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Road and Rail Infrastructure V

Stjepan Lakušić – EDITOR

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COMPARISON OF PEDESTRIAN BEHAVIOUR AT SIGNALIZED INTERSECTIONS AND OVERPASS LOCATIONS – CASE STUDY OF IZMIR, TURKEY

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Abstract

Vehicle – pedestrian collisions may result in serious injuries or fatalities. In order to reduce the number of collisions physical and operational measures are implemented. At signalized intersections pedestrian and vehicle flows are allowed to cross the common spatial zone at different times. In order to completely separate these two flows overpasses are built. In either case, a considerable number of pedestrians take the risk of crossing illegally (violating the red light rule or crossing at street level). Previously, two signalized intersections and two overpass locations in Izmir, Turkey were analysed in terms of the pedestrians' crossing speed and safety margins. In this study the data collected from these locations are compared. The observed areas have similar characteristics, such as the number of lanes, the posted speed limit. The overpasses do not serve an escalator or an elevator. The roads where the overpasses are located are divided by a median without any barrier or fence on it, thus providing an alternative crossing for pedestrians who do not prefer climbing the stairs. The signalized intersections are four-legged and offer similar cycle durations. A total of 1692 pedestrians at signalized intersections and a total of 836 pedestrians at overpass locations are observed. The attitude of pedestrians towards these two types of countermeasures will provide an insight to pedestrian risk perception.

Keywords: pedestrian behaviour, signalized intersections, overpasses, crossing speed, safety margin

1 Introduction

Vehicle – pedestrian collisions may result in serious injuries or fatalities. In order to reduce the number of collisions physical and operational measures are implemented. Signalized intersections and grade separated facilities are built to avoid pedestrian accidents. At signalized intersections pedestrian and vehicle flows are allowed to cross the common spatial zone at different times. On the other hand, in order to completely separate vehicle and pedestrian flows grade separated facilities are built. Although both countermeasures are beneficial for pedestrians' safety, pedestrians' tendency to use these facilities is critical. Pedestrians who wait for the green signal at signalized intersections and who use overpasses to cross the other side of the road are referred to as compliers. Pedestrians who cross at red signal or away from the crosswalk at signalized intersections and who cross at street level where overpasses exist are referred to as noncompliers. Pedestrians' crossing speed and safety margin might show variations due to traffic conditions, environmental factors, and pedestrians' characteristics such as gender, age, etc. In this study two signalized intersections and two overpass locations in Izmir, Turkey were analysed in terms of the pedestrians' crossing speed and safety margins. The data of noncompliers were extracted and compared for both type of pedestrian facilities.

In several countries pedestrians' crossing speed has been a research subject. In Australia, [1] found the average crossing speed to be 1.24 m/s at signalized intersections where the 15^{th} percentile crossing speed varied from 1.18 to 1.59 m/s. In Jordan, [2] recommended an average 15^{th} percentile speed of 1.11 m/s for design purposes. In Wisconsin, USA, [3] recommended a walking speed of 1,16 m/s at locations with normal pedestrian demographics and locations where the age or physical disability status of the pedestrian population is unknown. In Malaysia, 15th percentile crossing speed is found to be 1.09 m/s [4]. Highway Capacity Manual 2010 suggest a walking speed of 1.2 m/s [5]. In Turkey, 1.4 m/s a crossing speed is recommended which is relatively higher than HCM 2010 value [6].
Parameters affecting pedestrians' crossing speed have been investigated in previous studies. Researchers have specially given importance to parameters such as gender, age, group size, pedestrians' disability, number of lanes, the existence of a median, etc. It is generally found that males walked faster than females [2, 3, 4, 7]. Age has generally been grouped into three categories as children, adults and elderly pedestrians. Pedestrians who are older than 65 years has been accepted as elderly pedestrians [2, 3]. The results of the past studies showed that young pedestrians walked faster compared to adults and elderly pedestrians [2, 7, 8, 9]. Thus, at pedestrian crossings and intersections the minimum durations for pedestrian phases should be designed taking into account the elderly population [9]. Pedestrians who crossed individually walked faster than pedestrians who walked in groups [2, 3].
[10], studied the parameters that influence overpass use in Turkey. Researchers investigated the pedestrian behaviors within 25 meters away from overpass at both sides. [11] investigated the parameters contributing to overpass selection. In Delhi, five hundred pedestrians were interviewed to understand pedestrians' perceptions for pedestrian facilities. It is found that effectiveness of a grade-separated crossing depends on its perceived ease of use by the pedestrians [12].
[13] defines safety margin as: "The difference between the time a pedestrian crosses the traffic and the time the next vehicle arrives at the crossing point". Safety margin studies have commonly been conducted in virtual environments via simulators for midblock [14, 15, 16] and for intersections [17]. On site data have been used for gap studies, as well [18, 19, 20].
Two signalized intersections and two overpass locations in Izmir, Turkey were analysed in terms of the pedestrians' crossing speed, and safety margins, previously. In this study the data collected from these locations are compared. The attitude of pedestrians towards these two types of countermeasures will provide an insight to pedestrian risk perception.

2 Method

2.1 Study sites

Two signalized intersections and two overpass locations were observed in Izmir, Turkey. The posted speed limit is 50 km/h at all the observed locations. The signalized intersections are four-legged and are located in a central business district. The signals are activated via preprogramming. The length of the crosswalk in Sair Esref intersection is 22.50 m and its width is 3.45 m. The cycle length was 80 s of which the green signal duration was 16 s. In Cankaya intersection, the cycle length was 90 s. of which the green signal duration was 23 s. The length and the width of the crosswalk is 18.6 m and 3.82 m, respectively.
At overpass locations, pedestrians can reach the top of the overpass by climbing up stairs. The overpasses do not serve an escalator or an elevator. The roads where the overpasses are located are divided by a median without any barrier or fence on it, thus providing an alternative crossing for pedestrians who do not prefer climbing up the stairs. The overpasses have commercial and residential areas along both sides of the road. In Figure 1 photographs of the observed locations are demonstrated.

Figure 1 Photographs of the observed locations: a) Sair Esref intersection, b) Cankaya intersection, c) Ucyol overpass, d) Konak overpass

2.2 Data collection

Data was collected with video recording technique. Video cameras were mounted on specially built tripods reaching a height of 3 m to observe the noncompliers within 25 m from the signalized intersection and overpass. Recordings were made during afternoon and evening peak hours.
In literature the effect of several parameters on pedestrian behavior were investigated. In this study four of those parameters were included in the analyses, namely gender, age, group size, and items carrying. Apart from these parameters pedestrians' crossing time and safety margin were computed, as well. The extracted data were recorded into an Excel spreadsheet. For safety margin analysis, only the data of the first lane crossings were evaluated. Pedestrians could be at either side of the road (at refuge, at sidewalk or at the parking lane). The first lane is the lane that the pedestrian started crossing from either side of the road.
ANOVA analyses were conducted to reveal the factors affecting the pedestrian walking speed. Age was grouped into three categories: 19 or less, 20-64, and over 65 years old. Group size was categorized into two groups: individuals, and pedestrians who walked within a group of two and more people. Gender and items carrying included two groups. For each category average and 15th percentile crossing speed were computed. The ANOVA tests were performed using SPSS 24.0 software.

3 Results

In Table 1 number of compliers and noncompliers are presented for each observed location. At signalized intersections noncompliers are grouped into two categories. The first category is composed of pedestrians who violate the signal rule and cross during red light. The second category is composed of pedestrians who cross within 25 m from the crosswalk. Safety margin is computed for pedestrians that belonged to the second category. At overpass locations, noncompliers are pedestrians who cross at street level. A total of 1692 pedestrians have been observed at signalized intersections; among those, 60.23 % were noncompliers. At overpass locations a total of 836 pedestrians were observed. It was found that 81.58 % of the observed pedestrians crossed at street level.

Table 1 Number of observed pedestrians at signalized intersections and overpass locations

Location	Sair Esref		Cankaya		Ucyol	Konak
Number of compliers	498		175		92	62
Number of noncompliers	1st category	2nd category	1st category	2nd category	551	131
	484	8	418	109		
Total	990		702		643	193

3.1 Pedestrian crossing speed

Table 2 shows pedestrian mean and 15th percentile speeds in relation to gender, age, group size, and items carrying. The 15th percentile speed means that 85 % of pedestrians walk faster than this speed. The data of the two signalized intersections and two overpass locations were combined for each pedestrian facility. The crossing speeds given in Table 2 belong to the noncompliers.

Table 2 The average and the 15th percentile crossing speeds of noncompliers at each observed location

Pedestrian crossing speed [m/s] / Pedestrian 15th percentile crossing speed [m/s]				
		Signalized intersections		**Overpasses**
		1st category	**2nd category**	
Gender	**Female**	1.27/1.03	1.63/1.36	1.06/0.78
	Male	1.29/1.09	1.54/1.23	1.17/0.89
Age	**< 19**	1.36/1.13	1.45/1.34	1.14/0.81
	20 - 64	1.27/1.03	1.59/1.29	1.14/0.83
	> 65	1.10/0.91	-	1.02/0.74
Group size	**Individual**	1.32/1.09	1.60/1.26	1.14/0.83
	Group of 2+	1.23/1.03	1.47/1.24	1.07/0.82
Items carrying	**With items**	1.27/1.03	1.55/1.34	1.15/0.83
	Without items	1.27/1.07	1.55/1.24	1.08/0.80
Average		1.28/1.03	1.55/1.24	1.13/0.83

At signalized intersections among red light violators males walked faster than females. On the other hand, among pedestrians who crossed away from the crosswalk females walked faster than males. Young pedestrians who belonged to the first category were the fastest compared to other ages groups with an average crossing speed of 1.36 m/s. Pedestrians aged between 20-64 walked faster than young pedestrians in the second category. Pedestrians who crossed in groups walked slower compared to individuals for both categories. Pedestrians who carried items while crossing and pedestrians who walked without any items had the same average crossing speed for both categories, however their 15th percentile crossing speed differed slightly. At overpass locations similar results to signalized intersections were obtained. Young pedestrians and pedestrians aged between 20-64 had the same crossing speed at overpass locations. One significant result is that noncompliers at overpass locations had lower crossing speeds compared to noncompliers at signalized intersections. Anova analysis on crossing speed revealed that gender and age had significant effects on crossing speed at overpass locations. At signalized intersections group size, and age revealed significant effects. Gender did not have a significant effect on crossing speed, however gender*age and gender*items carrying interaction were found to be significant. Table 3 shows Anova results. At overpass locations gender is the most significant factor with $F(1,681) = 6.732$ and $p = 0.010 < 0.05$. At signalized intersections age is found to be the most significant factor with $F(1,989) = 10.583$ and $p = 0.000 < 0.05$.

Table 3 Anova results on crossing speed

Factor	Signalized intersection		Overpass locations	
	F	Significance level	F	Significance level
Gender	-	-	6.732	0.010
Age	10.583	0.000	3.484	0.031
Group size	7.275	0.007	-	-
Gender*Items carrying	3.792	0.050	-	-
Gender*Age	3.386	0.034		

3.2 Pedestrian safety margin

Safety margin is the time that a vehicle needs to arrive to the point where the pedestrian crosses. Safety margin calculations were made excluding the empty lane condition; hence only data of 117 pedestrians were analysed. In Table 4 safety margin values based on gender, age, group size and items carrying are given.

Table 4 Pedestrians' safety margin (s)

		Signalized intersections		Overpasses	
		Average	Std. Deviation	Average	Std. Deviation
Gender	**Female**	13.21	11.58	8.54	6.84
	Male	14.36	8.10	6.98	5.88
Age	**‹ 19**	14.87	13.49	9.98	9.33
	20 - 64	13.76	10.17	7.40	5.96
	› 65	23.20	18.28	7.36	5.98
Group size	**Individual**	14.02	10.58	7.59	6.16
	Group of 2+	14.55	12.25	7.65	6.94
Items carrying	**With items**	15.09	11.86	7.65	6.68
	Without items	13.77	10.84	7.55	5.76
Average		14.21	11.14	7.61	6.34

The average safety margin at signalized intersections is found to be greater compared to overpass locations. This may be related to the traffic volume. At overpass location observed traffic volume is relatively higher. This may result in lower vehicle speeds and pedestrians may take the risk of crossing with lower safety margins. At signalized intersections pedestrians over 65 years old had the highest safety margin. This is in line with the previous findings.

4 Conclusion

Pedestrians' crossing behaviour has been investigated for two type of pedestrian facilities. It is found that pedestrians' noncompliance rate is higher at overpass locations This may be due to the overpass characteristics, pedestrians' age, physical ability or timesaving. Pedestrians' age is a contributing factor to overpass use since elderly population may have difficulties in climbing up the stairs.
Age is found to be a significant factor affecting the crossing speed. Younger pedestrians walked faster than elderly pedestrians. Average safety margin at overpass locations were found to be the half of the safety margin computed at signalized intersections. The high traffic volume could be related to this finding since pedestrians could perceive lower risk where vehicle speed was lower due to congestion.
Signalized intersections and grade separated facilities are built to avoid pedestrian accidents. In order to benefit most of these facilities pedestrians' characteristics, pedestrian demographics, traffic and environmental conditions should all be well-investigated.

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