The Effect of Crosswalk Markings on Vehicle Speeds in Maryland, Virginia, and Arizona

REPORT NO. FHWA-RD-00-101August 2000

U.S. Department of Transportation
Federal Highway Administration
Research and Development
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296

Pedestrian & Bicycle Safety

FOREWORD

The FHWA's Pedestrian and Bicycle Safety Research Program's overall goal is to increase pedestrian and bicycle safety and mobility. From better crosswalks, sidewalks and pedestrian technologies to growing educational and safety programs, the FHWA's Pedestrian and Bicycle Safety Research Program strives to pave the way for a more walkable future.

Crosswalks are among the treatments used to help pedestrians cross streets safely. This study focused on the effect of crosswalk markings on vehicle speeds at uncontrolled intersections in three states: Maryland, Virginia, and Arizona. This study was part of a larger Federal Highway Administration research study investigating the safety effectiveness of crosswalks for pedestrians. It is hoped that readers also will review the reports documenting the results of the related pedestrian crossing studies.

The results of this research will be useful to transportation engineers, planners, and safety professionals who are involved in improving pedestrian safety and mobility.

Michael F. Trentacoste, Director
Office of Safety Research
and Development

NOTICE

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3 Recipient's Catalog No.
FHWA-RD-99-		

4. Title and Subtitle	5. Report Date
THE EFFECT OF CROSSWALK MARKINGS ON VEHICLE SPEEDS IN MARYLAND, VIRGINIA, AND ARIZONA	August 2000
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Richard L. Knoblauch and Paula D. Raymond	

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Center for Applied Research, Inc. 10213 Forest Lake Drive Great Falls, VA 22066-3608	11. Contract or Grant No. DTFH61-92-C-00138

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Office of Safety R&D Federal Highway Administration 6300 Georgetown Pike McLean, VA 22101-2296	Research Report July 1, 1996 - October 31, 1999
	14. Sponsoring Agency Code

15. Supplementary Notes

Contracting Officer's Technical Representative (COTR): Carol Tan Esse
The prime contractor for this study was the University of North Carolina Highway Safety Research Center.

16. Abstract

A before/after evaluation of pedestrian crosswalk markings was performed in Maryland, Virginia, and Arizona. Six sites that had been recently resurfaced were selected. All sites were at uncontrolled intersections with a speed limit of 56 km/h (35 mi/h). Before data were collected after the centerline and edgeline delineation was installed but before the crosswalk was installed. After data were collected after the crosswalk markings were installed. Speed data were collected under three conditions: no pedestrian present, pedestrian looking, and pedestrian not looking. All pedestrian conditions involved a staged pedestrian. The results indicate a slight reduction at most, but not all, of the sites. Overall, there was a significant reduction in speed under both the no pedestrian and the pedestrian not looking conditions. It appears that crosswalk markings make drivers on relatively low-speed arterials more cautious and more aware of pedestrians.

17. Key Words	18. Distribution Statement
Pedestrians, safety, crosswalks, crosswalk markings, unsignalized intersections	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161.

19 Security Classification (of this report)	20. Security Classification (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	9	

TABLE OF CONTENTS

Page

OVERVIEW

This research was conducted by the Center for Applied Research, Inc., as part of a subcontract from The University of North Carolina Highway Safety Research Center. Task Order 11, Evaluation of Pedestrian Facilities, was part of Federal Highway Administration research project DTFH61-92-C-00138, Pedestrian and Bicyclist Safety - Administrative and Technical Support.

BACKGROUND

The effect of crosswalk markings on approaching vehicle speeds was studied at six locations in three states: Maryland, Virginia, and Arizona. Sites were selected on roadways that were recently resurfaced. All sites were uncontrolled intersections with stop control on the minor leg. In the "before" condition, all other roadway delineation (e.g., edgelines, centerlines) were installed but the crosswalk had not yet been installed. "After" condition data were collected after the crosswalk markings were installed. Before and after measures were taken during the same time of day, never during rush hour, Monday mornings, or Friday afternoons. In Virginia and Maryland the crosswalks were installed soon after resurfacing so the before traffic measurements were taken within 1 month. In Arizona installation of the crosswalks was delayed so that 7 months separated the before and after periods. The speed limit at all sites was 56 km/h (35 mi/h).

All sites were observed under three pedestrian conditions. In the "No Pedestrian" condition, speeds were measured with no pedestrian present. In the "Pedestrian Looking" condition, a staged pedestrian approached the crosswalk, stopped at the edge of the curb as though waiting to cross and looked square at the oncoming traffic. In the "Pedestrian Not Looking" condition, the staged pedestrian approached the crosswalk, stopped at the edge of the curb as though waiting to cross and looked directly ahead, perpendicular to the oncoming traffic. The pedestrian wore neutral, seasonally appropriate clothes. The same pedestrian was always used for both the before and after measures at a site.

Traffic speed was measured by timing vehicles between two marked spots approximately 180 ft (55 m) apart. A trained experimenter with a stopwatch collected speeds of non-commercial vehicles. Lone vehicles and lead cars of platoons were timed in free-flowing traffic, with no pedestrians (other than the staged pedestrian) present. Speeds were taken on vehicles under each condition. To control for any time of day variation, data collection rotated through the Ped/No Ped conditions four times during the data collection effort.

The following sections will be addressed:

- Site-Specific Results
- Combined Site Results
- General Discussion

SITE-SPECIFIC RESULTS

Site 1: Jefferson Street, Rockville, MD

Jefferson Street is a north/south road running through a dense suburban residential/shopping area. Two lanes proceed in each direction. The crosswalk spans the road across from a retirement home on the west side and is slightly south of a shopping center on the east side.

Traffic was observed proceeding northbound and was timed over 56.7 m (186 ft). The staged pedestrian approached the crosswalk from the north, walking south (facing the observed traffic). The pedestrian then stood at the crosswalk facing west on the east side of the crosswalk.

As shown in Table 1 in the No Ped condition, drivers drove 0.55 km/h faster after striping. This change was not significant (NS). In the Ped Looking condition drivers went 7.77 km/h faster after striping ($t = 4.21$, $p < 0.001$). In the Ped Not Looking condition, drivers went 1.98 km/h faster after striping (ns).

Site 2: Battery Lane, Bethesda, MD

Battery Lane is an east/west road running through a dense semi-urban area on the fringes of DC. One lane travels in each direction. A nursing home is on the north side of the street, with most of the rest of both sides occupied by apartment buildings. Close to the campuses of the National Institutes of Health (NIH) and the Naval Hospital and within walking distance of a popular shopping/restaurant district, Battery Lane has regular pedestrian traffic at this crosswalk. A narrow pedestrian refuge island was installed prior to the before condition.

Traffic was observed proceeding westbound and was timed over 54.3 m (178 ft). The staged pedestrian approached the crosswalk from the east, walking west (facing away from the observed traffic). The pedestrian then stood at the crosswalk facing south on the north side of the crosswalk.

In the No Ped condition, drivers drove 0.26 km/h slower after striping; in the Ped Looking condition, drivers went 2.12 km/h slower after striping; in the Ped Not Looking condition, drivers went 2.79 km/h slower after striping. None of these differences were significant.

Table 1. The Effect of Crosswalk Markings on Vehicle Speed.

Site	Pedestrian Scenario	Mean Speed (km/h)		Speed Change	t (df)	Significance
		Before	After			
Site #1 Jefferson St. Rockville, MD	No Ped	60.60	61.15	+0.55	-0.26 (78)	NS
	Ped Looking	57.48	65.25	+7.77	-4.21 (78)	<0.001
	Ped Not Looking	59.57	61.53	+1.96	-1.26 (78)	NS
Site #2 Battery Lane Bethesda, MD	No Ped	55.77	55.51	-0.26	0.14 (78)	NS
	Ped Looking	58.89	56.77	-2.12	0.91 (78)	NS
	Ped Not Looking	56.48	53.69	-2.79	1.52 (78)	NS
Site #3 Burke Lake Road Fairfax County, VA	No Ped	72.14	66.36	-5.78	2.75 (78)	0.008
	Ped Looking	68.47	67.04	-1.43	0.70 (78)	NS
	Ped Not Looking	68.59	66.91	-1.68	1.03 (78)	NS
Site #4 Gallows Road Fairfax County, VA	No Ped	75.70	69.49	-6.21	3.30 (78)	0.001
	Ped Looking	73.34	68.44	-4.90	2.83 (78)	0.006
	Ped Not Looking	70.53	67.67	-2.86	1.80	0.076
Site #5 4th Ave. Extension at Main Canal Yuma, AZ	No Ped	63.85	58.94	-4.91	2.05 (78)	0.044
	Ped Looking	59.63	58.88	0.75	0.30 (78)	NS
	Ped Not Looking	62.58	55.29	-7.29	3.59 (78)	0.001
Site #6 4th Ave. Extension at 37th St. Yuma, AZ	No Ped	79.11	59.31	-19.80	5.81 (78)	<0.001
	Ped Looking	61.53	59.38	-2.15	0.79 (78)	NS
	Ped Not Looking	66.49	56.67	-9.82	3.91 (78)	<0.001
Sites 1 – 5 (weighted equally)	No Ped	65.64	62.32	-3.32	2.96 (384.76)	0.003
	Ped Looking	63.58	63.30	-0.28	0.26 (398)	NS
	Ped Not Looking	63.65	61.04	-2.61	2.69 (398)	0.007
All Sites (weighted equally)	No Ped	67.88	61.81	-6.07	5.32 (478)	<0.001
	Ped Looking	63.22	62.63	-0.59	0.58 (478)	NS
	Ped Not Looking	64.11	60.29	-3.82	4.16 (478)	<0.001

NOTE: In the original table for All Sites No Ped, df = 447.13, not 478, because there is heterogeneity of variances (use t and df for equal variances not assumed).

Site 3: Burke Lake Road at Grantham, Fairfax County, VA

Burke Lake Road is a northeast/southwest road running through a suburban residential/shopping area. Two lanes travel in each direction. The crosswalk runs between the southeast corner (at Grantham) and an entrance to a shopping center on the opposite side of the street. Except for the shopping center, the area consists of single-family homes.

Traffic was observed proceeding northeast and was timed over 56.1 m (184 ft). The staged pedestrian approached the crosswalk from the southeast on Grantham, walking northwest, facing perpendicular to the observed traffic. The pedestrian then stood at the crosswalk facing northwest on the southeast side of the crosswalk.

In the No Ped condition, drivers drove 5.78 km/h slower after crosswalk striping ($t = 2.75$, $p < 0.01$). In the Ped Looking condition, drivers traveled 1.43 km/h slower after striping (ns). In the Ped Not Looking condition, drivers traveled 1.68 km/h slower after striping (ns).

Site 4: Gallows Road at Anderson Drive, Fairfax County, VA

Gallows Road is a roughly north/south suburban arterial running through a residential and commercial area. There are three lanes in each direction. The crosswalk runs between an apartment complex on the west side and the entrance to the Mobil headquarters campus on the east side. A bus stop is located on the northwest corner of the intersection, with the crosswalk spanning the southwest/southeast corners. The area mostly consists of corporate headquarters and companies related to the nearby hospital.

Traffic was observed proceeding southbound and was timed over 622 m (204 ft). The staged pedestrian approached the crosswalk and stood at the crosswalk facing west on the east side of the crosswalk.

In the No Ped condition, drivers drove 6.21 km/h slower after striping ($t = 3.30$, $p < 0.001$). In the Ped Looking condition, drivers went 4.90 km/h slower after striping ($t = 2.83$, $p < 0.01$). In the Ped Not Looking condition, drivers went 2.86 km/h slower after striping (ns: $t = 1.80$, $p = 0.076$).

Site 5: 4th Avenue Extension and Main Canal, Yuma, AZ

The 4th Avenue Extension is a straight and relatively level north/south collector street with one traffic lane in each direction. It is located about 0.8 km from 4th Avenue, which is a major four-lane arterial. There are no sidewalks, but 2.0-m to 2.4-m (6-ft to 8-ft) shoulders provide for relatively safe pedestrian travel. There is moderate commercial development and a number of mobile home parks are nearby. The mobile home parks cater to winter visitors who arrive during November and leave in late April and early

May. The winter visitors ("snowbirds") tend to drive more cautiously than do year-round residents. Speeds were taken on southbound traffic. The staged pedestrian approached the roadway from the west and faced in an easterly direction.

In the No Ped condition, drivers drove 4.91 km/h slower after striping ($t = 2.05$, $p < 0.044$). In the Ped Looking condition, drivers traveled 0.75 km/h slower after striping ($t = 0.30$, $p < 0.768$). In the Ped Not Looking condition, drivers went 7.29 km/h slower after striping ($t = 3.59$, $p < 0.001$).

<u>Site 6: 4th Avenue Extension and 37th Street, Yuma, AZ</u>

Site 6, like Site 5, was on the 4th Avenue Extension. Speeds were taken on northbound traffic. The pedestrian approached from the east. In the No Ped condition, drivers drove 19.80 km/h slower after striping ($t = 5.81$, $p < 0.001$). In the Ped Looking condition, drivers went 2.15 km/h slower after striping ($t = .79$, $p < 0.430$). In the Ped Not Looking condition, drivers went 3.91 km/h slower after striping ($t = 3.91$, $p < 0.001$). The No Ped before speed is, for some unknown reason, much faster than would be reasonably expected. Because of this, the findings from this site must be viewed with some skepticism.

COMBINED SITE RESULTS

Because of the inexplicably large speed reduction found in the No Ped condition at Site 5, it was decided to exclude Site 5 from the analysis of all sites combined. The bottom portion of Table 1 shows the aggregate speeds across the remaining five test sites for each pedestrian scenario. All five sites were weighted equally. The crosswalk alone (e.g., no pedestrian present) results in an average speed reduction of 3.32 km/h. This difference is significant ($p = < 0.003$). Of the five individual sites, four had a similar significant reduction; one had a very small but not significant increase. In the pedestrian looking scenario there was a small (0.28 km/h) decrease in speed that was not significant. Three of the five individual sites similarly showed small but not significant decreases while one had a significant decrease and one had a significant increase (Site 1). In the pedestrian not looking scenario, like the no pedestrian scene, there was a significant (2.61 km/h) decrease in average speed. Although five of the six sites also had reduced speeds for this condition, the differences were only significant in Yuma. The other site had a slight but insignificant increase in speed during the pedestrian not looking scenario.

DISCUSSION

The results of this evaluation are not clear cut. Although four of the six test sites showed modest, and in some cases statistically significant, speed reductions, there were two notable exceptions. One site (Site 1) had slight but insignificant increases in the No Ped and Ped Not Looking scenarios and a moderate (+7.77 km/h) increase in vehicle speeds in the Ped Looking scenario. A second site (Site 6) had what appears to be a very large

(19.80 km/h) speed reduction.   It is difficult to believe that drivers slowed to that extent merely because of the marked crosswalk.

A close examination of the Site 6 data suggests that the apparent speed reduction is actually due to unusually high speeds recorded in the before No Pedestrian condition. Although the Site 5 before No Pedestrian condition speeds were high, the speeds for both of the pedestrian conditions were not notable. If drivers were going faster at Site 6 in the before period, for whatever reason, at least they slowed down when a pedestrian was present. The before data were taken in April and the after data were taken in November. Although it could be hypothesized that the speed reduction was due to the influx of winter resident “snowbirds” that occurs at about the time the after data were taken, this appears unlikely since the effect is not noticeable at the other Yuma site. Since the same time schedule was followed within a site for the before and after time of day speed effects do not explain the unusually high speed. The fact that the before data were taken on a Tuesday and the after data on a Monday is believed to be inconsequential. For some reason the 40 vehicles we selected to measure between the hours of 9:40–9:55 a.m., 3:50–4:00 p.m., and 4:55–5:05 p.m. on Tuesday, April 14, 1997, were traveling faster than expected. We may never know why.

Any speed reduction in response to the crosswalk marking alone (e.g., with no pedestrians present) is somewhat surprising. The crosswalk markings are intended merely to inform drivers to slow and prepare to yield to a pedestrian if one (or more) is present. It is technically not necessary to slow down unless a pedestrian(s) is present, yet four of the six sites had a significant (at the 0.05 level or better) speed reduction. The aggregated, all sites, data also showed a significant (<0.003) speed reduction.

The Ped Looking scenario data are somewhat less perplexing. An adult pedestrian standing at the roadside actively looking at oncoming traffic is probably not seen as a potential hazard. The approaching vehicles were all timed within approximately 60 m (200 ft) of the crosswalk. Given their approach speeds, approximately 60 km/h (35 mi/h), it is very unlikely that an alert adult pedestrian would begin crossing; hence, there is no reason to slow down. The fact that one site (Site 1) showed a significant speed increase and a second site (Site 4) showed a significant speed decrease cannot be explained.

The Ped Not Looking scenario is perhaps the most revealing situation. A pedestrian standing at the roadside next to a marked crosswalk and not looking at approaching traffic represents a real potential hazard. A driver, in that scenario, would approach with caution—appropriately slowing down. Five of the six sites showed speed reduction, two of which were significant. The “all sites” total showed a 2.69 km/h (1.61 mi/h) reduction that was significant at the 0.007 level.

In conclusion, it appears that drivers are aware of—and respond to crosswalk markings—by slowing down slightly. It also appears that drivers react differently to the different pedestrian scenarios that were staged. They are more careful (e.g., they slowed more) when the pedestrian does not appear to be paying attention to approaching traffic and this is the situation where they, as drivers, need to be especially careful. It is, however, noteworthy that none of the approaching vehicles actually stopped and yielded to the pedestrian. Given the operating speeds at the test sites—speeds averaged nearly 65 km/h (40.3 mi/h)—stopping and yielding would not be desirable behavior—especially on multi-lane roadways.

Thus, based on the speed reductions that were generally observed, crosswalk markings on relatively low-speed arterials appear to make drivers more cautious, or more aware of pedestrians. And that is a good thing.