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Safety effectiveness of pavement design treatment at intersections: Left turning vehicles and pedestrians on crosswalks

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ABSTRACT

Pedestrians are the most vulnerable road users as they are more exposed than other road users. Pedestrian safety at road intersections still remains the most vital and yet unsolved issue. One of the critical points in pedestrian safety is the occurrence of accidents between left-turning vehicle and pedestrians on crosswalks at signalized intersections. A crosswalk is a place designated for pedestrians and cyclists to cross vehicular roads safely. Drivers are expected to give priority to pedestrians or cyclists during interactions between them on the crosswalk. If a driver exhibits non-yielding behavior, the interaction will turn into a collision. This study examined the safety effect of three crosswalks designed with different materials such as red-colored material or brick pavement based on a safety performance study. The safety performance study considered left-turning driver's gap acceptance behavior and the severity of traffic conflict events between left-turning vehicles and pedestrians. The results of the study indicates that using brick pavement on a crosswalk increases the safety level of the crosswalk. Drivers at such crosswalks are more acquiescent to the priority rule.

1. Introduction

Road intersections are very important and crucial locations where conflicts between different road users travelling from different directions are easily generated. To control traffic from different directions, traffic signals are very commonly used at intersections. They are operated for controlling the movement of conflicting road users. At a signalized intersection, usually, left-turning vehicle drivers (in a left-hand traffic system) are permitted to use the same signal phase that is allocated for the through vehicle. For operational efficiency of traffic, pedestrians are also allowed to use the same signal phase along with through vehicles from the same direction. The through vehicles and pedestrians move parallel to each other, while left-turning vehicles turn through the crosswalk by cutting the walking line of pedestrians (Fig. 1). Since a crosswalk is the place designated for pedestrians to cross the road safely, the maneuvering of turning vehicles at crosswalks is characterized by their compliance with the priority rule: in interactions between left-turning vehicles and pedestrians on a crosswalk, the pedestrians should be allowed to pass first.

Interactions between pedestrians and left-turning vehicles at crosswalks are critical situations in which the driver has to show modest behavior by changing his speed to avoid collision with the pedestrian. If the driver fails to do this, the interaction will turn into a collision. Accident data reveal that numerous accidents involved left-turning vehicles and pedestrians on crosswalks. In Japan, in the period 2008 to 2012, 49% of all pedestrian accidents occurred at signalized intersections. Of these accidents, 7.8% fatalities involved left-turning vehicles and pedestrians [1]. This indicates that left-turning vehicles do not give priority to pedestrians properly on crosswalks. Many situations, including invisibility problem, traffic volume, road geometry, road user behavior, and traffic signaling policy, may influence such accidents. Some researchers identified several factors influencing the yielding behavior of drivers, including speed limits and number of lanes [2], pedestrians' distance from the curb [3], pedestrians' clothes [4], and the number of pedestrians waiting to cross [5]. The number and positions of pedestrians were also studied in some other works [6,7].

Among all road users, pedestrians are the most vulnerable road user as they are the least unprotected users. In a collision between a car and a pedestrian, the severity is high for the pedestrian. In such a collision, usually, the car does not face any danger except for the risk of hitting other objects or cars because of the swerving motion for avoiding collision with the pedestrian. Therefore, it is important to ensure pedestrian safety on crosswalks. Some countermeasures such as roundabouts, raised crosswalks, curb extensions, raised intersections, and right-turn

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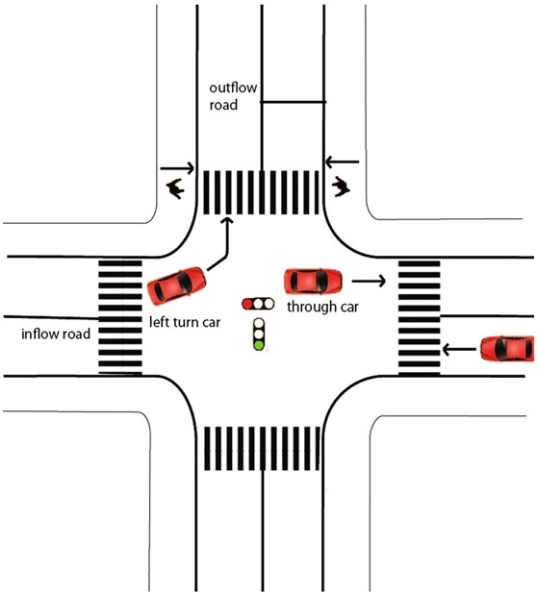

Fig. 1. Pedestrian and car directions when the signal is green.

channels, were implemented in order to improve pedestrian safety. However, all of these countermeasures have some limitations depending on the different road characteristics. It is more desirable to explore and execute new low-cost engineering solutions to improve pedestrian safety on crosswalks.

Some researchers found that there is a close relationship between road geometry and road user behavior [8–10]. Considering this, the main purpose of this study is to investigate the effect of brick pavement or red color at intersections on the behavior of left-turning vehicle and evaluate their contribution to pedestrian safety on crosswalks. In this study, a comparative safety analysis with three pavement design scenarios was conducted on the basis of the gap acceptance of left-turning cars and the traffic conflict analysis method. The three scenarios are listed below:

1. No pavement design
2. Red colored pavement design
3. Brick pavement design

Each of these three signalized intersections were installed in a segment of an urban road one by one (Fig. 2). Except for the pavement design, all other traffic characteristics were almost the same (Tables 1, 2).

This remaining parts of this paper are arranged as follows: After an introduction, the background related to gap acceptance and traffic conflict analysis study is described. Next, the paper describes the safety performance method, linking gap acceptance and Swedish traffic conflict analysis. Thereafter, the result and conclusions and future works related to this study are discussed.

2. Study Background

In order to study safety performance, two topics are reviewed and summarized: the gap acceptance study and the traffic conflict analysis.

Fig. 2. Three sites with different pavement designs (Source: Google Map).

Table 1
Geometric and traffic characteristics at observational sites.

Intersection	Average left turning car	Average pedestrian /cyclist		Intersection corner angle	Width of Major road (m)	Width of Minor road (m)
	(veh/h)	Ped.	Cyc.			
No pavement design	6	12	17	90°	6	6
Red colored pavement	8	9	13	90°	6	6
Brick pavement	5	7	13	90°	6	6