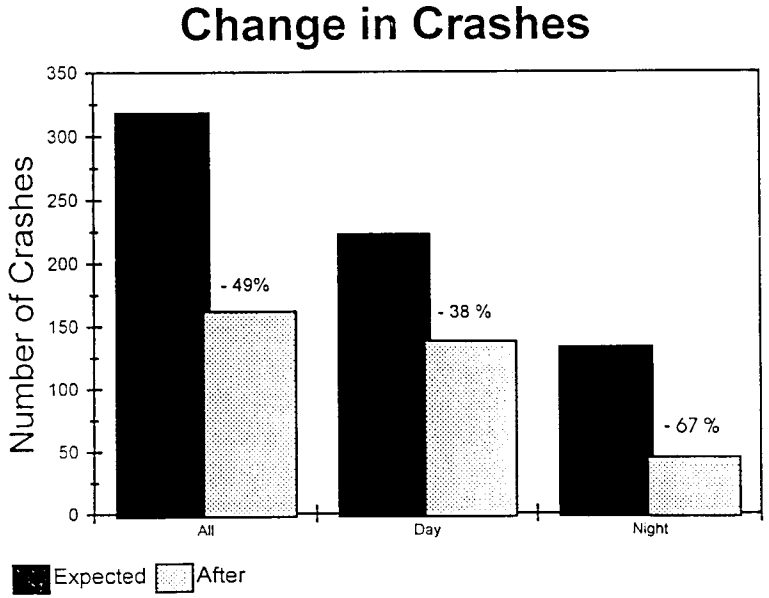
- fatal crashes reduced **70 %**
  - serious crashes reduced **70 %**
  - minor crashes reduced **32 %**

- loss of control crashes overall reduced **47 %**
  - on open roads reduced by **43 %**
  - in urban areas reduced by **62 %**

- head-on crashes overall reduced **75 %**
  - on open roads reduced by **76 %**
  - in urban areas reduced by **69%**

- At the 9 sites where only chevrons were installed, crashes overall reduced **70 %.**

Graph 1. Change in Crashes



Introduction

In 1985, the government approved a programme of systematic crash investigation. The Land Transport Safety Authority (formerly the Ministry of Transport, Land Transport Division) developed a Crash Investigation Monitoring System in 1989, which contains data on sites which have had works implemented as part of the joint crash investigation programme. The "after" data on this database is used to analyse the effects of specific "actions" or treatments at sites.

This paper looks specifically at the effect of installing chevrons at 103 bends, although other works may also have been implemented at the selected sites.

Site Selection

The criteria for selection were:

1. All works were implemented
2. Treatment includes installing chevrons

Using the above criteria, there were 103 bends in total. Eighty-three bends were on open roads and 20 of the bends were in urban areas.

"Open road" refers to speed limits greater than 70 km/h, while "urban" refers to speed limits less than or equal to 70 km/h.

The following table shows the split of bends by road controlling authority and speed limit category.

Table 1.

	No. Sites	Open Road	Urban
Local authority controlled	28	12	16
TNZ controlled	75	71	4
Total	103	83	20

Control Factor

Trends in crashes have been taken into account when calculating reductions at the monitored sites.

The "control" factor calculated for each site adjusts for urban or open road crash trends in the local authority (ie high, medium or low growth rate), depending on whether the site is urban or open road.

This factor is applied to the number of crashes before improvements were made ("before" data) to give the expected number of crashes if the improvements had no effect. Comparing this number with the actual crashes after improving the site ("after" data) gives the crash reduction.

Analysis

The overall crash change at each site was calculated as:

$$\text{Change} = -\frac{(\text{sum Expected} - \text{sum after}) \times 100}{\text{sum Expected}}$$

Multiplying by the ratio of after to before years adjusts for the difference in before and after time periods.

$$\text{Expected} = \text{before crashes} \times \text{control} \times \frac{\text{after yrs}}{\text{before yrs}}$$

After = after crashes

where

- *Expected* is the expected number of after crashes, assuming the treatment had no effect.
- *Before crashes* is the actual number of before crashes.
- *Control* is the factor calculated by crash rate and urban/rural/regional location.
- *After* is the actual number of after crashes which occurred.
- *Before years* is the number of years in the before period.
- *After years* is the number of years in the after period (after implementation).

Note that a negative "Change" is a reduction in crashes.

Table 2 summarises the reductions in crashes by speed limit, movement type, and crash type, at the selected bends.

Table 2. Overall Reductions at Sites

	Before	Expected After	After	Change	Confidence Interval
Overall (open road)	340	247.4	129	-49 %	-30 % to -68 %
Overall (urban)	98	69.9	32	-48 %	-25 % to -71 %
ALL	438	317.3	161	-54 %	-36 % to -73 %
Lost control (bend)	371	237.4	127	-47 %	
Head-on (bend)	56	40	10	-75 %	
Day	340	221.7	137	-38 %	
Night	189	132.0	44	-77 %	
Twilight	16	9.0	7	-22 %	
Fatal	33	26.7	8	-70 %	
Serious	156	119.8	36	-70 %	
Minor	249	170.8	117	-32 %	

The confidence interval is defined as

$$Y \pm t(1 - \alpha/2;\ n - 1)\ \sigma(Y)$$

where

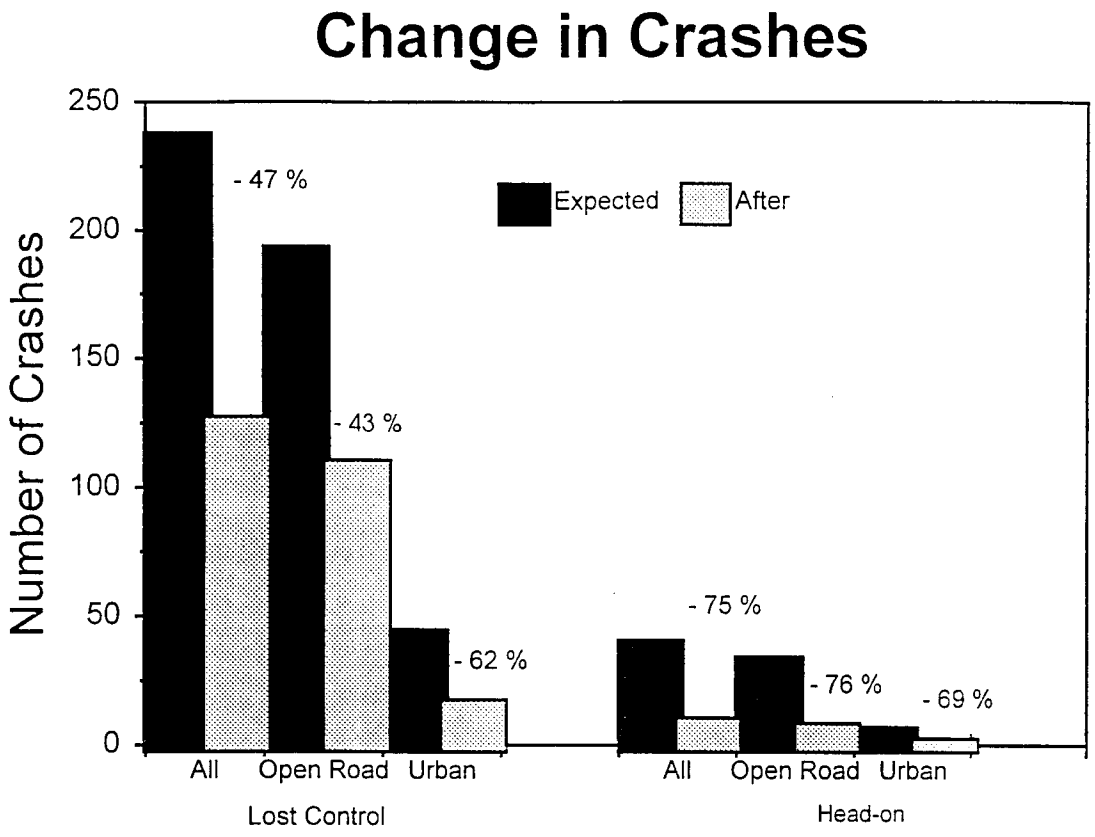
Y is the mean value of the reduction
$t(1 - \alpha/2;\ n - 1)$ is the t-value for the mean
where $\alpha = 5$ (a 95% confidence interval)
n is the number of sites, $(n - 1)$ is the degrees of freedom
and $\sigma(Y)$ is the standard deviation of the mean.

Table 3 shows the changes in crashes by OPEN ROAD and URBAN split, and crash type

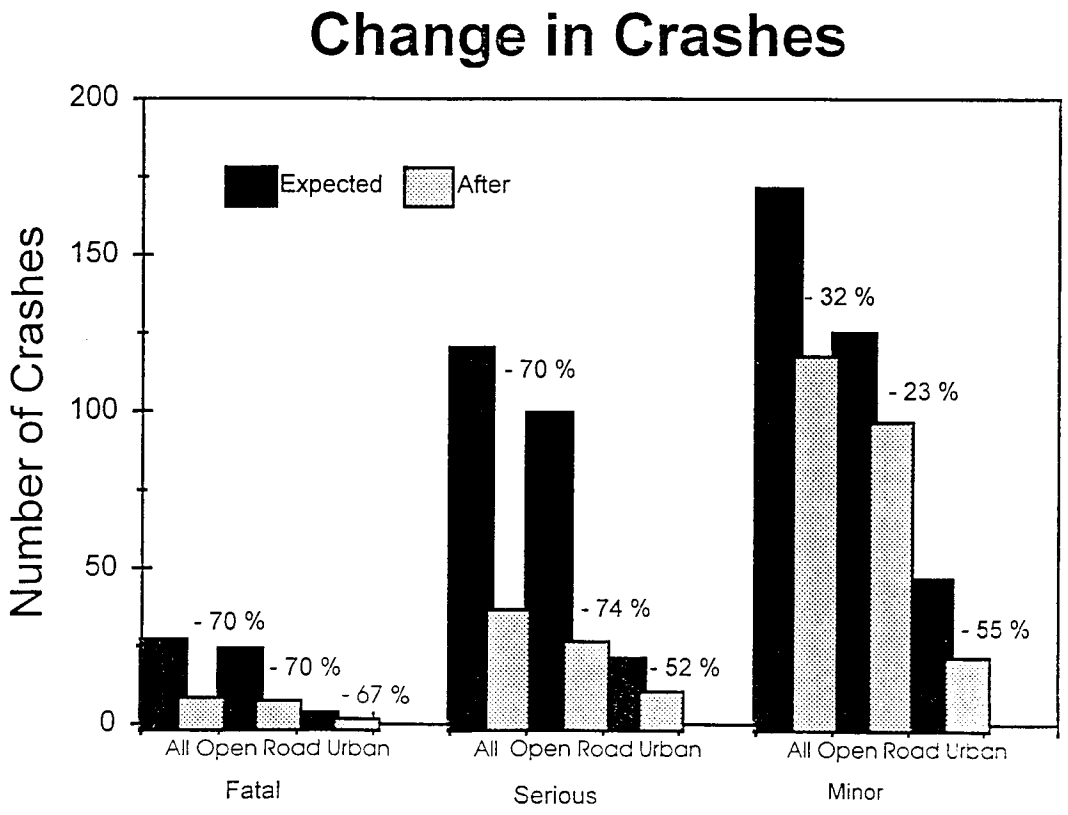
Table 3. Changes in crashes by Speed Limit

	OPEN ROAD bends (n=83)				URBAN bends (n=20)			
	Before	Expected After	After	Change	Before	Expected After	After	Change
ALL	340	247.4	129	-48 %	98	69.9	32	-54 %
Lost control (bend)	305	193.2	110	-43 %	66	44.2	17	-62 %
Head-on (bend)	44	33.6	8	-76 %	12	6.4	2	-69 %
Day	277	178.4	113	-37 %	63	43.3	24	-45 %
Night	146	105.1	35	-67 %	43	26.9	9	-66 %
Twilight	13	6.3	5	-21 %	3	2.7	2	-27 %
Fatal	28	23.7	7	-70 %	5	3.0	1	-67 %
Serious	127	99.1	26	-74 %	29	20.7	10	-52 %
Minor	185	124.6	96	-23 %	64	46.2	21	-55%

Graph 2. Change in Crashes by Crash Type



Graph 3. Change in Crashes by Crash Severity



Regression-to-Mean

Regression-to-Mean is a recognised phenomenon inherent in before and after studies. At present there is no definitive method for coping with this effect. Evidence suggests that as the number of years of data increases, the effects of regression-to-mean decrease.

The monitoring system uses five years of before data in calculations "before" improvement. For the sites where crashes at bends were treated by installing chevrons, an average of 3.1 years is used for "after" improvement calculations. Therefore, regression-to-mean is not considered to have a major effect on the results and no correction has been used.

The average before period at the bends was 5.3 years. The average after period was 3.1 years.

Other Works

There were other actions implemented at the selected bends. An average of 6 other actions were implemented at each of the bends.

The most common actions implemented at the bends were:
(List 1)

Install chevrons (103 bends)
Install traffic signs (57 bends)
Install rrpms (29 bends)
Move traffic signs (29 bends)
Upgrade edge marker posts (17 bends)
Install edge marker posts (11 bends)
Install guard rail (10 bends)
Re-align geometric alignment (9 bends)
Paint edgeline (9 bends)

Other works implemented at the bends were:
(List 2)

Reseal pavement (2 bends)
Install shoulder (5 bends)
Paint markings and delineation (2 bends)
Paint centreline (8 bends)
Paint continuity line (4 bends)
Remove trees/vegetation (6 bends)

The frequency of the combinations of the actions in List 1 is shown in table 4.

Table 4. Combinations of actions implemented at bends

INSTALL	No. Bends
Chevrons only	9
Chevrons and List 2	25
Chevrons and rrpms and List 2	8
Chevrons and traffic signs ony	11
Chevrons and traffic signs and List 2	18
Chevrons and edge marker posts and List 2	1
Chevrons and guard rails and List 2	3
Chevrons, rrpms, and traffic signs and List 2	15
Chrvons, rrpms, and edge marker posts and List 2	1
Chevrons, traffic signs, and edge marker posts and List 2	6
Chevrons, traffic signs, and guard rails and List 2	2
Chevrons, rrpms, traffic signs, edge marker posts and List 2	2
Chevrons, rrpms, traffics, guard rails, and List 2	1
Chevrons, rrpms, traffic signs, edge marker posts, guard rails, and List 2	1
Totol no. of bends	103

Note: reference to "List 2" in the above table indicates that any or all of the works in List 2 may have also been implemented at the site.

Conclusion

From the bends selected for analysis, installing of chevrons, along with traffic signs (curve warning signs and advisory speed signs) are common treatments.

These actions, as well as installing rrpms, edge marker posts, and guard rails could be expected to aid in the reduction of crashes at bends.