TECHBRIEF

Pedestrian and Bicycle Safety

Effects of Yellow Rectangular Rapid-Flashing Beacons on Yielding at Multilane Uncontrolled Crosswalks

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This document is a technical summary of the Federal Highway Administration report, *Effects of Yellow Rectangular Rapid-Flashing Beacons on Yielding at Multilane Uncontrolled Crosswalks* (FHWA-HRT-10-043).

Objective

This study examined the effects of side-mounted yellow light-emitting diode (LED) rectangular rapid-flashing beacons (RRFBs) at uncontrolled marked crosswalks in a series of experiments. Many methods have been examined to increase driver yielding behavior to pedestrians at multilane crosswalks at uncontrolled sites with relatively high average daily traffic (ADT). Only treatments that employ a red phase have consistently produced sustained high levels of yielding in previous studies.(1) A series of five experiments examined the efficacy of RRFBs to increase driver yielding behavior. These studies examined the effects of RRFBs at 22 sites in 3 cities in the United States (St. Petersburg, FL; Washington, DC; and Mundelein, IL). Data were also collected over a 2-year follow-up period at 18 of these sites to determine the long-term effects of the RRFB treatments. Another objective of the study was to compare the RRFB with a traditional overhead yellow flashing beacon and a side-mounted traditional yellow flashing beacon. A final objective of the study was to attempt to identify ways to further increase the effectiveness of the treatment. Variants subjected to evaluation included mounting additional units on a median or pedestrian refuge island and aiming the RRFB system to maximize brightness at a target site.

Introduction

Drivers generally fail to yield right-of-way to pedestrians in marked crosswalks at uncontrolled sites. From the beginning of 2004 to the end of 2006, there were a total of 14,351 pedestrian fatalities and 212,786 pedestrian injuries resulting from pedestrian-vehicle accidents nationwide.(2) Decreasing the occurrence of these crashes would increase the safety and overall walking experience for pedestrians. One alternative to in-roadway signs and yellow flashing beacons is to add yellow LED RRFBs to pedestrian warning signs, which are similar in operation to emergency flashers on police vehicles. Figure 1 shows an example of an RRFB mounted below a W11-2 pedestrian warning sign at a crosswalk. This system is solar powered and is linked to the unit on the other side of the street by radio frequency transmitters and receivers. Each LED flasher is 6 inches wide and 2.5 inches high and placed 9 inches apart. In addition, each unit is dual indicated, with LEDs on the front and

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Figure 1. RRFB with two forward-facing LED flashers and a side-mounted LED flasher.

back. Each side of the LED flasher illuminates in a wig-wag sequence (left and then right). The left LED flashes two times in a slow volley each time it is energized (124 ms on and 76 ms off per flash). This is followed by the right LED, which flashes four times in a rapid volley when energized (25 ms on and 25 ms off per flash) and then has a longer flash for 200 ms. The effect has been described as a "stutter flash effect."[3] Advance yield markings were installed before all installations during the baseline measurement phase to reduce the risk of multiple threat crashes.

Methodology

The general methodology followed for all of the experiments included measuring driver yielding behavior and vehicle/pedestrian evasive conflicts. Observers scored the percentage of drivers yielding and not yielding to pedestrians. Drivers were scored as yielding if they stopped or slowed and allowed the pedestrian to cross. Conversely, drivers were scored as not yielding if they passed in front of the pedestrian but would have been able to stop when the pedestrian arrived at the crosswalk.

The Institute of Transportation Engineers signal formula applied to calculate the duration of the yellow signal phase was used to determine whether a driver could stop safely.[4] A landmark associated with this distance was identified for each approach to the crosswalk. Drivers who passed this landmark before the pedestrian started to cross could be scored as yielding to pedestrians but not as failing to yield because they might not have sufficient distance to stop safely. Drivers beyond the landmark when the pedestrian entered the crosswalk could be scored as yielding or not yielding because they had sufficient distance to stop safely. When the pedestrian first started to cross, only drivers in the first half of the roadway were scored for yielding. Once the pedestrian approached the painted median, the yielding behaviors of drivers in the remaining two lanes were scored. This procedure was followed because it conformed to the obligation of drivers specified in the statutes of each of the three cities that were studied.

Results

Geographic Sustainability

Yielding during the baseline period before the introduction of the RRFB ranged between zero and 26 percent. The introduction of the RRFB was associated with yielding that ranged between 72 and 96 percent at the 2-year follow-up. Table 1 shows the percentage yielding at each of the 22 sites.

The general statistical methodology used in this study and presented in table 2 was based on the general time-series intervention regression modeling approach described in Huitema and McKean and McKnight et al. (See references 5–8.)

The five main parameter estimates are shown in table 2. There is an immediate and large level change from the baseline to day 7, a small but statistically significant additional increase from day 7 to day 30, a minor and not statistically significant level decrease at day 60, and a general trend after day 60 that has little slope across the remaining observation days. Therefore, the evidence for change is overwhelming and is maintained for the duration of the study. In the table, there are 166 degrees of freedom for all tests.

Two-Beacon Versus Four-Beacon Systems

This experiment evaluated the effectiveness of the installation of only two RRFBs (one for each direction of approach mounted at the right-hand side of the approach) compared to the installation of four RRFBs (two per approach with one on the roadway median and one on the right-hand side). The average yielding during baseline conditions across four sites was 18.2 percent. Installation and activation of the two RRFB systems increased the average yielding to 81.2 percent. The addition of the median beacons produced a further increase in yielding to 87.8 percent. Yielding for the four-beacon system continued to improve over time during follow-up data collection.

Site	Baseline (Percent)	Day (Percent) 7	30	60	90	180	270	365	730
Florida									
31st Street south of 54th Avenue S	0	54	76	N/A	59	N/A	91	75	83
4th Street at 18th Avenue S	0	63	72	N/A	69	N/A	69	80	80
22d Avenue N and 7th Street	0	97	96	91	93	92	91	98	96
9th Avenue N and 26th Street	0	80	82	85	95	81	88	77	78
22d Avenue N and 5th Street	8	87	89	92	92	87	96	92	95
Martin Luther King Street and 15th Ave S	1	86	84	85	82	N/A	89	88	88
Martin Luther King Street and 17th Ave N	0	96	94	80	82	83	88	82	83
1st Avenue N and 13th Street	2	85	87	75	78	N/A	91	88	N/A
9th Avenue N and 25th Street	0	86	90	83	90	N/A	88	81	79
1st Street and 37th Avenue N	0	79	87	85	87	N/A	90	97	95
58th Street and 3d Avenue N	0	85	84	85	85	79	92	82	88
Central Avenue and 61st Street	0	94	95	77	73	72	79	67	72
1st Avenue S and 61st Street	5	68	72	73	75	72	90	72	78
1st Avenue N and 61st Street	0	75	75	68	82	42	76	79	83
83d Avenue N and Macoma Drive	0	86	93	91	73	88	84	80	90
9th Avenue N and 45th Street	0	54	91	89	90	80	83	77	78
22d Avenue S west of 23d Street	0	89	86	78	77	60	75	81	82
62d Avenue S and 21st Street	0	77	76	77	53	78	81	84	80
9th Avenue N and 31st Street	16	93	95	89	88	82	82	89	N/A
Average	2	81	86	82	80	76	86	83	84
Illinois									
Midlothian Road and Kilarny Pass Road	7	62	62	N/A	N/A	N/A	N/A	N/A	N/A
Hawley Street and Atwater Drive	19	71	68	N/A	N/A	N/A	N/A	N/A	N/A
Average	13	67	65	N/A	N/A	N/A	N/A	N/A	N/A
Washington, DC									
Brentwood Road and 13th Street	26	62	74	N/A	N/A	80	N/A	N/A	N/A
Average Yield (All Sites)	4	78	82	83	80	77	85	83	84

Table 1. Baseline and follow-up yielding data at sites in Florida, Illinois, and Washington, DC.

N/A indicates that the measure was missed or has not yet been scheduled.

Table 2. Florida data estimates of treatment effect parameters and associated *t*-ratios and *p*-values.

Treatment Effect Parameter	Estimate Parameter	*t*-Ratio	*p*-Value
Baseline level	1.79		
Level change day 7	77.25	29.22	0.001
Level change day 30	6.03	2.38	0.02
Level change day 60	–4.26	–1.75	0.08
Follow-up slope	0.0059	1.62	0.11

Note: Certain cells were left blank because only *t*-ratios and *p*-values that show change from the baseline were included.

Aimed Versus Unaimed Beacons

This experiment evaluated the effectiveness of RRFBs with LEDs aimed parallel to the approach roadway compared to RRFBs with LEDs specifically aimed toward the eyes of approaching drivers at a given distance in advance of the crossing using a system that allowed the engineer to aim the LEDs. The percentage of drivers yielding to pedestrians during the baseline condition was zero percent. The average yielding compliance 7 days after RRFB installation increased to 33.4 percent. There was an additional increase to 72 percent 30 days after installation. The change from parallel LEDs to the LEDs that could be aimed produced an increased average of 89 percent.

Night Versus Day Operations

Night data were collected at one site where data had been collected during the daytime. During daytime collection, the site had a baseline average of 18.3 percent. The initiation of the two- and four-RRFB systems increased yielding to 86.7 and 89.6 percent, respectively. When the site was evaluated during nighttime hours, baseline yielding was only 4.8 percent. Introduction of the two- and four-RRFB systems showed increases in yielding to 84.6 and 99.5 percent, respectively.

Standard Beacons Versus RRFBs

Two sites were selected for this experiment. The first site had an above roadway standard yellow flashing beacon, while the second site was equipped with a side-mounted standard yellow flashing beacon attached to the pedestrian warning sign. The average baseline yielding when the standard beacons were not activated was 12 percent for the above roadway beacon and zero percent for the side-mounted beacon.

The activation of the overhead standard beacon produced an average yielding compliance of 15.5 percent. The introduction of a two-beacon RRFB system at this site produced an increase in yielding to 78.3 percent. The introduction of the four-beacon RRFB system was associated with 88 percent yielding compliance. At the second site, activating the side-mounted standard beacon produced 12 percent yielding compliance. The two-beacon rectangular rapid-flashing system produced 72 percent yielding compliance. A four-beacon RRFB system was not available for this second site.

Conclusion

The results show that the rectangular LED yellow RRFBs appear to be an effective tool for producing large numbers of drivers yielding right-of-way to pedestrians in crosswalks at sites where drivers rarely yielded to pedestrians. The results seem to be maintained over time. Because 19 systems were introduced in St. Petersburg, FL, it is clear that the effects do not diminish when a modest number of systems are installed. However, it is not clear whether the effect of the device would diminish if it were installed at hundreds of sites. The findings of the present study suggest that the RRFB used in conjunction with advance yield marking can increase yielding and may increase safety at uncontrolled crosswalks at high ADT multilane sites. Future research should examine crash data using time-series or empirical Bayes methodology to determine the safety benefits of the RRFB.

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