

TECHBRIEF



U.S. Department of Transportation
Federal Highway Administration

Research, Development, and
Technology

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Crosswalk Marking Field Visibility Study

FHWA Publication No.: FHWA-HRT-10-067.

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This document is a technical summary of the Federal Highway Administration (FHWA) report, *Crosswalk Marking Field Visibility Study*, FHWA-HRT-10-068.

Objective

The objective of this study was to investigate the relative daytime and nighttime visibility of three crosswalk marking patterns: transverse lines, continental, and bar pairs.

Background

Crosswalk markings provide guidance for pedestrians crossing roadways by defining and delineating paths on approaches. These markings are used in conjunction with signs and other measures to alert road users to a designated pedestrian crossing point. Part 3 of the *Manual on Uniform Traffic Control Devices* (MUTCD) contains basic information about crosswalk markings.⁽¹⁾ Because some States adopt their own supplement or manual on traffic control devices and some develop policies and practices for subjects not discussed in the MUTCD, differences in markings occur among States, cities, and other jurisdictions.

While greater emphasis has recently been placed on researching pedestrian treatments, there is insufficient research to identify the relative visibility and driver behavior effects of the many different styles and patterns of crosswalk markings being used in the United States and abroad. Previous studies focused on whether the presence of the markings (rather than a specific pattern) was effective.⁽²⁻⁴⁾ The lack of knowledge of the relative visibility of different marking patterns has inhibited the development of a consensus on whether more uniformity is needed in the form of tighter MUTCD standards or more comprehensive guidance on crosswalk markings.

Study Approach

In this study, participants drove an instrumented vehicle on a route through the Texas A&M University campus in College Station, TX. The route provided an open road environment that included portions in a typical college setting (e.g., sidewalks, buildings, basketball arena) and roads through the agricultural area of the campus, which were more rural in feel. Roadway lighting was present at each of the crosswalk locations. The study vehicle was equipped with instrumentation that allowed the researchers to measure and record various driving performance data. However, the vehicle operated and drove like a normal vehicle.

The 78 participants were divided almost evenly between groups of male and female participants and between groups of younger (younger than 55 years old) and older (55 years old or older) participants.

Existing markings (six intersection and two midblock locations) and new markings installed for this study (nine midblock locations) were tested. Figure 1 shows an example of the bar pairs installed for this study, figure 2 shows a continental example, and figure 3 shows a transverse marking example.

Once the participant was comfortable in the instrumented vehicle and had arrived in a parking lot near the start of the route, he or she was reminded to indicate when one of the following

items was seen: crosswalk markings, two-way left-turn arrows, and speed limit signs. The arrows and signs were included to ensure that the driver utilized a normal eye glance pattern and was not exclusively searching for crosswalks. As soon as the driver said “crosswalk,” the rear seat experimenter pressed the appropriate button to place a mark indicating detection in the computer file. Detection distances were adjusted by an experimenter response-time factor determined through pretesting. For the nine crosswalks installed for this study, the adjustments to the participant’s detection distance ranged between 3 and 13 percent.

After completing the initial route, the participant was given additional instructions and asked to drive the same route again to rate each crosswalk marking on how easy it was to see using a scale of A (excellent: very easy to see) to F (completely unacceptable: I would have missed it if I was not looking for it).

Figure 1. Photo. Example of bar pairs markings installed for this study.



Figure 2. Photo. Example of continental markings installed for this study.



Figure 3. Photo. Example of transverse markings installed for this study.



Results

The primary objective of this research was to study the visibility of crosswalk markings by determining detection distance and identifying the variables that affect this distance. The differences in detection distances were evaluated with consideration of variables in the following classes:

- Light (day or night).
- Site characteristics.
 - Marking type (transverse, continental, and bar pairs).
 - Location (study, existing intersection, existing midblock).
 - Street characteristics (crossing width, posted speed limit, sidewalk presence, rural or urban feel).
 - Retroreflectivity.
- Traffic characteristics.
 - Traffic presence that could affect detection distance.
 - Pedestrian or bicyclist presence.
 - Driver speed.
- Vehicle type (sedan or SUV).
- Driver characteristics.
 - Driver eye height
 - Gender.
 - Age group (younger than 55 years old or 55 years old and older).

Initially, the statistical model examined contained all main effects and possible two-way interactions (termed the “extended” model). Not all variables could be included in the extended model due to exact linear dependency issues for some of the factors (i.e., a linear combination of one or more factors’ values can exactly duplicate another factor’s values). Next, several models with a subset of variables in the extended model were explored to determine the best model for identifying the variables that influence detection distance (termed the “reduced” model). Interactions were dropped from the reduced models when the p -value was less than 0.05 (they were not statistically significant).

The evaluations were conducted separately for the study sites (where new markings were installed at midblock locations) and the existing sites (where markings were already present at an intersection or were already present midblock and had pedestrian warning signs). The preliminary evaluations clearly showed a difference in detection distance for day and night. Because the nighttime condition had the additional variable retroreflectivity to consider and because some variables were expected to have different effects during the night (such as marking type, vehicle type, and driver eye height), separate analyses were done for daytime and nighttime conditions. In all combinations, daytime detection distances were longer than nighttime detection distances.

For the study sites, the marking type (bar pairs, continental, or transverse) was statistically significant. The detection distances to bar pairs

and continental markings were statistically similar, and they were both statistically different from the detection distance to the transverse markings both during the day and at night (see figure 4).

The presence of traffic had an impact on detection distance at the study sites, in most cases limiting the ability to see the markings farther upstream, as expected (see figure 5). The impact of traffic on the transverse markings was minimal as the detection distances to these markings were already small compared to the detection distances for bar pairs or continental. Overall, shorter detection distances were associated with higher operating speeds; however, in most cases the detection distances were only slightly shorter. The characteristics of the streets also influenced the detection of the crosswalk markings. An unexpected result was that the street group with a posted speed limit of 45 mi/h had longer nighttime adjusted detection distances than the 30 mi/h roadway sections. This finding was opposite the finding for daytime conditions.

Figure 4. Graph. Least square mean detection distance by marking type and light level for study sites.

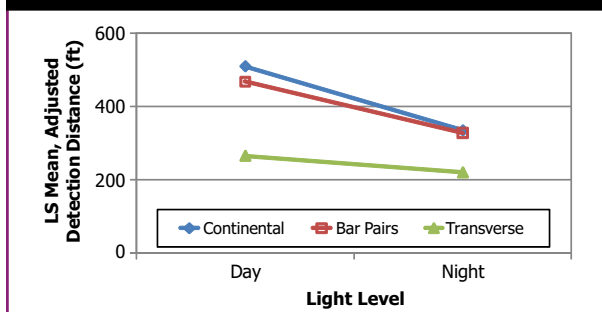
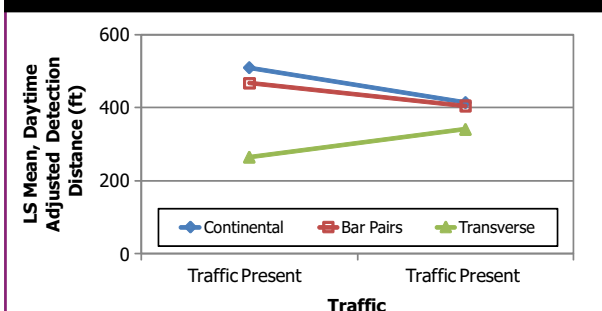


Figure 5. Graph. Least square mean daytime adjusted detection distance by marking type and traffic presence at study sites.



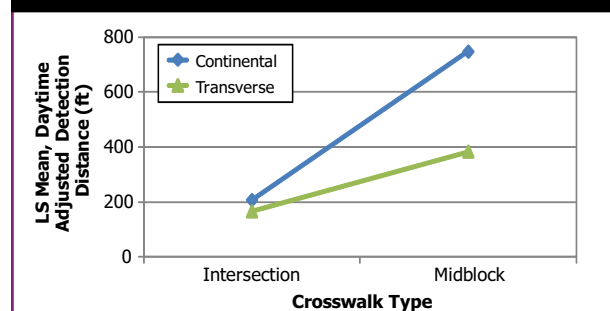
Daytime adjusted detection distances were slightly shorter for higher speeds.

Age (younger versus older) was only a significant factor during the day for the existing sites. However, the size of this difference was quite small and was not considered to be of practical significance. Variables that included gender, driver eye height, and vehicle type as part of an interaction term were found to be statistically significant, but closer examination found them to not be of practical significance.

For the existing sites, marking type had a significant effect on detection distance during the daytime at midblock crosswalks (as shown in figure 6) and at nighttime. There were no existing sites with bar pairs markings, hence only continental and transverse markings were compared. During the day, the detection distances to the continental and transverse markings at intersections were not significantly different. The detection distance to midblock continental was statistically different (longer) from the detection distance to midblock transverse markings.

During nighttime conditions at existing sites, variables in addition to marking type had an effect on detection distances, such as location (midblock or intersection) and driver speed. Driver speeds had mixed effects on detection distance depending on location (intersection or midblock) and light level (day or night). For intersections, an increase in driver speed was

Figure 6. Graph. Least square mean daytime adjusted detection distance by marking type and location at existing sites.



associated with longer detection distances for both the daytime and nighttime conditions. All of the intersections included in this project were either stop-controlled or signal-controlled. Several drivers appeared to be more focused on the stopping maneuver than the detection task and would not call out the recognition of a crosswalk until close to the stop bar.

For midblock (uncontrolled) approaches, the finding was dependent on light level. Nighttime detection distance at midblock was similar to intersections—longer detection distances were associated with the higher speeds. For daytime, the opposite occurred—higher driver speeds were associated with shorter detection distances at the midblock crosswalks. While the higher driver speeds were associated with shorter detection distances, the differences were small and would not be considered of practical significance.

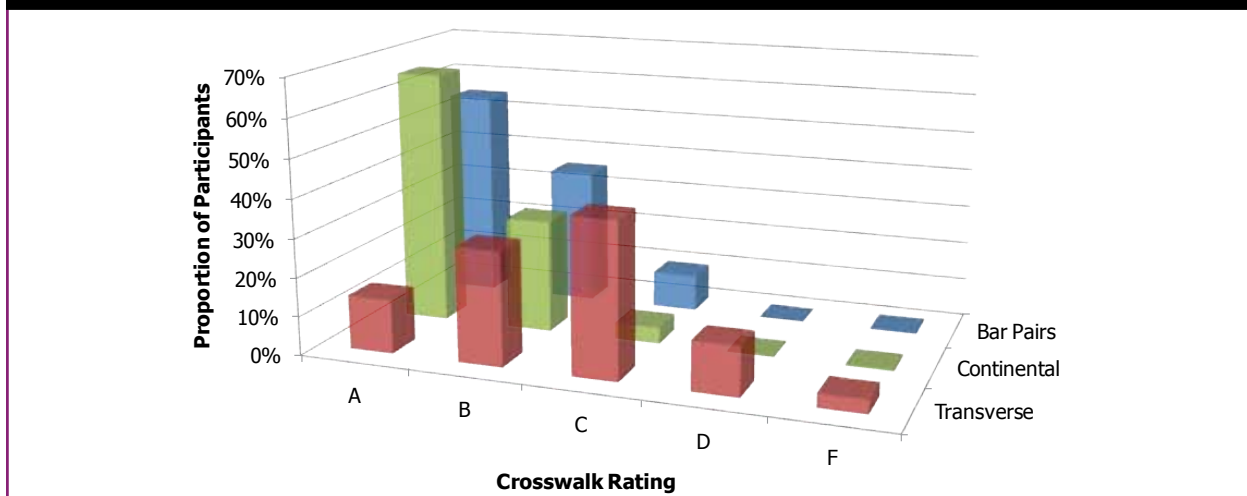
The subjective ratings of visibility using the letter-grade system were compared for all the groups/variables identified in the preceding analysis. The ratings for continental and bar pairs were consistent over various comparison groups, with better ratings for bar pairs and continental markings than for transverse markings. Figure 7 shows the overall rating received by each marking type for study sites.

Conclusions

The conclusions from this study are as follows:

- The detection distances to continental and bar pairs are statistically similar. The detection distances to continental and bar pairs are statistically different from transverse markings.
- For the existing midblock locations, a general observation is that the continental marking was detected at about twice the distance upstream as the transverse marking during daytime conditions. This increase in distance reflects 8 s of increased awareness of the crossing for a 30-mi/h operating speed.
- The results of the appearance ratings of the markings on a scale of A to F mirrored the findings from the detection distance evaluation. Participants preferred the continental and bar pairs markings over the transverse markings.
- Participants gave the continental and bar pairs markings similar ratings during both the day and night. However, the transverse marking ratings differed based on the light level. The participants gave slightly better ratings, although still worse than continental or bar pairs markings, for transverse markings during the nighttime as compared to the daytime. The lower ratings during daylight conditions could be due to sun glare or shadow issues mentioned by the participants.

Figure 7. Graph. Rating by marking type for study sites.



Recommendations

Based on the findings from this research, the researchers recommend that consideration be given to revising the MUTCD as follows:

- Add bar pairs as a usable crosswalk pattern.
- Provide typical dimensions for the marking patterns including spacing that will assist in avoiding wheel paths.
- Consider making bar pairs or continental the “default” for all crosswalks across uncontrolled approaches (i.e., not controlled by signals or stop signs), with exceptions allowing transverse lines where engineering judgment determines that such markings would be adequate, such as a location with low-speed residential streets.

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Key Words—Crosswalk marking types, Driver preference of marking types, and Unsignalized intersection.

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