In-Street Yield to Pedestrian Sign Application in Cedar Rapids, Iowa

CTRE Project 02-115

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INTRODUCTION

Vehicle-pedestrian crashes are a major concern for highway safety analysts. Research reported by Hunter in 1996 indicated that one-third of the 5,000 vehicle-pedestrian crashes investigated occurred at intersections, and 40 percent of those were at non-controlled intersections (Hunter et al. 1996). Numerous strategies have been implemented in an effort to reduce these accidents, including overhead signs, flashing warning beacons, wider and brighter markings on the street, and advanced crossing signs. More recently, pedestrian-activated, in-street flashing lights at the crosswalk and pedestrian crossing signs in the traffic lane have been investigated. Not all of these strategies are recognized as accepted practices and included in the *Manual on Uniform Traffic Control Devices* (MUTCD), but the Federal Highway Administration (FHWA) is supportive of experimental applications that may lead to effective technology that helps reduce crashes.

The Traffic Engineering Department of Cedar Rapids, Iowa, a city of approximately 125,000 people, frequently received letters expressing concern for pedestrian safety at key non-controlled intersections. The city has 21 designated pedestrian crosswalks at non-intersection, non-school, and non-trail crossings, as well as numerous uncontrolled intersections. In 2002, the Cedar Rapids City Council gave preliminary approval to implement a pedestrian-actuated overhead flasher system and an in-pavement flasher system. However, before proceeding with these projects, the Cedar Rapids Traffic Engineering Department sought assistance from the Iowa Department of Transportation to evaluate a lower cost option, an in-street flexible sign to remind motorists of their obligation to yield to pedestrians.

This report summarizes the results from a small-scale study to evaluate the effect of an experimental in-street sign, “State Law–Yield to Pedestrians in Crosswalk.” Three sites with widely different characteristics were selected by the city, and the Center for Transportation Research and Education at Iowa State University provided a small-scale assessment. Although only two of the sites were open to normal traffic flow during the study period, all sites are generally discussed in this report.

LITERATURE REVIEW

Various forms of an in-street “State Law–Yield to Pedestrian” sign (see Figure 1) have been tested in other states, including New Hampshire, New York, Minnesota, and Wisconsin, and in the District of Columbia. Early applications used signs mounted on plastic drums (New York), but those signs were unsatisfactory because they were a potential danger as they moved when they were hit. Improved designs made from a durable flexible plastic may be ballasted or fixed versions that can be bolted to the street. These signs return to the original position if they are struck by a vehicle.

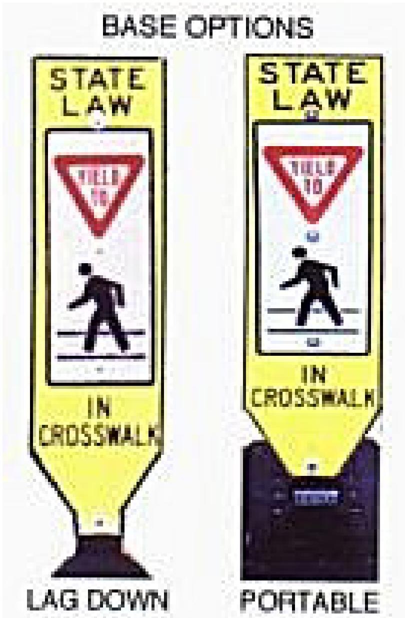

Figure 1. State Law–Yield to Pedestrian Sign

FHWA Multi-strategy Research

The FHWA supports research to evaluate several types of innovative crossing tools (Huang et al. 1996). Studies in the state of New York and in Portland, Oregon, most closely related to the sign of interest for this study. Three measures of effectiveness were used, including percent of vehicles stopping for pedestrians, percent of hurried or aborted crossings, and percent of pedestrians who diverted from non-marked crossings to the "protected" crossing. Overall, the researchers found a statistically significant increase in the percent of vehicles stopping for pedestrians, an increase from 62 percent to 81 percent. Hurried or aborted crossings were not changed, nor was the likelihood for moving to the protected intersection.

Wisconsin Yield to Pedestrians

The Madison, Wisconsin, Traffic Engineering Department applied the "Yield to Pedestrian" sign at five locations, one of which for a two-year period (Madison, Wisconsin, 2000). Increases in percent of vehicles stopping were observed at all locations, although one location did not have sufficient observations for a statistical evaluation. The percent yielding, however, was considerably lower than in the New York and Portland applications. In Madison, the before studies indicated 0 percent to 10 percent yielding before the signs and 10 percent to 20 percent after the signs were in place. The methodology used in Madison carefully tracked brake light applications and speed variations prior to the intersections. A driver was credited with "yielding" if the pedestrian was initiating a crossing, but not if a pedestrian was already in the crosswalk. Further, braking and gradual slowing in advance of the intersection had to be detected to be classified as yielding. Left-turning vehicles were neither recorded as yielding or non-yielding.

Madison traffic engineers reported strong support from the pedestrians. Frustration and even disappointment were expressed when signs were removed for the winter. They also reported the need to replace several signs that had been hit frequently, but they have received no claims for damage to vehicles or other property.

Nova Scotia, Canada, Research

Researchers in Nova Scotia investigated the impacts of adding in-street pedestrian yield signs to enhance pedestrian safety at several locations that were already equipped with pedestrian-activated flashing beacons (Van Houten et al. 2002). The sites studied contained a mix of one-way versus two-way operations, and urban versus rural applications. Their rural sites were low-speed areas with a speed limit of 30 mph. The study design included before and after evaluations of effectiveness measures at application sites as well as control sites. The measures of effectiveness included reduction in "erratic" behavior by drivers and pedestrians, distance from the crosswalk that vehicles stopped, and percent of drivers stopping. Because the experience in Nova Scotia allows a third feature that is not incorporated in the U.S. trials, only the results from the percent stopping data are reviewed here. The added marking available in Canada is a pavement marking feature referred to as "advance yield markings." These markings are solid white triangles that are 40 cm at the base and 60 cm tall, painted 7 to 15 meters in advance of the crosswalk.

From the 24 sites in this study, the percent of drivers stopping 6 meters (or more) before the crosswalk increased from 13 percent to 54 percent, and the percent stopping 3 meters or more before the crosswalk increased from 37 percent to 83 percent. Both changes were statistically significant.

University Campus Application

Traffic planners on the Michigan State University campus supplemented new crosswalk markings with the portable version of yield to pedestrian signs on a rotating basis throughout the campus ("Crosswalk Safety Problem," *Public Works*). Their signs were placed only during daytime hours. An informal study of the project indicated a very substantial increase in the number of drivers who stopped at the signed crosswalk. Although drivers quickly returned to the previous habits after the signs were removed, the university concluded the system was serving them well. The number of applications will more than double in the next season as they convert to a longer term, fixed-base structure for the next stage.

STUDY PLAN FOR CEDAR RAPIDS

Cedar Rapids identified three sites, discussed below, where the research team was to observe and evaluate pedestrian-vehicle behavior during the summer of 2002. The city applied for and received approval from the FHWA for application of an experimental "State Law–Yield to Pedestrian" (YTP) sign. The Cedar Rapids Traffic Engineering Department installed the signs at the selected locations.

Study Sites

Three uncontrolled designated crosswalks, each with a uniquely different need, were submitted by the Traffic Engineering Department for the experimental applications:

1. **First Avenue East and 4th Street NE, downtown Cedar Rapids.** First Avenue, or U.S. Highway Business 151, is a major arterial with four lanes of traffic, two parking lanes (one on each side) and a continuous left-turn lane in the central business district of Cedar Rapids. Several businesses, including the U.S. Cellular Center and the Crown Point Hotel, are along the block that was studied. The intersection of First Avenue East and 4th Street NE presents special concerns because the Union Pacific Railroad, which serves nearby industry, crosses First Avenue between the crosswalk and 4th Street. In addition, the crosswalk serves as a pedestrian/bicycle trail, which parallels the rail line, and the crosswalk falls partially within a hotel service drive that parallels the rail line on the north side of the street. Surface parking is available on the street opposite the Convention Center. Pedestrians using the crosswalk can step into the parking lane to signal their desire to cross without being in immediate exposure to moving traffic and receive some benefit from the continuous left-turn lane, which provides an unofficial refuge area because the left-turn volume is small. However, the total crossing distance is large, approximately 79 feet curb to curb. The speed limit in the area is 25 mph and the average daily traffic (ADT) is approximately 25,000 vehicles per day. See Figure 2.

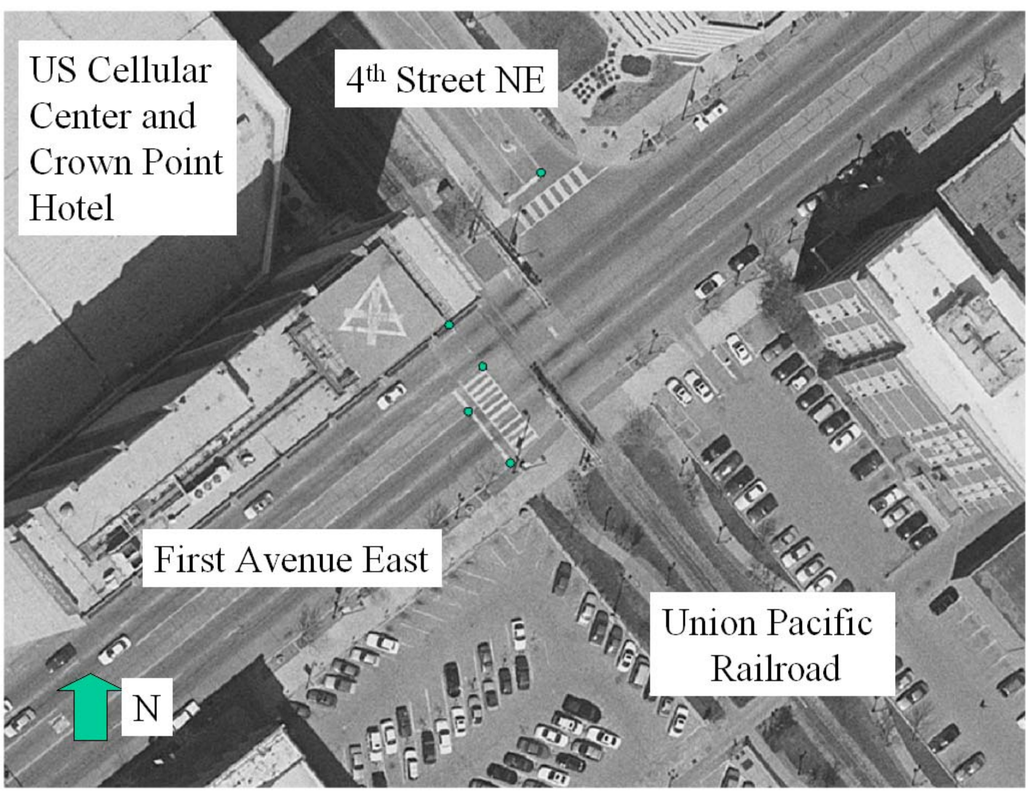

Figure 2. First Avenue East, 300 block, Downtown Cedar Rapids

2. **First Street SW and 10th Avenue SW, the Penford site.** First Street SW serves a major industry of Cedar Rapids, Penford Products Company. Because the Cedar River and the CRANDIC rail line restrict the area at the rear of the property, employee parking for office personnel is provided across First Street, between 10th Avenue and 11th Avenue. Employees must cross two-way traffic (approximately 44 feet wide) to reach the work site. This intersection also is the site of several Linn County offices. Although the county employees and users do not cross First Street at this location, the county offices represent a traffic generator for the area. The speed limit in the area is 30 mph, and the ADT is approximately 7,400 vehicles per day. Due to construction throughout the summer, traffic was reduced to one lane. Although the city eventually was able to place signs at this site, no speed data or crossing conflict data were gathered here. See Figure 3.

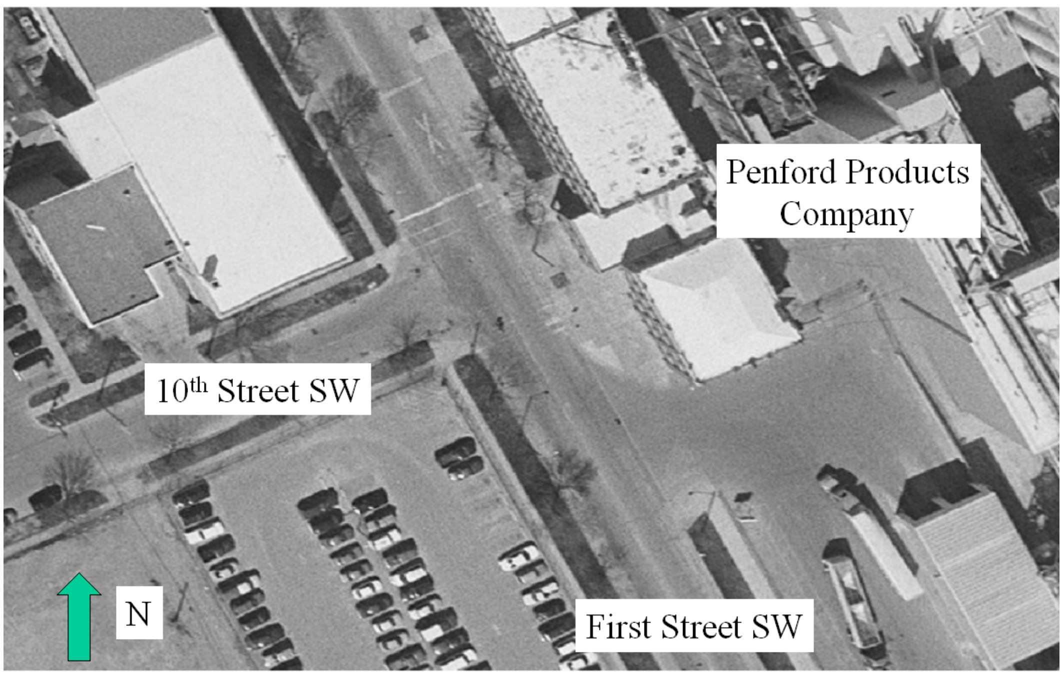

Figure 3. First Street SW and 10th Avenue SW—Penford Site

3. **Ellis Boulevard NW and N Street NW, at the Boys and Girls Club.** Ellis Boulevard NW is a two-lane minor arterial street, approximately 31 feet wide. The study location at Ellis and N Street NW is the site of the Boys and Girls Club. The building is on the east side of Ellis Boulevard at a T-intersection with N Street, but an open play space on a church property is available across Ellis Boulevard. An elementary school is approximately three blocks away, west of the study location. Parking restrictions that are in place along the street have been an issue for residents for several years. Parking is not permitted in this area. The speed limit in the area is 30 mph, and the ADT is approximately 5,400 vehicles per day. See Figure 4.

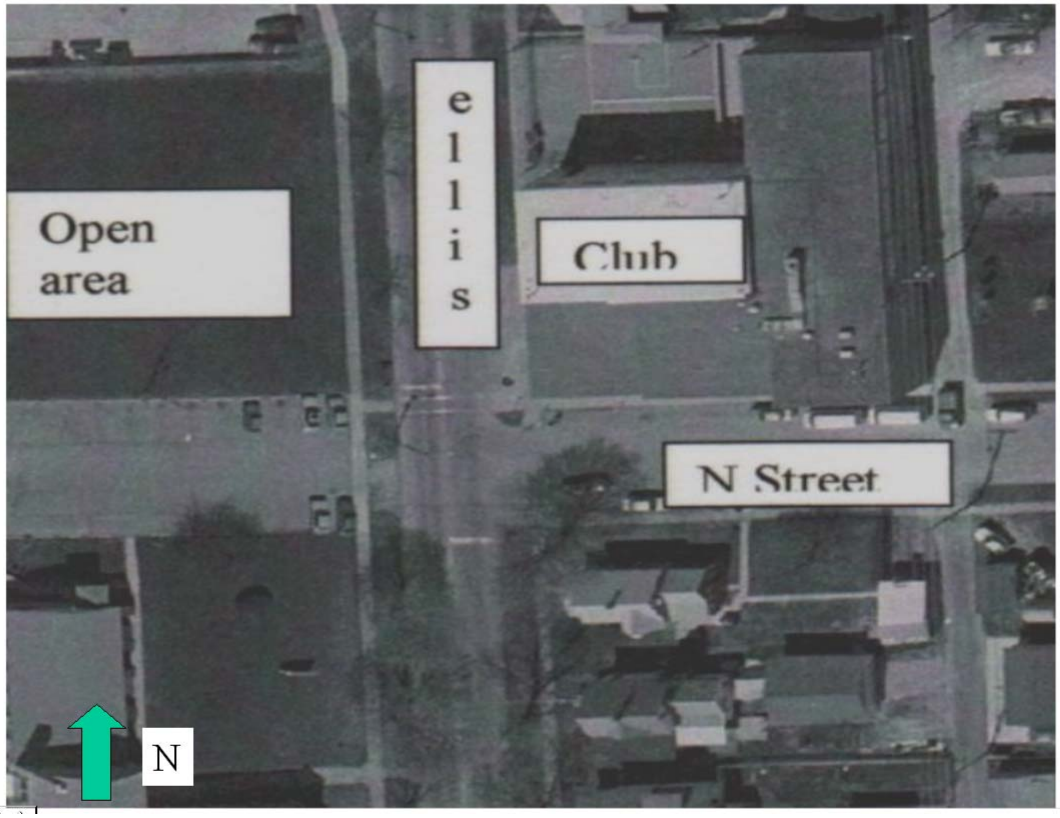

Figure 4. Boys and Girls Club on Ellis Boulevard NW

Data Collection—Original Plan

The original plan for the study was to conduct a before and after study at each location. The research team was to videotape pedestrian/vehicle activity in June 2002 and make speed measurements prior to sign installation. Two-hour time blocks were to be observed as follows:

- work-shift change at industrial site
- AM peak period at Boys and Girls Club
- lunch hours in Central Business District

A similar observation set was to be obtained for an after-study after the signs were in place for a minimum of three weeks. To ensure consistency in before and after data, observations were to be made under comparable weather conditions.

Measures of Effectiveness

The measures of effectiveness to be used included the following:

a. vehicle speed changes during periods in which pedestrians are present in before and after periods
b. percentage of "first vehicles" that stop for pedestrians when pedestrian steps from curb
c. percentage of aborted or hurried crossings

Implementation Delays and Modified Activity

The research staffing plan was centered around using a student researcher during the summer of 2002. However, due to delays in contract approval and delivery from the provider, the new signs were not in place until the end of August. This created a loss of data collection opportunities for the after period, but vehicle speeds at the Boys and Girls Club and vehicle-pedestrian interactions at the First Avenue East location were collected and evaluated.

DATA ANALYSIS

First Avenue East and 4th Street NE

Pedestrian-vehicle conflicts at First Avenue East and 4th Street NE were videotaped for later analysis from the second level of the municipal parking garage that is located in the northwest quadrant of this intersection. The observation point provided an excellent position for capturing the video data. The before data were collected in June 2002, and the after data were collected in October 2002.

Speed Data

To prevent drivers from detecting radar signals from standard radar units, the research team wanted to obtain speeds using a laser speed detection device. The observer attempted to obtain the readings from the ramp monitoring location. Unfortunately, the laser gun required that the vehicle be tracked on the same portion of the vehicle for up to 3 seconds for the best results. When the data were post-processed, the research team determined that it was not able to obtain satisfactory speed data with the detector because the overhead signs, posts, and vegetation interrupted the tracking. The resulting speed data were unsatisfactory. A second strategy using road tubes across the lanes was tried on another day. The speed data from this trial were also unsatisfactory. The two major faults were identified after the data were collected. First, the observer learned that a vehicle in the parking lane was parked on the road tube, thus eliminating data collection during a significant portion of the study time. Second, although the equipment supplier indicated that speeds could be detected, by lane in multi-lane operations, the reality was that vehicles passing close to the same time in the two lanes produced several vehicle speeds in excess of 50 mph. The observer realized these speeds were not occurring on the street. The speed data were not further analyzed at this site.

Stopping for Pedestrian Data

The most important observations were the change in behavior for vehicles stopping. Before the in-street YTP signs were installed, 350 pedestrian crossings were observed when vehicles were present; these were nearly equally split by direction of crossing. In the after study of driver-pedestrian interactions taken in October, only 90 crossings were observed; these were nearly equally split by direction of crossing. The primary measured value was the percent of the time that the first, second, third, fourth, or fifth vehicle stopped for the pedestrian. Ideally, we would find that 100 percent of the time the first vehicle arriving after a pedestrian initiates a crossing would slow or stop to allow the pedestrian to proceed. The cumulative percent-of- vehicles-stopping data were tabulated by lane and by direction of travel. A general representation is shown in Figure 5 for one direction of travel. Lane 1 is always adjacent to the curb lane. The following “rules” were used to establish if the driver would be counted as yielding or non-yielding:

- Lane 1—driver had responsibility to stop only if a pedestrian had stepped from the curb into the parking lane.
- Lane 2 and turning lane—driver had responsibility to stop only if a pedestrian had entered the adjacent lane.

The same analyst completed the before and after assessment in order to maintain the most consistent judgment about driver stopping or yielding behavior. The results are summarized in Table 1.

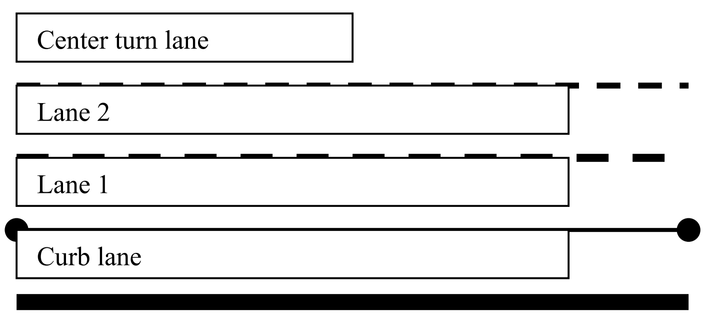

Figure 5. General Representation for One Direction of Travel

Table 1. Cumulative Percent of Drivers Stopping for Pedestrians Before and After Implementation

First Vehicle to Stop, Arrival #	Eastbound Vehicles				Westbound Vehicles			
	Lane 1 Before	Lane 1 After	Lane 2 Before	Lane 2 After	Lane 1 Before	Lane 1 After	Lane2 Before	Lane 2 After
1	70.0%	84.2%	71.3%	75.0%	64.2%	67.4%	57.3%	55.0%
2	87.5%	100.0%	88.3%	82.1%	82.1%	87.0%	72.0%	100.0%
3	93.8%	100.0%	95.7%	92.9%	93.5%	95.7%	91.5%	100.0%
4	95.0%	100.0%	96.8%	96.4%	95.2%	97.8%	92.7%	100.0%
5	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	
N	80	19	94	28	82	20	25	96

Lane 1, in the eastbound direction, exhibited the most dramatic change. Prior to use of the YTP signs, the first vehicle stopped only 70 percent of the time, but after the installation, the first vehicle stopped 84 percent of the time. For westbound traffic, the percent change was much less dramatic, changing from only 64 percent to 67 percent of the first arriving drivers who yielded to the pedestrians.

A contingency table analysis of the eastbound traffic was conducted by comparing the before and after period using two groups; group 1 was the first driver stopped and group 2 was "all other cells" combined into a second category. Although stopping behavior improved in the various lanes, due to the small sample size in the after stage, only the eastbound improvement of stopping behavior was found to be statistically significant at the 0.80 level for this approach. Although a 95 percent confidence level is a more typical statistical test standard, demonstration of change at the 0.80 level may be considered beneficial if the cost of the improvement is low.

The large difference in eastbound versus westbound compliance may be associated with the geometrics of the intersection. For eastbound traffic, the major crosswalk is before the railroad crossing and before the 4th Street intersection. The drivers generally are looking at this as a condition that deserves special attention. On the other hand, westbound drivers have just cleared the 4th street intersection and crossed the railroad tracks. They may perceive a much greater need to clear their vehicle from the path of cross traffic and the train and are therefore paying less attention to the pedestrians.

Ellis Boulevard NW at the Boys and Girls Club

Ellis Boulevard NW operates as a two way minor arterial street with an ADT of approximately 5,400 vehicles per day. The Boys and Girls Club is located on the east side of Ellis Boulevard, but through agreements with a church across the street, the club can schedule outdoor activities that require crossing the street. As seen in Figure 6, the site already has MUTCD-approved "Advance Warning and Pedestrian Crossing" signs at the crosswalk. When the in-street sign was placed, an aluminum sign with the same message was also mounted at the curb.

Figure 6. Northbound Approach to Boys and Girls Club

Interviews with the club employees indicated that the peak arrival time during the summer was between 8:30 AM and 9:00 AM. However, most participants were either picked up and delivered by the club ban or dropped off by a driver. During three different days at the club, the pedestrian volume was too small to make any meaningful statistical assessments about vehicles slowing or stopping for pedestrians in a before and after comparison. However, three days following the installation and again five weeks later, the four employees enthusiastically praised the presence of the YTP signs. They indicated the drivers were responding more consistently to pedestrians outside the club.

To test the potential effect of the signs, a before and after speed study was completed. The speed data were obtained by placing road tubes across the lanes from both directions and were reported by approach direction. Figure 7 shows the distribution of the speeds in the before and after studies for the northbound direction. The figure shows a slight shifting to the left, indicating that the speeds approaching the club from the south were reduced a small amount. The mean and median speeds dropped from 28 mph to 26 mph for these vehicles. The differences for vehicles from the north were not this large, probably because a stop controlled intersection is just one block north of the site and drivers were already driving somewhat slower at 25 mph. The standard error of the mean was 0.2 mph, which indicates the speed reduction is statistically significant at the 95 percent level, but when all vehicles on both sides of the site are averaged the speed changes are too minor to be considered important, even if statistically significant. This may also be partially a reflection of the fact that pedestrian volumes were low at the time of the study.

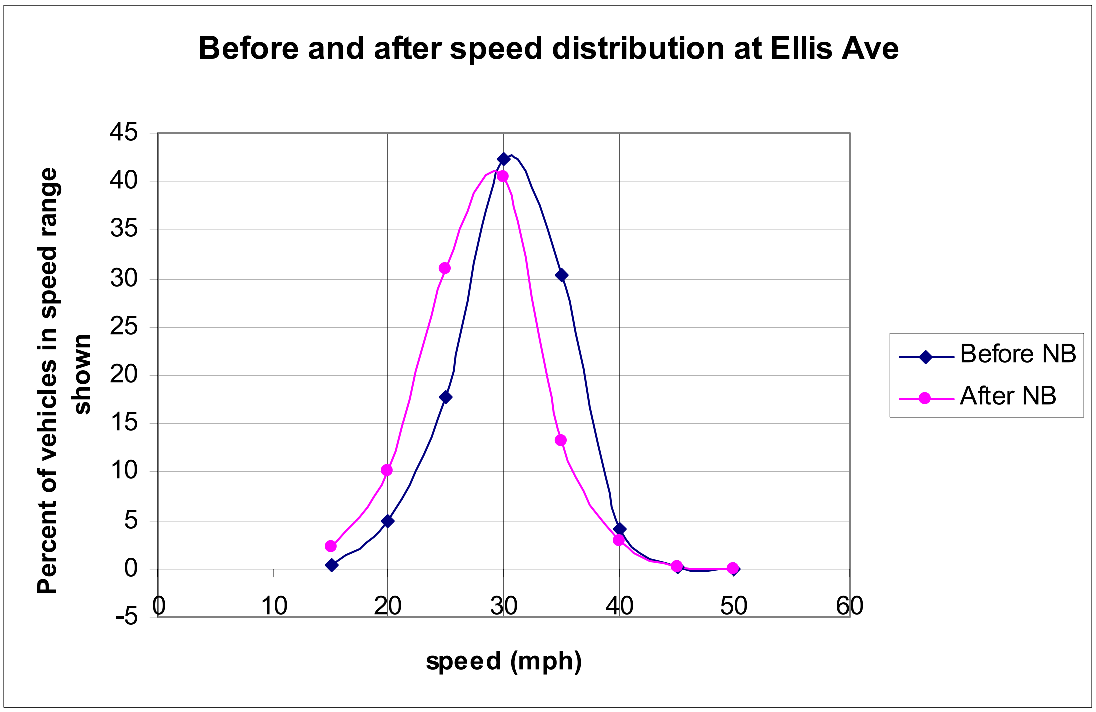

Figure 7. Boys and Girls Club Speed Distribution in Before and After Study

First Street SW, the Penford Site

Because of street construction throughout the summer, it was not possible to collect before data at the Penford site prior to installing the YTD. A brief employee interview after the installation indicated very positive support for the installation.

Additional Input from Traffic Engineering Department

Throughout the project Mr. Ron Griffith, a traffic engineer with the City of Cedar Rapids, was the primary contact. He reported that response from pedestrians has been consistently positive. No injuries or crashes were reported at the sites due to the presence of the signs. However, on two occasions the signs at the Boys and Girls Club had been stolen. These were recovered a short distance from the site shortly after they were reported missing. Also at this site and at the Penford site the sign panels were damaged significantly, most likely from being hit by vehicles and/or trucks. Going into the winter season, the city removed the signs, except those on First Avenue East due to concerns with maintenance and damage from snowplows. The city has decided not to reinstall the signs at these locations and will assess future directions and policy regarding the placement of these signs. If and when these devices are the accepted as approved devices by the MUTCD, then the city may consider reinstalling the signs.

The city purchased, installed, and maintained the in-street signs and placed supplemental aluminum signs at curbside locations. The installation and maintenance costs include the use of two laborers and a sign truck. The actual or estimated costs for these are as follows:

YTP signs	8 @ $210 each	$1,680
Supplemental signs	5 @ $40 each	$200
Installation cost	$75 to $110 per site	~ $300
Maintenance	20 hours @ $110 per hour	$2,200
Total		~$4,380

The Penford Products and Boys and Girls Club sites experienced the greatest need for maintenance. The portable bases were glued and, in some cases, taped down. They remained in position, but the sign panel faces were significantly damaged by vehicle hits. In one instance, the signpost was snapped. In general, the crews and staff judged the damage to be associated with turning vehicles rather than reckless intent to destroy. The signs were removed at these sites at the beginning of the winter due to increasing damage to the sign surface.

Signs placed on First Avenue received considerably less damage than those at the other sites. The availability of the low-volume two-way left turning lane, which provided additional street width, was felt to be a contributing factor to the lower damage.

Six months after the start of the project, approximately one-third of the 16 sign faces (8 signs x 2 faces per sign) were still in good enough condition for continued use. Although the sign faces had been damaged, there were no known pending claims against the city for vehicle damage.

No special community awareness programs or police enforcement programs were put in place to bring the new sign to the attention of the users.

CONCLUSIONS

The “State Law–Yield to Pedestrian” sign has had a positive impact on driver behavior, although the effect is not dramatic in all applications. The Cedar Rapids experience is similar to other studies examined in the literature. Speed reductions at one site and improved driver compliance at another were identified. However, the changes are not uniform throughout. In particular, at First Avenue East and 4th Street NE, the location of the major crosswalk with respect to the competing demands for attention (railroad crossing, bike path, and intersection) appears to affect the degree to which drivers adjust their driving habits. If drivers perceive that their own safety is jeopardized, compliance with the sign message will be diminished.

The low pedestrian volume conditions at two of the three sites provided very limited opportunity to measure changes in driver/pedestrian behavior. The Boys and Girls Club site provided vehicle speed data, but even if future studies are conducted during peak activity greater than observed in the summer of 2002, the results are likely to be largely of a general, positive nature. With a large sample size, small vehicle speed changes can be statistically detected, but a small change does not necessarily indicate that pedestrian safety will be increased overall.

The physical features of the two sites provided important information for the city. Due to turning traffic near the signs, physical damage to the signs occurred early in the project. In future applications, in-street signs at or near intersections would need to be placed at a greater distance from the crosswalk they are protecting. Since the signs are intended as an alert or warning, and not as a crossbar, this adjustment would apparently reduce the maintenance costs. Applications where center medians, or wider turning or storage bays, are available appear to be the best candidate locations.

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