WHEN FLASHING IS GOOD

PEDESTRIAN CROSSING WARNING LIGHTS TRIAL

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ABSTRACT

We all have had problems or comments on the safety of mid block pedestrian crossings. We all strive to make the situation as safe as we can. But where do we go when we have done all the conventional improvements and we still have a problem?

The safe operation of a pedestrian crossing relies on a balanced relationship between the driver, pedestrian and environment. If this balance is out of order then safety can be compromised.

In a joint study between ACC and CCC, 3 pedestrian crossing sites were selected for the trial of in-ground flashing warning light systems.

The initial effectiveness of the warning lights in enhancing safety at each crossing and inducing positive changes in driver and pedestrian behaviour at the crossings has been quantified based on a before and after analysis.

Through feedback and analysis it has been shown that the warning light system is highly effective in heightening driver awareness when approaching a crossing, and has been the main contributing factor to the positive change in driver and pedestrian behaviour observed during this trial.

This paper looks at the effect prior to, and following the implementation of three trial sites for the use of in-ground flashing warning light systems

INTRODUCTION

In December 2005, the Christchurch and Auckland City Councils (CCC and ACC) submitted a proposal to the then Land Transport New Zealand to evaluate the effectiveness of in-ground flashing warning lights (the lights) on two pedestrian crossings in Christchurch Central Business District (CBD) and one in Royal Oak, Auckland. The proposals were documented in a report prepared by MWH New Zealand Limited (MWH) for CCC and ACC and were approved as 'Trials of Traffic Control Devices' by Land Transport New Zealand on 16 January 2006.

The purpose of the Trial is to evaluate in-ground flashing light warning systems activated by pedestrians about to enter a pedestrian crossing. In particular, the trial intention was to:

a. Determine the effectiveness in producing desirable driver and pedestrian behaviour that will improve safety of the crossing;

b. Identify operational and maintenance issues to assist in measuring reliability and cost effectiveness of these systems; and

c. Assist in the formulation of any standards, guidance or possible changes to the Land Transport Rules.

The 'Pedestrian Crossing Warning Lights Trial' (the Trial) commenced on 1 March 2006 and was completed on 28 February 2008. Reference New Zealand Gazette 19/1/2006, No. 5, p. 104.

The initial effectiveness of the warning lights in enhancing safety at each crossing and inducing positive changes in driver and pedestrian behaviour at the crossings has been quantified based on a before and after analysis.

The analysis undertaken allowed the study of the effectiveness of in-ground flashing light warning systems. Two of the three sites are located within the CBD in Christchurch and the other is located at a multi-lane site in the Auckland suburb of Royal Oak. The evaluation sought to determine the safety benefits for pedestrians and motorists by measuring key aspects such as:

- Changes in vehicle operating speeds in the vicinity of the crossings and drivers' ability to recognise when a pedestrian is crossing or is about to step onto the crossing;
- A reduction in pedestrian / vehicle conflicts on the crossings;
- A reduction in the proportion of drivers encroaching onto the crossing before yielding right of way to a pedestrian;
- A reduction in the proportion of pedestrians crossing the road not on but within 50m of the crossings;
- An increase in a sense of safety for users of the crossing during poor weather or light conditions.

SITES PROBLEMS / PRIOR WORK

Tuam Street Pedestrian Crossing

The Tuam Street pedestrian crossing in Christchurch is a mid-block crossing located outside the Civic Offices. The crossing was subject to a road safety audit carried out in June 2003 following a collision between a pedestrian on the crossing and a car in February of the same year. Refer to Figure 1 and Figure 2 for location and layout details.

Of note was the concern expressed by the public and Council staff at the operational safety of the Tuam Street pedestrian crossing location. The comprehensive results of the audit are available in the road safety audit report, but the main conclusions raised was that there were important safety concerns at this crossing, which needed addressing in the near future.

Figure 1: Tuam Street Pedestrian Crossing Location

'Before'

'After'

Figure 2: Tuam Street Pedestrian Crossing 'Before' and 'After'

The 'Before' figure shows the low pedestrian platform and vegetation obstructing sight lines. The 'After' figure shows the new raised platform, low planting and improved sight lines. The in-ground flashing studs are located along the road centreline and across the road near the limit line.

The safety audit recommended horizontal and vertical alignment changes to the roadway at the Tuam Street crossing. The pedestrian crossing was reconstructed to the new design road shape to enhance awareness and to improve drainage. In addition, changes to the kerbside parking with the relocation of the loading zone to the departure side of the crossing improved intervisibility between the driver and the pedestrian.

Hereford Street Pedestrian Crossing

Investigations at a second (uncontrolled) crossing point for pedestrians in Hereford Street near Westpac Lane in Christchurch highlighted the need to improve this facility.

An earlier study indicated that the crossing point should give priority to pedestrians. The warrant conditions for a 'Zebra' pedestrian crossing facility were met. The Council initiated a project to construct kerb build-outs and install a 'Zebra' pedestrian crossing on a raised platform at Westpac Lane early in 2006. This work was completed in early 2007. Refer to Figure 3 and Figure 4 below for location and layout details.

Figure 3: Hereford Street Pedestrian Crossing Location

'Before'

'After'

Figure 4: Hereford Street Pedestrian Crossing

The Hereford Street site was a new facility, and concern was raised during the consultation process as to the operational safety of a new mid-block pedestrian crossing in the CBD. Concerns expressed reflected the concerns raised at the current Tuam Street pedestrian crossing.

The implemented site improvements included the replacement of some kerbside parking with a kerb build out on each side of the road, bollards and chain to restrict pedestrian crossing movement away from the crossing point, improved lighting at the crossing and the installation of in-ground flashing warning lights.

The transformation of an existing road to a new facility allowed the opportunity to study behaviour before, post construction with no flashing studs and, lastly, with the flashing studs active. This allowed for an excellent comparison of effectiveness of the safety devices.

Mt Albert Road Pedestrian Crossing

The Mt Albert Road pedestrian crossing in Auckland is on a four lane major arterial section of roadway adjacent to a roundabout at Royal Oak that has five legs and pedestrian crossings on all approaches. The roundabout is adjacent to a block of shops and a small shopping mall. Refer to Figure 5 and Figure 6 below.

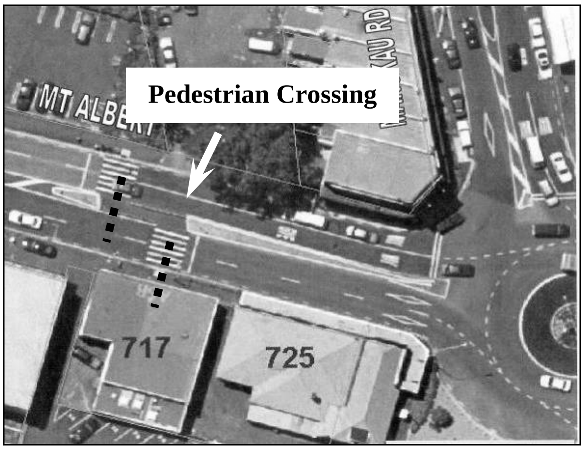


Figure 5: Mt Albert Road Pedestrian Crossing Location

'Before'

'After'

Figure 6: Mt Albert Road Pedestrian Crossing 'Before' and 'After'

The crossing used for the trial is on the departure leg of the roundabout on Mt Albert Road. It is located approximately 35m from the intersection and, due to the closeness of the corner building and a pedestrian safety railing, sight visibility to the pedestrian crossing is compromised for motorists exiting the roundabout. The complexity of the roundabout also diverts drivers' attention away from the pedestrian crossing. By the time drivers are aware of someone on the crossing they often have little time to react to the situation.

The other problem is the two-lane approach to the pedestrian crossing. A conflict is created when one driver stops and the driver of the vehicle in the other lane continues to pass the stopped vehicle unaware that the other driver has stopped for a pedestrian. Numerous near hits and vehicle / pedestrian conflicts were recorded for the Royal Oak pedestrian crossing.

LAYOUT & IMPLEMENTATION

Mid block pedestrian crossing locations have demonstrated considerable concern to users, with vehicles often failing to stop. This situation is further complicated in the Central Business District where roadside activity and pedestrian movement has complicated the driver's detection of pedestrians entering a pedestrian crossing point.

A large number of trials of various treatment types have been conducted over the years with varied success. These include the use of active and passive warnings, alternate road markings and signs. Many of the active measures suffered reliability issues with false activations of the warning systems, leading to a loss in confidence by all users.

These treatment systems have been implemented and monitored through the NZTA Crash Site Monitoring System. This project allowed the evaluation of developing technology to determine if there were alternative systems that yielded better results, and hence improved road safety.

Flashing Stud Configuration

Flashing studs have been utilised overseas for a short number of years with mixed success. The success of the systems has been limited due to the poor reliability of emerging technology, false activations leading to a loss of confidence and poor light output. Recent developments in technology through the use of photoelectric sensors, ultra-bright LED's and more robust in ground systems has allowed the development of a smarter, more efficient and accurate system.

The proposal incorporated the layout of the in-ground flashing light warning system in a 16-light configuration, as opposed to 26 lights utilised in Australia. An example configuration layout is shown in Figure 7 below.

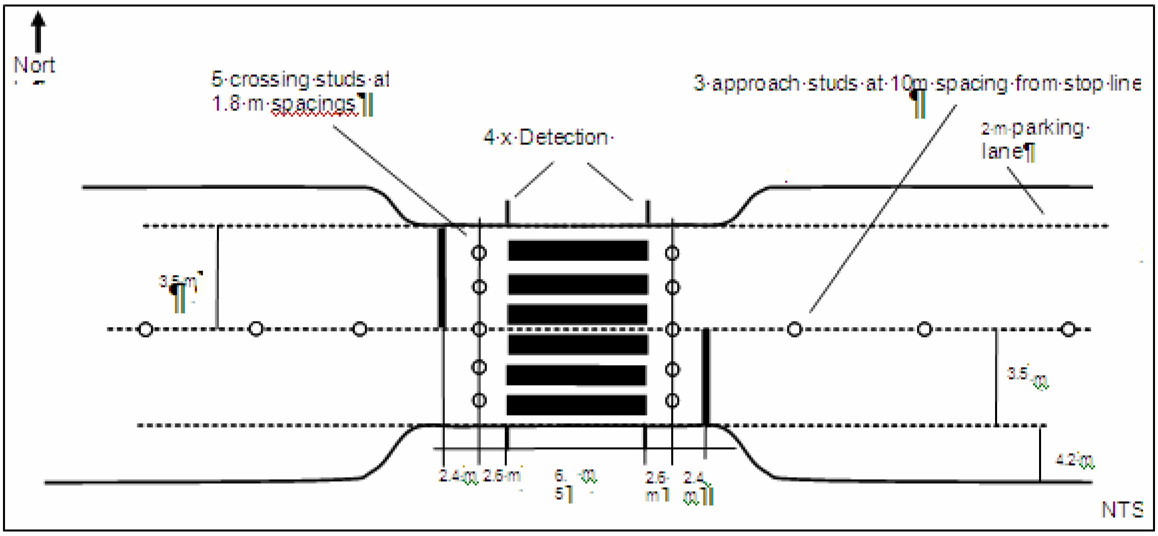


Figure 7: Typical Example – Flashing Stud Layout

The typical configuration comprised of kerb build-outs narrowing the road lane down to a nominal 3.5m in width. The sites adopt 10m to 15m spacing for the approach studs and 1.85m spacing for the crossing studs. The crossing studs are placed beyond the limit line some 2.5m back from the edge of the zebra crossing markings. The limit line is set some 5m form the edge of the zebra crossing markings.

For the Christchurch installations the detection units are mounted within pairs of guide rails on each pedestrian approach to the crossing. Each guide rail contains two motion sensors which enable the system to determine when a pedestrian is stepping on or off the crossing.

For Hereford Street, CCC installed inductive 'Smartstud' flashing warning light studs manufactured and marketed by Harding Electronic Systems Ltd.

The system used on Tuam Street was the Hard-Wired Flush (HWF) in-ground flashing warning light studs from Astucia and marketed by Highways Ltd.

For the Mt Albert configuration ACC installed the inductive 'Smartstud' flashing warning light studs manufactured and marketed by Harding Electronic Systems Ltd.

Power Supply

The flashing warning light systems require a power source but, given that all designs utilise LED technology, power consumption is very low. Whilst the Christchurch sites are connected to a mains power source they could have been powered alternatively by using solar panels and deep cell batteries, neither of which requires mains power.

In connecting to an existing mains power source there is uncertainty with regards to the condition of cables associated with this source. Cables in poor condition could require costly replacement. Therefore, to minimise the risk of unforeseen cable renewal costs the use of solar panels and deep cell batteries should be strongly considered to reduce the overall installation cost of providing power to the system.

System Activation

Historically, similar types of systems overseas have utilised pedestrian call button or pressure pad activated systems. Both of these systems relied on pedestrians initiating the in-ground flashing studs.

Each of these systems could initiate false-positive sequences when the pedestrian exited the system. This has led to drivers and pedestrians losing confidence in the installations and resorting to the usual behaviour of poor compliance to yield to pedestrians using the crossing point.

Unique to the Christchurch configuration was the utilisation of photoelectric detection technology that detected the direction of travel of a pedestrian. The system is activated when a photo-electric beam is broken as pedestrians step up to the crossing. The beam sensors are mounted on guide rails on approach to the crossing. This direction identification ensures positive detections only. A timer, based on crossing distance, de-activates the system.

Installation, Operation and Maintenance

Identifying operational and maintenance issues for each site was an important part of the trial. Reliability of the light activation systems, the lights, their effectiveness and costs are important if, at the end of the trial, a decision is made by NZTA to approve the use of in-ground flashing warning lights for pedestrian crossings.

Thought should also be given to the offset of the detectors in relation to the approaches to the crossing facility. On the north side of the Tuam street crossing the pedestrian approaches the crossing perpendicular to the crossing before turning onto the crossing. Thus the distance from the ground to the crossing is short and pedestrians cannot attain a ‘fast pace’ to cross the carriageway.

Contrary to this the desire line and approach angle to the Hereford street crossing is parallel with this crossing. Thus pedestrians approach this crossing at a greater ‘pace’ therefore the activation rails need to be set slightly further back to ensure activation when a pedestrian enters the crossing and not half way across before activation of the lights.

For the lights to be approved for use on roads in New Zealand, road controlling authorities would be seeking technical information on the new traffic control device, any constraints on use and ways in which the device can improve safety of pedestrian crossings.

It has been found during the trial that installation costs vary from between $18,000 to $26,000. The higher cost can be expected if connecting to an existing, dated mains power supply. In such circumstances dated wiring associated with the supply terminal may have to be updated.

Both the Harding Smart Stud system and the Astucia system to date have had minimal maintenance liabilities.

It was, however, noted that the second light in on each approach sustained damage and eventually required replacement. It was discovered this damage was due to front ‘skirts’ grinding the pavement as low riding vehicles negotiated the pedestrian platform. One recommendation from this trial is that the lights should be relocated to the limit line and not the foot of the platform ramp.

DATA COLLECTION

As with all robust analysis measuring the effectiveness of a system, it is essential to have a baseline to compare against. In this instance two sites had existing pedestrian crossing facilities, while one (Hereford Street) was a totally new installation.

‘Before’ and ‘After’ data sets were obtained through three key methods:

- Video footage,
- Vehicle speed surveys, and
- Questionnaire survey interviews.

A key measure of the effectiveness of the system is driver alertness and the change in number of driver violations reported.

The ‘Before’ trial data could not be collected until the upgrading of the existing pedestrian crossings in Tuam Street and Mt Albert Road had been completed. It was decided to conduct surveys at the Hereford Street site before the pedestrian crossing was installed (Before Survey) and to repeat the surveys once the crossing had been in operation (Intermediate Survey) and following a period long enough for new traffic patterns to develop, activating the system and allowing it to stabilise for the ‘After Survey’.

The ‘Before’ and ‘After’ programme for analysing the effectiveness of the lights proved to be ambitious in that the researchers were relying on video footage to obtain traffic flow and behaviour data as well as pedestrian / vehicle conflicts (driver violations).

The data gathering to ascertain the speed of vehicles approaching the crossings also proved to be difficult due to an inability to determine free speeds in CBD areas that are often congested and with speeds lower than 40km/h. These are discussed further in the following sections.

Video

Useful video footage was obtained for both ‘Before’ and ‘After’ the installation of the lights at the Tuam Street and the Mt Albert Road sites. Because of building works at the Hereford Street trial site, it was not possible to capture video footage at this site during the trial period. Follow up video is currently being considered.

It should also be noted that the ground level footage did not provide the expected clarity to determine where motorists brake in advance of the limit line. Speed data (where available) was therefore used to determine whether or not there was any change in the speed of approaching traffic.

Key issues identified when utilising video capture for the performance of the warning system included:

- The need to have a clear view of a pedestrian crossing event and the position of vehicles stopping in relation to a pedestrian and the stop line precluded a camera angle that captured the rear of approaching vehicles;
- There was considerable clutter around some of the trial sites including cycle stands, planters, parked vehicles, benches and pedestrian barriers, which made the positioning of the camera difficult;
- Traffic congestion also resulted in vehicles braking within a moving queue making it difficult to discern whether a driver had braked for a pedestrian on the crossing or braked to avoid a preceding vehicle;
- The Hereford Street trial site was undergoing some major building works in proximity to the crossing and this meant disruption to normal traffic flow and presented difficulties in locating a suitable camera position.

Speed

'Before' and 'After' vehicle speeds along Tuam Street, and Mt Albert Road were measured. NZTA were responsible for this task in accordance with the proposal. Hand held / vehicle mounted detection units were used to record 'After' vehicle speeds at the Tuam trial site whilst additional speed data was recorded from tube counts.

Due to the disruption created by the building works on Hereford Street, 'Intermediate' and 'After' speeds were not recorded at this site.

Questionnaire

Survey interview forms were distributed to members of the public. They were invited to complete questionnaires and return them to the CCC or ACC as appropriate. Two methods were used to distribute the 'Before' and 'After' surveys: hard copy and electronic questionnaires.

Hard copies were hand delivered in a face-to-face situation. This allowed an explanation to the recipient of the project. An electronic survey was also utilised to solicit further responses from users. The responders to the 'Before' survey are not necessarily those who took part in the 'After' survey. The survey was accessed via the Council's Internet website.

Visibility Aspects

Of note at all three sites was the aspect of a general east west orientation of the road alignment. In all locations there was a real issue with sun strike at certain periods of the day and year. During periods of low sun, it is typical for the driver to lower their sun visor and, if necessary, divert their eyes down towards the pavement to minimize glare. This is considered an unsafe orientation when one considers the view angle required to safely observe pedestrians utilising a pedestrian crossing point.

A point to consider was that of the apparent light intensity generated by each system in relation to the crossings environment. The Harding System found in Hereford street which is bounded by tall high sided buildings produced a very high quality visible light. The Astucia system found in Tuam Street, which is in shade to the north side but open to the south gives off a less intense light. Thus consideration to which light system is more appropriate given its location should also be considered.

The key component of the in-ground flashing lights was the active warning of the pedestrian crossing use through the flashing studs that raises the driver's alertness, similar to that experienced for school zones.

Of additional importance is the installation of a raised platform to assist with the definition of the crossing and assist with that awareness.

RESULTS

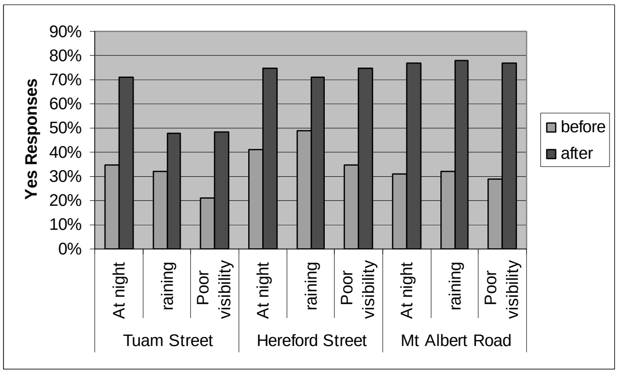
The changes in driver behaviour that the evaluation sought to measure are all functions of the effectiveness of the pedestrian warning lights to heighten the alert state of drivers when approaching the pedestrian crossings.

The warning lights were made operational in October 2006 in Christchurch and December 2006 in Auckland. The systems were operational for up to four months before monitoring commenced during a four month period thereafter. It is acknowledged that this time frame is short. Additional assessments should be undertaken after 2 plus years to ensure that the ongoing results are statistically valid.

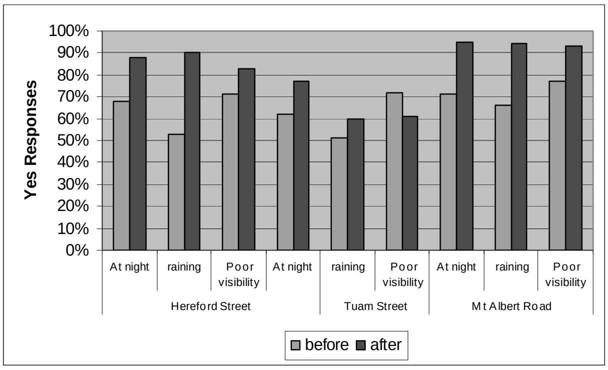
The validity of the trial was overseen by the then Land Transport New Zealand, with a final report being submitted to the then Land Transport New Zealand for consideration of formal approval for installation of pedestrian crossing in-ground warning lights under Traffic Control Devices 2004; Rule 54002 .

Performance Impacts

The installation and use of in-ground flashing warning lights has been assessed through site observations, questionnaires and measurements. From these methods, it has been shown that there has been a notable improvement in the safety of the pedestrian crossings. Examples of the change in performance presented in the final report are shown below.



PEDESTRIAN
Pedestrian perception of the crossing safety with and without active flashing lights.



DRIVER
Driver response to compliance to yield under specified conditions with and without flashing lights.

Figure 8: Pedestrian and Driver perception responses

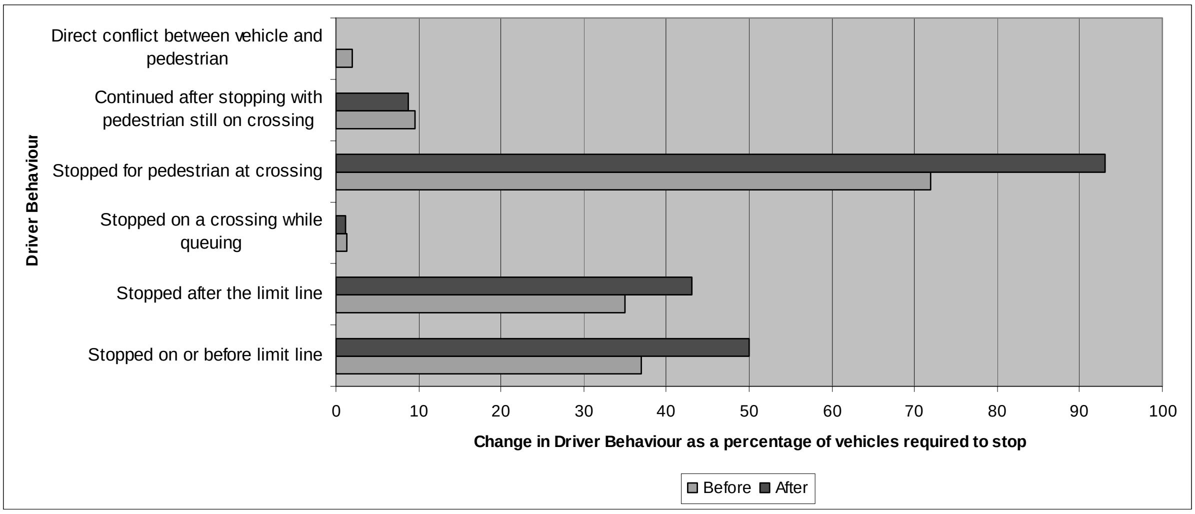


Figure 9: Change in Driver Behaviour Following Implementation of Warning Lights – Tuam Street

Key results from the trial include the following:

- There has been an ***increase*** (ranging from ***5% to 21%***) in the proportion of drivers stopping for pedestrians at the trial sites, thus reducing delay for pedestrians;
- There has been an ***increase*** (ranging from ***4% to 20%***) in drivers stopping on or before the limit line;
- The number of direct ***conflicts*** has ***reduced*** from 2% to virtually nil at each site;
- Positioning of the crossing studs before the limit line is more effective in increasing the proportion of drivers who stop at or before the limit line;
- The proportion of pedestrians choosing to cross at the crossing has either increased or remained unchanged. However, pedestrians choosing to run on some crossings has increased;
- Initial data highlights a mean and 85th percentile ***speed reduction*** occurring during critical times following the implementation of the warning lights;
- There is an increase in drivers who slow down or approach a crossing with caution;
- The majority of drivers agreed that the warning lights had assisted them in recognising when a pedestrian is at or on a crossing;
- Pedestrian participants at all sites have indicated that they feel safer using the crossings with the new warning lights in place;
- The largest shift from feeling unsafe to feeling safer relates to the multi-lane trial site in Auckland;
- No crashes have been reported at the trial sites since the warning lights were activated;
- Once set up to reflect individual site circumstances, the performance of the two systems (HWF and the Smartstud) are considered to be working well albeit that the HWF system, (being flush with the road surface) is less susceptible to damage from vehicle impact.

- The chosen detection methods are also considered to be working well, with the photoelectric detection system having the advantage of being able to identify and activate only when a pedestrian steps onto the crossing;

- No maintenance costs have been incurred since the systems were activated.

Maintenance Aspects

The holistic approach to these trials also provided valuable information in terms of maintenance requirements which affect Councils Operational Budgets. Both light systems did suffer from initial minor operational problems which yielded valuable information for the Asset and Maintenance Teams within Council.

One unfortunate area the trial did not cover related to powering these two systems. Cost variation took place on one system due to the location of the nearest power source to the crossing. In hindsight staff would have liked to investigate an alternate power supply like solar which could have reduced installation costs.

Results Outcomes

The results showed that this trial application of in-ground flashing lights at pedestrian crossings have produced positive trends at this early stage.

The validity of the trial was overseen by the then Land Transport New Zealand, with a final report being submitted to the then Land Transport New Zealand for consideration of formal approval for installation of pedestrian crossing in-ground warning lights under Traffic Control Devices 2004; Rule 54002 .

NZTA approval for the installation of Pedestrian Crossing in-ground warning lights under Traffic Control Devices 2004; Rule 54002 was given mid 2008.

CONCLUSIONS

On the basis of the aggregation of the positive responses to the questionnaire survey and the recorded change in driver behaviour, it is concluded that the warning light system is trending in the right direction in heightening driver awareness when approaching a crossing and hence has produced the expected safety benefits of reduced vehicle / pedestrian conflicts, and an improvement in the public's safety perception of the pedestrian crossings. This perception is also believed to be a function of a highly accurate activation instance, leading to confidence in the system.

The use of three different sites in three different situations, over two separate cities has added validity to the trial by the removal of bias in the results by location.

Additional questions to determine why pedestrians feel safer and whether drivers associated the warning lights with a pedestrian crossing could provide additional understanding of the effectiveness of the warning system.

Each of the trial sites were accompanied by physical improvements such as new lane markings, kerb build outs and raised platforms. This resulted in the most cost effective approach to providing improvements at the crossings.

These physical improvements have supported the operation of the warning lights but it is considered that it is the warning lights that are the main contributing factor to the positive change in driver behaviour observed during this trial.

It is recommended that follow up monitoring be undertaken at regular intervals to track the performance of the trial sites, and allow early intervention in any emerging issues.

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