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Gap acceptance of pedestrians at overpass locations

Y. Alver *, P. Onelcin

Ege University, Faculty of Engineering, Civil Engineering Department, Izmir, Turkey

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ABSTRACT

Most of the studies related to pedestrian behavior focus on signalized intersections while a few focus on overpasses. In this study pedestrians' behaviors at overpass locations are investigated. For this purpose, two overpass locations were selected and pedestrians either using the overpass or crossing illegally were recorded by video cameras and 2713 accepted/rejected time gaps were measured. Raff's method (deterministic approach) is used to estimate the critical gap. The collected data were then evaluated by a binary logit model (probabilistic approach) to estimate time gaps. The selected overpasses were observed on weekdays continuously for six hours. At the overpass locations 656 illegal crossings were observed on weekdays continuously for six hours. Safety margin of 377 pedestrians were evaluated by ANOVA analysis to identify the significant factors. ANOVA results revealed that interactions of gender, age, and vehicle position, items carrying, group size had significant effects on safety margin.

1. Introduction

Overpasses are designed for pedestrians to avoid pedestrian-vehicle interactions. Building grade separated facilities appear to be an effective countermeasure but if only they are preferred by pedestrians. In most cases pedestrians cross at street level to save time and this may lead to risky situations. Here, gap acceptance gains importance which changes for each pedestrian. Critical gap is defined as "the time in seconds below which a pedestrian will not attempt to begin crossing the street. If the available gap is greater than the critical gap, it is assumed that the pedestrian will cross, but if the available gap is less than the critical gap, it is assumed that the pedestrian will not cross." (HCM, 2010). Raff and Hart (1950) defined the critical lag as the gap with the property that the number of accepted lags shorter than it is equal to the number of rejected gaps longer than it. The authors did not consider the gaps in their study. On the other hand, some researchers stated that lag and gap data can be combined (Fitzpatrick, 1991; Solberg & Oppenlander, 1966).

Pedestrians who cross when the lanes are clear are not exposed to great danger. However, at streets where the traffic volume is high it is not expected that pedestrians wait for the lanes to be clear to cross especially where the speed is low. They might use rolling gap instead (Brewer, Fitzpatrick, Whitacre, & Lord, 2006). Depending on the conditions at the time a pedestrian attempts to cross gaps are defined as available, accepted, and rejected gaps and depending on the characteristics of the site gaps are defined as adequate and critical gap. Brewer et al. (2006) found that 85th percentile accepted gaps varied between 5.3 and 9.4 s. The average accepted gap was found to be 8.4 s which is identical to the finding of Koh and Wong (2014) for non-complying pedestrians who crossed during a red light.

* Corresponding author.
E-mail address: yalcin.alver@ege.edu.tr (Y. Alver).

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Critical gap consists of two components: crossing time and safety margin. The crossing time is defined as the time needed for a pedestrian to cross a particular street (from the time a pedestrian steps into the lane until reaches the sidewalk on the other side of the road). Safety margin is defined as the difference between the time a pedestrian crosses the traffic and the time the next vehicle arrives at the crossing point (Chu & Baltes, 2001).

Safety margin studies have commonly been conducted in virtual environments via simulators for midblock (Dommes, Cavallo, Vienne, & Aillerie, 2012; Lobjois & Cavallo, 2009; Oxley, Ihsen, Fildes, Charlton, & Day, 2005) and for intersections (Liu & Tung, 2014). Some studies have been conducted on site for midblock (Brewer et al., 2006; Kadali & Vedagiri, 2013; Oxley, Fildes, Ihsen, Charlton, & Day, 1997; Zhuang & Wu, 2012) and for intersections (Koh & Wong, 2014; Onelcin & Alver, 2015).

The effect of age and sex (Connelly, Conaglen, Parsonson, & Isler, 1998; Dommes et al., 2012; Guo, Gao, Yang, & Jiang, 2011; Liu & Tung, 2014; Lobjois, Benguigui, & Cavallo, 2013; Lobjois & Cavallo, 2007; Oxley et al., 2005; Rosenbloom, 2009; Wang, Guo, Gao, & Bubb, 2011), group size (Brosseau, Zangenehpour, Saunier, & Miranda-Moreno, 2013; Dommes, Granié, Cloutier, Coquelet, & Huguenin-Richard, 2015; Rosenbloom, 2009), vehicle type (Das, Manski, & Manuszak, 2003) have been investigated on pedestrian behavior.

Overpasses prevent interruptions to the traffic therefore, reduce the delay of motorized vehicles and provide an increase in the vehicle speed. However, the noncompliant behavior of pedestrians disrupts the ideal conditions. A pedestrian who waits for an available gap might become impatient and accept a smaller gap and this may force the driver to slow down and yield the pedestrian. Khatoon, Tiwari, and Chatterjee (2013) compared the risk taking behavior of pedestrians before and after the construction of grade separated facilities. The relation between waiting time and accepted gaps showed that pedestrians accepted smaller gaps after the construction of the grade separator.

Rasanen, Lajunen, Alticafarbay, and Aydin (2007) observed five different kinds of pedestrian overpasses on the two one-way main streets in Turkey. Both overpass users and the pedestrian crossings at street level within 25 m of the overpass were considered. Familiarity with the area and time saving affected the pedestrians' choice whether to use the overpass or not. The authors suggested that overpass use was rather a habit than coincidental behavior. Demiroz et al. (2015) investigated four overpass locations in Izmir, Turkey to determine the crossing time, crossing speed of the pedestrians, and their gap perception.

The aim of this research is to investigate pedestrians' gap acceptance and safety margin for overpass locations in Izmir, Turkey. The effect of several factors, such as gender, age, group size on safety margin has been analyzed by ANOVA. The critical gap is computed by Raff's method and a binary logit model is used to compute the probability that a pedestrian accepts a gap to cross the street. This study differs from previous studies in terms of the observation sites chosen to analyze illegal crossings.

2. Data collection

Two overpass locations have been investigated to analyze illegal crossings and overpass use in Izmir, Turkey. Izmir is the third biggest city of Turkey. There are 4,113,072 inhabitants in Izmir. The number of vehicles is 1,135,325 by September 2014 of which 604,671 are private vehicles. Fig. 1 shows drawings of observed overpasses and Fig. 2 shows photographs of the observed overpasses.

Ucyol overpass is located in Ucyol and spans two lanes in each direction, totalling four lanes of traffic, with a posted speed limit of 50 km/h. Pedestrians reach the top of the overpass by climbing up stairs. No escalator or elevator is available for pedestrian use. There are 46 steps and most of them are broken making it impossible in particular for elderly pedestrians to climb up. The road is divided by a 0.9 m wide and 0.15 m high median without any barrier or fence on it, allowing pedestrians to wait for an available gap to cross the second side of the road. The overpass in Ucyol is built on a major road that has both commercial and residential areas along both sides of the road. Bus stops and shopping places close to the overpass increase pedestrian volume in this area.

Kostence overpass is located in Gaziemir and spans three lanes in each direction, totalling six lanes of traffic, with a posted speed limit of 70 km/h. Pedestrians reach the top of the overpass by climbing up stairs. No escalator or elevator is available for pedestrian use. The road is divided by a 3.7 m wide and 0.6 m high median without any barrier or fence on it. The overpass in Gaziemir is built in a residential area and there is a public hospital within a walking distance. Parking is observed during the video recordings. There is also a bus stop located just under the overpass. Buses preclude the curbside lane from being used during the stopping time. Pedestrians cross the first lane confidently during the time that the bus stops. Both parking vehicles and stopping buses generate a safe crossing environment in the first lane for pedestrians. In this research pedestrians' gap acceptance in flowing traffic is of interest and therefore the first lane is ignored. Hence, gap acceptance of pedestrians at the second and the third lane are considered.

Data were collected at the overpass locations using a video recording technique. Video cameras were fixed at the top of the overpasses and on the sidewalks to observe pedestrians crossing illegally and using the overpass. Observations were made for six hours (12.00–18.00) to catch both the peak hour and off peak hour traffic. The number of observed pedestrians using the overpass and crossing at street level is given in Table 1. In total 656 illegal crossings were observed.