Rectangular Rapid Flashing Beacons (RRFB) Pilot Project

Nominated for: The City of Calgary
Category: Road Safety Engineering Award
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ABSTRACT

Pedestrians are some of the most vulnerable road users of transportation systems. Accommodation of pedestrians at crosswalks in a safe and interactive manner has always been a great challenge to transportation professionals. In 2012, the City of Calgary decided to pilot Rectangular Rapid Flashing Beacons (RRFB) at 8 locations to evaluate motorists' yielding behavior to pedestrians. Reliability of the solar powered battery system in winter conditions and comparison of RRFB installation costs with the special crosswalk were also part of the pilot project. The results of before-after study were presented to The City of Calgary Council in 2013. Following the encouraging results, The City of Calgary has decided to expand the RRFB installation to 25 locations by 2015.

This project aimed to evaluate the effectiveness of RRFB in improving safety of pedestrians at crosswalks. Before-after studies indicated that the level of motorists' yield compliance to pedestrians increased significantly at pedestrian crossings from lower to mid 80% to over 95% in most cases. With the increase in motorists' yield compliance, it is expected that the risk of pedestrian related conflicts and collisions will decrease at these locations. Given the relatively low installation cost compared to overhead flashers (approximately 1/3rd) and yet very high yield compliance rate, this device could provide a cost-effective method to improve pedestrian safety at crosswalks (both intersections and mid-block locations).

The rapid flash pattern of RRFB appears to be very effective in getting driver's attention thereby increasing motorists' yield compliance to pedestrians at crosswalks. Versatile nature of this device with options to power by solar batteries or by connecting to permanent power grid provides a perfect opportunity to use this device in various climatic conditions, especially in Canadian context.

This pilot provided a platform for evaluating its effectiveness in terms of yield compliance and reliability of solar powered batteries in winter weather conditions. With the recent TAC approval of RRFB as a traffic control device, RRFBs are expected to be widely used across Canada once the warrant process has been established.

This submission provides further details of the Rectangular Rapid Flashing Beacons Pilot Project for the nomination in the Road Safety Engineering Award category.

INTRODUCTION

(All related figures are included in Appendix 1)

Calgary is one of the fastest growing cities in Canada with population over a million. With the diversity in population growth in recent years the City is facing enormous challenges to provide safe and credible pedestrian crossing facilities. Due to their vulnerability, pedestrians are more frequently injured or killed as compared to occupants of motor vehicles. In 2013, 348 injury and fatal collisions involving pedestrians occurred within the City of Calgary roads. During the same period, pedestrians were involved in 24% of fatal collisions and 13% of injury collisions while being involved in less than 1% of total collisions.

Transportation Association of Canada (TAC) has published a number of guidelines to improve pedestrian safety at crosswalks through the implementation of traffic control devices. However, there still exists a significant gap between a marked and signed crosswalk and a special crosswalk, in terms of structure and cost. After the interim approval of Rectangular Rapid Flashing Beacons (RRFB) by Federal Highway Administration (FHWA), a number of cities in the United States have started using RRFB as a pedestrian activated tool to reinforce signs and markings at pedestrian crossings to improve pedestrian safety. This device however, has not been commonly used in Canada because of the lack of Canadian Standards and implementation guidelines.

Despite the lack of Canadian guidelines, The Calgary City Council decided to undertake the RRFB Pilot Project in 2012 to assess motorist yielding behaviour and the performance of the solar power system. Funding in the amount of $200,000.00 for the RRFB Pilot Project was provided by the Mayor's Innovation Fund. The goal of the project was to test new and innovative technology in Calgary conditions. Products from different vendors were used for pilot to gather information on their performance, although the intent was not to specifically compare products and pick one for future use. This pilot project, however, did provide crucial information to the project undertaken by the TAC to get approval of RRFB as a traffic control device.

In alignment with the global initiative - Decade of Action for Road Safety 2011-2020, Transport Canada's Road Safety Strategy 2015, and Alberta's Traffic Safety Plan 2015, the City of Calgary's Safer Mobility Plan has the vision to provide safe mobility to all users of the transportation system. One of the 11 strategies of the Safer Mobility Plan is the 'Vulnerable Road Users Safety' which aims to achieve 12 percent reduction in vulnerable road user casualty collision rate per 100,000 population which is 51.2 per 100,000 population based on the 3 year rolling average of 2009 to 2011 (Figure 1). This pilot project aimed to contribute towards achieving the target set for the vulnerable road user safety strategy.

PHASE 1 INSTALLATIONS

1. SITE SELECTION

Eight locations were chosen as part of the Phase 1 installations of the RRFB in 2012 and 2013. The pilot occurred over a one-year period, beginning in May 2012. In the absence of proper warrant process for selection of RRFB installation locations, a number of criteria were considered to make sure that the selected locations represent various traffic levels, speed limits, geometric characteristics and geographic conditions. The traffic volumes at selected locations ranged from less than 5,000 vehicles/day to approximately 15,000 vehicles/day. Speed limit at these locations varied from 30 km/h to 60 km/h. The selected locations included 2 freeway interchange ramps, 2 multi-lane arterials with concrete median, 2 multi lane arterials with wide grassy median and 2 collectors within school zone. All the RRFBs were installed at locations with existing signed and marked crosswalks. These locations were identified based on the history of citizen complaints related to pedestrian safety issues.

2. SELECTION OF RRFB DEVICES

Products from four different vendors were used in the Phase 1 pilot. All of these installations were solar powered. Figure 2 to Figure 4 show various types of RRFB devices installed in Calgary. To continue the dialogue with suppliers regarding the emerging technologies and the performance of solar powered batteries, The City of Calgary conducted a number of vendors' forum following the Phase 1 installations.

EVALUATIONS

1. YIELD COMPLIANCE STUDY

The effectiveness of the RRFB was evaluated based on before-after yielding compliance study using staged crossings. Data were collected for each staged crossing when vehicles were present, during weekdays and sunny or overcast weather conditions. The staged crossings were conducted in a consistent manner as naturally as possible. A designated pedestrian approached the crosswalk and placed one foot in the crosswalk when the vehicle was beyond the threshold distance. If the driver made no attempt to stop, the pedestrian did not proceed to cross.

For each location the observer measured the following behaviours:

Yield compliance: The vehicle was recorded as yielding if vehicle stopped or slowed to allow pedestrian to cross. It was recorded as not yielding if it did not stop, but would have been able to do so safely. The ability to stop safely was determined based on stopping sight distance on the approach. For each crossing, all incompliant vehicles were noted as not yielding until the first yielding vehicle was noted.

Yield location: The yield distance categories used for the study were: less than 3 m, more than 3 m but less than 6 m, more than 6 m but less than 10 m, more than 10 m but less than 15 m, more than 15 m but less than 20 m, more than 20 m but less than 30 m, more than 30 m.

At each site, the data collection was conducted in one direction of travel, either due to one-way traffic or location on an uncontrolled leg of a two-way stop-controlled. 100 samples were collected during a day and split between the morning peak, lunch peak, and afternoon peak periods.

Results: Study results indicated that the devices improved the yielding behaviour in all cases to between 90% and 100% (Figure 5 – Figure 7). The majority of locations where the driver yielding behavior to pedestrians were already high (mid 70% to 90% in most cases), experienced a consistent increase to over 90% (up to 100% in some cases).

Yield distance graph (Figure 6) indicates that yielding within 10 m of the crosswalk increased by 18% after the installation of the RRFB devices. The highest increase from 20% to 33% occurred in the 3-6 m category. The increase in percentage of vehicles yielding within 10 m was evident in all single lane approaches. However, the same trend was not noticed in the multi-lane approaches. Based on the observations, the shift in yielding location was likely due to drivers making the decision to stop when in closer proximity of the crosswalk with the presence of an RRFB as compared to the baseline condition when the drivers at those situations would proceed without stopping. The increase in yielding within 10 m of the crosswalk with a single lane approach is not likely to pose significant safety concerns to pedestrians.

The stopping location is of most concern with the multi-lane approaches when the stopped vehicle blocks the sight lines between a pedestrian and a vehicle in the adjacent lane. However, yielding within 10 m of the crosswalk decreased in the after period along multi-lane approaches which further improves the safety of pedestrians.

A follow up yield compliance study conducted in June 2014 to examine the effectiveness of these devices after a year in operation revealed that the RRFB continues to be highly effective in increased ‘yield to pedestrian’ compliance levels by motorists.

2. CONFLICT ANALYSIS

Unsafe behaviors that constitute conflicts with the pedestrians were recorded. Common types of conflicts noted were:

- Attempts to pass a stopped/yielding vehicle,
- Hard braking behind a stopped/yielding vehicle,
- Vehicle/pedestrian conflicts involving evasive action taken by a driver or pedestrian, and
- Pedestrian trapped at centerline/median

There was one incidence of a vehicle attempting to pass a stopped/yielding vehicle during the before period and none observed during the after period. However, there were several incidences of hard braking behind a stopped/yielding vehicle at three locations:

- At Glenmore Trail and 18 Street ramp two vehicles engaged in hard braking during the before period and four vehicles during the after period.
- At Crowchild Trail and Shaganappi Trail ramp two vehicles engaged in hard braking during the before period and two vehicles during the after period.
- At Sun Valley Blvd and Sun Harbour Road three vehicles engaged in hard braking during the before period and none during the after period.

However, these results were not statistically significant as the number of occurrences was too low for statistical analysis. There were no incidences of conflicts involving evasive action taken by a driver or pedestrian or pedestrians trapped at centerline/median during that data collection.

3. COLLISION ANALYSIS

Before-after collision analysis was not feasible as part of the pilot project reporting in 2013 because of the unavailability of two years of before-after collision data. As the pilot project was completed in 2012-2013, two years of before collision data (2010-2011) and two years of after collision data (2014-2015) will be used to perform the collision analysis when required collision data are available.

As part of the before-after analysis, collisions involving pedestrians will be compared before and after RRFB installations. The change in collision numbers at the study locations will be compared to a test site with similar characteristics to remove the bias. To account for the other conflicts such as hard braking, before-after comparison of rear end collisions will also be conducted.

4. FUNCTIONALITY/TECHNICAL ASPECTS

All RRFB installed as part of the Phase 1 pilot used solar power. An important component of this pilot project was to assess the functionality of the solar power systems in Calgary's winter weather. The RRFBs were tested at each location after a period of cold weather (below -20 degrees Celsius). Testing was conducted during daytime and included activating the flasher for 20 cycles. A video of the flashing beacon was taken before and after the 20 flasher activations to assess any visual degradation in intensity and flashing time measurements. The functionality tests did not reveal any major concerns.

Maintenance and functionality of each installation were monitored. Regular monthly maintenance schedules were performed throughout the winter months and additional trouble calls were documented. Figure 8 provides a summary of common issues and repairs completed during regular monthly maintenance as well as incidents reported by the citizens.

Reliability of solar power was one of the major concerns. The importance of reliable power source to maintain pedestrian safety is critical at all times. Although the manufacturers proposed innovative solutions to improve the reliability of solar batteries, The City of Calgary has decided to continue investigations with the following alternatives.

Connecting to Permanent AC Power:
This option eliminates the need for battery maintenance which historically has been the most significant negative aspect to solar power devices. Batteries require regular monthly maintenance and have a relatively short life cycle. The approximate cost to provide power to the existing and future units would be $10,000 – $25,000, variable depending on location.

Connecting to Streetlight Power:
This option uses streetlight power to supplement the solar power used to recharge batteries. As streetlights are only powered at night, this recharging will occur overnight. There are challenges with connecting to streetlight power, including conforming to the Canadian Electrical Code and existing capacity constraints. Further investigation will be conducted to determine the feasibility of connecting to streetlight power. This solution may only be feasible at specific locations.

Retrofitting with Automatic Alarms:
This option involves installing a device that triggers delivery of an email to the maintenance team if an RRFB's battery voltage is low. This device would decrease maintenance response times and would increase the device reliability by ensuring shorter and fewer disruptions to their function. There would be an added costs associated with device installation as well as possible increases in maintenance costs. However, the maintenance costs would reflect actual needs as opposed to needs determined from complaints or monthly checks.

5. COSTS COMPARISON

Typical cost of a complete system with two sides (no median island RRFB) including poles and installation:

Solar: $15,000 - $20,000

AC system: $25,000 – $40,000

Hybrid system: $25,000 - $40,000 (i.e. wireless communication across the street with AC power or AC backup, but will provide similar reliability to an AC system for power and the versatility of a solar system).

In comparison, a typical special crosswalk (based on City of Calgary estimates) with a continuous power supply is $85,000. This indicates that RRFB could provide a cost effective alternative to the traditional special crosswalk.

PHASE 2 INSTALLATIONS

After presenting the Phase 1 report to the City Council in 2013, City of Calgary decided to extend the pilot to total 25 locations by 2015. The positive results from Phase 1 study also garnered attention and support from the City Councillors and concerned citizens. A few installations have already been completed as part of the Phase 2. Figure 9 shows a new installation at Bowness Road NW.

One of the main differences of the new RRFB installations compared to the Phase 1 is the placement of the flashing beacons. Initially, the beacons were installed below the Pedestrian Crosswalk Sign (RA-4). However, the new installations have the flashing beacon above the sign.

As solar power continues to be the dominating source for powering the RRFB batteries, the City of Calgary has decided to connect RRFBs to permanent AC power at four locations in 2015. Monitoring and evaluation of the performance of this device will continue for years to come.

FURTHER RESEARCH

City of Calgary plans to continue research on the performance of the RRFB in coming years to ensure the reliability of this device in terms of operational and technical performance. Discussions are underway with the University of Calgary to involve the graduate and post graduate students in a more scientific research.

The main goal of using this device is to reduce pedestrian vehicle conflicts and hence provide safer road crossing opportunities for the vulnerable road users. A before-after collision analysis will be conducted after 2015 collision data is available; which will provide critical information on the effectiveness of this device in reducing the frequency or severity of collisions.
In addition, The City of Calgary has initiated before-after yield compliance study for a few special crosswalks. These results can be compared with the results from the RRFB yield compliance study to get an idea of the relative performance of these two types of traffic control devices.

CLOSING REMARKS

Although a variety of traffic control devices are being used in Canada to improve safety of pedestrians at crosswalks, the Rectangular Rapid Flashing Beacons seem to be a very promising measure to address safety concerns at a very reasonable cost. The rapid flash pattern of this innovative device is able to better attract drivers' attention, thereby increasing the yield compliance by the motorists.

Despite the popularity of the RRFB in the United States especially after FHWA provided interim approval for the use of this device, Canadian cities have not yet embraced the use of RRFB as traffic control device. This is likely due to the lack of uniform application guidelines and warrant procedures that are yet to be developed.

Striving for innovation, continuous improvement and finding cost effective alternatives, The City of Calgary undertook the investigation on the performance of the RRFB in terms of effectiveness (operational and technical) through this pilot project. With the encouraging yield performance results, The City of Calgary has decided to further extend the pilot. The Phase 1 pilot provided an opportunity to test the device in the Canadian context and garnered a lot of critical information that provided a platform for the study led by TAC in 2014. As a result, the RRFB is now a TAC approved traffic control device.

With the recent TAC approval of the RRFB as a traffic control device, it is expected that once the warrant procedure is developed, Canadian cities will start using this device where appropriate. Given the similarity of winter weather in Canadian jurisdictions, results of this pilot study are expected to be directly transferable to other jurisdictions throughout Canada.

Appendix 1: Photos related to RRFB Pilot Project

Figure 1: Calgary Safer Mobility Plan – Vulnerable Road User Casualty Collision Reduction Target

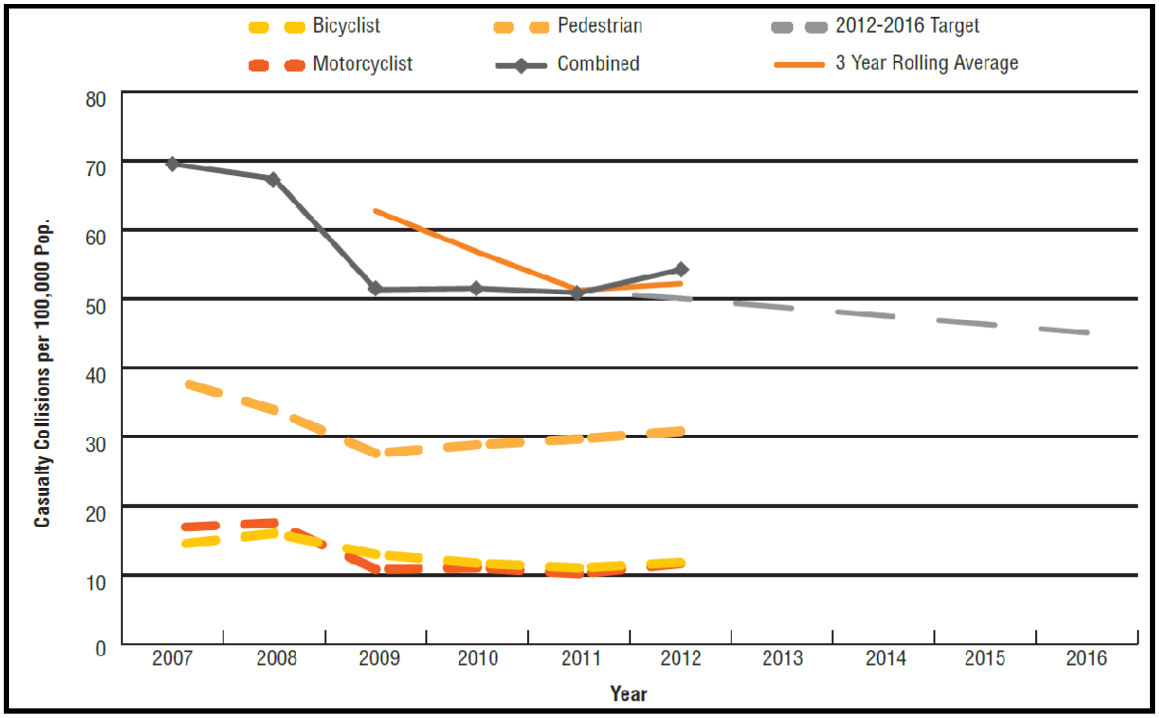

Figure 2: RRFB installed at Glenmore Tr/18 St SE ramp

Figure 3: RRFB installed at Douglasdale Bv/Douglasridge Cl SE

Figure 4: Various types of RRFB devices used in Calgary

Figure 5: Phase 1 RRFB Installation Locations and Yield Compliance Results

#	Location	Facility Type	Traffic Volume	Lanes	Speed (km/h)	Median	Yielding Percentage Before	Yielding Percentage After	Yielding Percentage Follow up
1	Glenmore Trail/18 Street SE	Interchange Loop Ramp	10,208	1	50	-	81	100	95
2	Crowchild Trail/Shaganappi Trail NW	Interchange Channelized Right Turn Ramp	4,776	1	60	-	77	90	85
3	Sun Valley Boulevard/Sun Harbour Road SE	Multi-lane Arterial near a recreation area	8,098	5	60	Concrete	87	98	100
4	18 Street/Riverview Close/Riverwood Circle SE	Multi-lane Arterial	14,565	5	50	Concrete	74	100	95
5	Radcliffe Drive/100 Radcliffe Place SE	Collector within School Zone	7,479	2	30	-	84	99	100
6	Douglasdale Boulevard/Douglas Ridge Close SE	Collector within School Zone	6,051	2	30	Boulevard	94	99	100
7	Harvest Hills Boulevard/harvest Oak Drive NB	Multi-lane Arterial	11,306	2 1-way	50	Grassy	87	98	95
8	Harvest Hills Boulevard/harvest Oak Drive SB	Multi-lane Arterial	8,999	2 1-way	50	Grassy	83	96	93

Figure 6: Yield distance

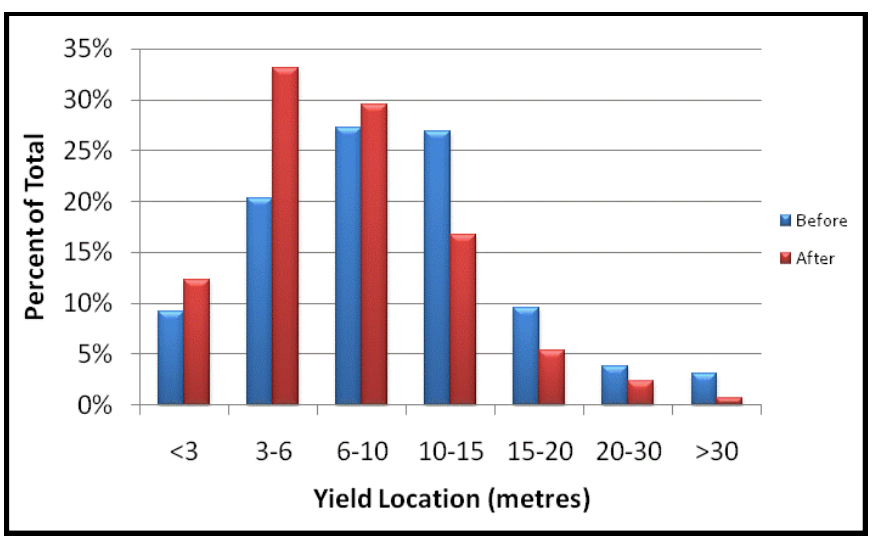

Figure 7: Graphs indicating Yield compliance percentage by motorists

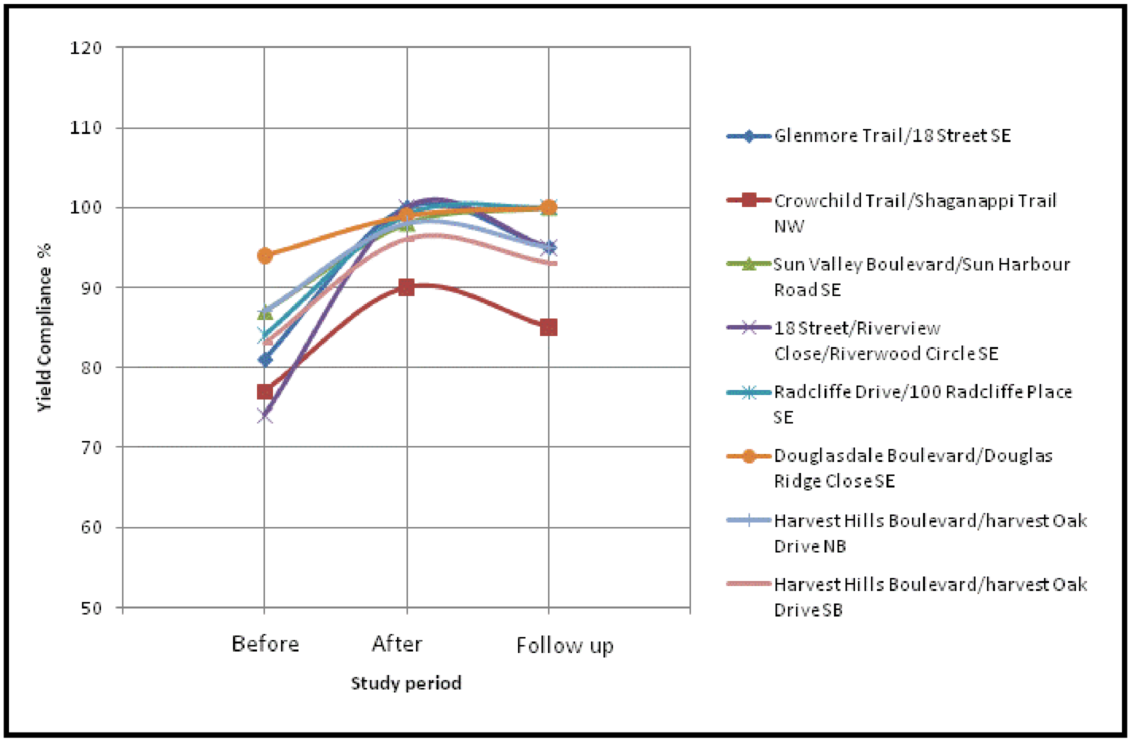

Figure 8: Common issues encountered during winter months

#	Type of issue/actions taken
1	Not functioning - Snow covered solar panels
2	Unit not working/water in heads/had to seal heads
3	Unit not working/removed snow /now charging
4	Main fuse board blown and new fuse board blown
5	Not functioning - Water in apparatus
6	Snow covered solar panels/ push button not working
7	Median pole strobe not functioning
8	Snow covered solar panels/removed snow /now charging
9	Flashers stuck on
10	Pole cover missing
11	Replaced circuit board
12	Not functioning/ trouble shooting with manufacturer

Figure 9: New RRFB installation on Bowness Rd NW as part of Phase 2 Pilot). Please note - The flashers are placed above the sign as opposed to below the sign in previous installations)