The perception of Malaysian pedestrians towards the use of footbridges

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The footbridge is a vital structure in the road network and a cornerstone among crossing facilities. Yet, it suffers from the low usage by pedestrians as they try to cross the street on the level. This study endeavours to analyse the perceptions of Malaysian pedestrians towards the use of footbridges with the consideration of different factors. This was carried out by collecting data from both the field and the questionnaire to be analysed by using the multiple linear regression models. The study found that the most influential factor cited by pedestrians in making a decision to use the footbridge is the existence of an escalator. Hurriedness and the fear of heights were significantly associated with choosing not to use the footbridge. Zebra crossing was chosen as the most favourable type of crossing facility by the majority of respondents. Also, installation of fence and barriers were proposed as procedures to prevent jaywalking. For building new and effective footbridges in the future, the study suggests considering the traffic volume, the posted speed limit and lanes number, as these are the most influential factors to predict the usage rate. The study also encourages the decision makers and the stakeholders to consider providing escalators for the new footbridges. These findings will provide information to help the authorities in enhancing the safety procedures for the pedestrians in Malaysia.

Keywords: footbridge; usage rate; pedestrian safety; pedestrian preferences; multiple linear regressions

Introduction:

In the last two decades, Malaysian authorities have proposed many solutions in order to reduce the road fatalities down to 50% through an integrated road safety plan extending until the year 2020 (Malaysian Institute of Road Safety Research 2014). For this purpose, pedestrians' infrastructures were built, and appropriate procedures to enhance the compliance with safety were implemented (Rizati, Ishak, and Endut 2013). For instance, the authorities tried to organize the relationship between the pedestrians and the road they walk in by defining the safe corridors and crossings for them so that any pedestrian who leaves the sidewalk and walks on the carriageway will be subjected to pay a fine of 500 Malaysian Ringgit (MALAYSIA 1987). The same goes to the pedestrian who is just a hundred meters from the pedestrians crossing, and yet doesn't use it (MALAYSIA 1987). With regard to providing convenient facilities, decision makers focused on the urban areas where the number of accidents and injuries is higher than in rural areas, therefore, a higher number of footbridges were built in order to secure the safety of pedestrians when crossing the streets in the congested cities (Arias Gallegos 2012). This structure has effective characteristics that secure maximum safety, yet it suffers from the low usage by pedestrians as they try to cross the street on the level (Rizati, Ishak, and Endut 2013, Räsänen et al. 2007). This behaviour leads to increase the proportion of accidents and death rate, and will badly affect the free traffic flow. Perhaps the insufficient safety awareness is one of the most important causes of such a behaviour, and this will pose a challenge to convince these pedestrians to get used to utilize the footbridge instead of jaywalking, which is very similar to convince people to fasten the seatbelt while driving, or to wear the helmet while riding (Sabet 2013). In addition, the case of infrequent usage at some locations compared to the high cost of building will call for the reconsideration of alternative cheaper crossing facilities to footbridges (Rizati, Ishak, and Endut 2013).

All of the aforementioned suggests that shifting of footbridges' utilization to a higher level is still unfulfilled, and some gaps still need to be researched such as what is the pedestrians' perception under the impact of various factors, and what are their preferences when crossing the road. These questions were investigated in this study by distributing a questionnaire among the pedestrians in the area of four footbridges in Ipoh city, Malaysia. A multiple linear regression was built in order to analyse the contributing factors to the usage rate of the footbridges.

Methodology:

Study Sites:

The study was conducted in the city of Ipoh, the fourth largest city in Malaysia. Out of seven footbridges located in Ipoh CDB (Central Business District) and the Old Town of Ipoh, four different bridges were chosen for the study. Each area of each footbridge included elementary or secondary schools, shopping malls, bus stops, car parking and some houses and restaurants. These various facilities and amenities were well used by the population in their journeys. The characteristics of footbridges and roads are summarized in Table 1. All footbridges were covered, and sidewalks were supplied by fencing in each location. Bridge 1 and 4 were provided with lighting and tile surface, while Bridge 2 and 3 had no lighting, and the surface was just plain concert without tile covering. The street beneath each of Bridge 2 and 3 has a two-way road that is separated by a median. Also, the road has a traffic signal on each of Bridge 2 and 4 locations. Fig. 1 shows photos of the four footbridges.

In order to provide sufficient data for building a multiple linear regression models, second round of data collection was executed in the following cities: Chow Kit (Kuala Lumpur), George Town (Penang), Kajang (Selangor), and Seremban (Negeri Sembilan). One footbridge was chosen from each city to be studied. The characteristics of footbridges and roads are summarized in Table 2. All footbridges were covered, and all of them were provided with lighting except for the footbridge of Seremban area. The tile surface was only provided for the footbridge of Chow Kit area, while the rest had concrete surface. The street beneath each footbridge of Kajang and Seremban area has a two-way road that is separated by a median. Also, the road has a traffic signal for all footbridges except for the footbridge of George Town area.

Data Collection:

Observations of pedestrians who crossed the area were conducted in order to count their volumes. The usage rate, which is the ratio between people using the footbridge and the total number of people crossing the road, was calculated. Volumes of pedestrians were counted by the manual counters, for the people who were on the footbridge and on the street within one hundred meters away from the footbridge location on both sides, and for every 15 minutes interval during three peak periods, each period lasting an hour: (10:00-11:00 am), (2:00-3:00 pm), (5:00-6:00 pm), for one week for each footbridge including the weekends. Pedestrians were classified as male, female, children, and physically challenged. At the same time of the pedestrians' counting periods, vehicles volumes were counted manually. The speed of each chosen vehicle was measured by the laser gun, and this was only for the first vehicle in a queue, or for separated cars with an acceptable distance (minimum 7 seconds time distance), excluding vehicles following too closely.

Pedestrians' Perception Survey:

A questionnaire was designed and distributed on the street among the public. The design of the questionnaire contained questions about pedestrians' perception towards using the footbridge under the impact of various factors. These factors represent the role of some structure elements of the footbridge, and the effect of some proposed traffic treatments and situations on pedestrians' choices and preferences. In order to guarantee the simplicity of the questionnaire for both participants and analysis process, the scale of each answer was chosen to range from 1 to 2 (No=1 or Yes=2). In order to understand whether these questions in the questionnaire are all reliably measuring the same desired variable (i.e. the use or non-use of the footbridge), a Cronbach's alpha test was carried out. The test resulted in an acceptable value of 0.71, which shows that convenient feedbacks were obtained from the stated questions to be used in explaining the pedestrians' perception.

Pedestrians are heterogeneous in their characteristics (age, gender, etc.), therefore sampling the studied population is required. In this study, the quota sampling was chosen to be used. On the site, the author kept inviting the pedestrians to participate in filling the questionnaire until each quota was filled, and the total sample size was completed. The following equation was used to determine the sample size (Yamane 1967):

$$n = N/(1 + N * e^2) \qquad \text{Eq (1)}$$

Where n = the sample size, N = the peak fifteen minutes pedestrian population who crossed the area, e = margin of error, which is determined to be 5. Respondents for this study were in total 191 pedestrians (age ranged from 11 to over than 59 years, 62.3% male).

Data Analysis:

SPSS software (Statistical Package for Social Science.V.20) was used in analysing and interpreting the collected data for this study. This program is used most frequently by researchers in many fields such as engineering, health, science, education, and psychology.

Results:

Usage Rates of the Footbridges:

Table 3 shows the usage rates of the four footbridges, as well as the vehicles speed and volume. The highest percentage of users was 74% for the Bridge1 with one direction of traffic and four lanes street. Bridge 3 had 60% of pedestrians' volume as users, while the usage rate for Bridge 2 was as low as 35%. The lowest share of users was 19% for Bridge 4 with the existence of a traffic signal. Traffic volume was the highest at the street of Bridge 1, followed by smaller volumes at streets of Bridge 2, 4 and 3 respectively. The 85th percentile spotted speed for vehicles during one hour of measurement was on average 53 km/h for Bridge 1, 2 and 3, while it was 33 km/h for Bridge 4.

Table 4 shows the usage rates for each footbridge from each city of the second round of data collection. The highest percentage of users was 75% for the footbridge of Kajang area, while the footbridge of Chow Kit area had the lowest pedestrians' volume as users of 22%. Traffic volume was the highest at the street of George Town area, while the highest 85th percentile spotted speed for vehicles during one hour of measurement was 57 km/h for the footbridge of Seremban area.

Participants' Perception Under the Impact of Various Factors in Ipoh City:

Participants of this study were asked about their past involvement in traffic accidents while walking, and 61% of them stated that they had no accidents in the past. Of this percentage, 57% were footbridge users, and 43% were non-users. Men were more involved in accidents in the past than women. Statistically, there was no significant impact of the past involvement in traffic accidents on the footbridge usage.

Another question was to investigate if the provision of entertainment, such as free mobile applications or free cold water, will encourage people to use the footbridge more. This type of methods was implemented by several studies using behavioural theories, such as attracting pedestrians to use the footbridge by placing a candy dispenser in the middle of the deck (Arias Gallegos 2012). From results, people who thought that the entertainment will attract them to utilize the footbridge formed 72.3% of all participants, and of this percentage, users were 60.1% and the non-users were 39.9%.

The majority of the participants (79.1%) agreed that the law enforcement in the field of safety is weak, and that drove the study to request the participants to state their opinion about how effective is the law with regard to the use of the footbridge. More than half of the participants (51.8%) ranked the law enforcement as ineffective, while 31.4% believed that it is reasonably effective. As the previous studies about using the footbridge proposed to strengthen the capacities of governments in law implementation (Sabet 2013, Hidalgo-Solórzano et al. 2010), the participants were asked to state their opinion about proposing a national policy of making the use of the existed footbridge as mandatory. More than half of the participants (59.2%) believed that a nation-wide safety-enhancement policy that notices the footbridge as a mandatory crossing will be a beneficial one in the field of pedestrians' safety. A statistically significant association was found between considering this national policy and the use of the footbridge (χ^2 (1, N=191) = 7.062, p = 0.008, and Phi & Cramer's v = 0.192). This means that a higher percentage of footbridge user participants believed in the feasibility of a national policy of considering the footbridge as a mandatory crossing than non-user participants.

From another point of view, participants were asked if they will be attracted by the shape of the footbridge and its beauty. 78.5% of the participants stated that they would like to utilize a well-designed footbridge in their journeys rather than jaywalking. 59.7% of the participants assessed the footbridge location in the studied area as appropriately located while 40.3% disagreed, which reflects the dissatisfaction of some participants and explains why they avoided it. Furthermore, the questionnaire aimed to obtain the participants' willingness to utilize the footbridge if they are in a hurry. Most of the participants (78.5%) chose to jaywalk in the case of being in a hurry. The Chi-square test for association indicated that there is an association between being in a hurry and choosing not to use the footbridge (χ^2 (1, N=191) = 8.946, p = 0.003, and Phi & Cramer's v = 0.216). The whole participants in the sample were asked to name their most preferred crossing facility to utilize in their crossing. The ranks showed that the highest percentage was for the free crossing (32.5%) followed by the zebra crossing (25.1%). The underpass came in the last ranking of preferences (7.9%) as the least popular

crossing. The majority of non-user participants (74.1%) stated that they will use the zebra crossing instead of the footbridge

The participants were asked if they have fears of using the footbridge because of its height. 38.2% of them considered the fear of height as a source of discomfort while utilizing the footbridge and this was one of the causes of not using the footbridge by 58% of non-user participants. Half of the female participants in this study stated that they have a fear of heights. The Chi-square test for association indicated that there is an association between the fear of heights and both of gender of the participant and being a user or non-user of the footbridge (χ^2_{gender} (1, N=191) = 8.488, p = 0.004, and Phi & Cramer's v = 0.211 and χ^2_{usage} (1, N=191) = 23.363, $p < 0.0005$, and Phi & Cramer's v = 0.350).

From a structural point of view, most of the participants (82.2%) approved that installing fence and barriers at the street and the median will prevent jaywalking. Noteworthy, the majority of footbridge non-users (82.7%) believed in having intentions to change their behaviour and start using the footbridge due to these barriers installation.

In order to investigate the suitable procedure for increasing the usage rate, participants' opinions were obtained about what an escalator can add to the footbridge in order to increase its usage rate. The results showed that 82.7% of respondents approved that the existence of the escalator will encourage them to utilize the footbridge constantly. Remarkably, the results included 66 non-users (81.5%) who chose to reconsider using the footbridge while crossing the street in the presence of an escalator.

The drawn results from the questionnaire about participants' safety awareness showed that the majority of them (82.7%) believed in the greatness of parents' role in safety education. The survey showed that more than half of participants (52.4%) opted the television as the most preferred source of safety education, followed by the internet (26.2%), the radio (11.5%), and the newspaper (9.9%). There was a statistically association between the gender of the participant and the preferred source of education (χ^2 (3, N=191) = 8.051, p = 0.045, and Phi & Cramer's v = 0.205), where men were significantly more likely than women to watch the television and use the internet for safety education purposes.

Predictors of the Use of All Pedestrian Footbridges:

In order to analyse the affecting factors on the usage rate of the footbridges, a multiple linear regression was built from the data collected from Ipoh city and the four cities. The dependent variable (Yi) is the usage rate of the pedestrian bridges (continuous scale measured from 0 to 100). On the other hand, the independent variables (Xi) include twelve possible structural factors and factors of traffic characteristics that affect the percentage of the footbridges usage. These factors are: traffic volume, posted speed limit, road width, directional flow, lanes number, fence installation, the existence of a median, traffic light existence, number of stairways, bridge cover, lighting provision and the bridge surface. Out of these factors, only three factors were significant in its association with the footbridge utilization at the 95% significance level, and these are: traffic volume, posted speed limit and lanes number. Table 5 shows all models with the coefficient of determination R^2 and the F test value. The best model by using the stepwise method is model number 3, which relates the usage rate of the footbridges with the traffic volume, posted speed limit and lanes number.

Discussion:

The results showed that pedestrians are different in their perceptions and preferences of ways and options of crossing the road, where some are used to cross by using pedestrians' facilities, and others used to jaywalk. Statistically, the past involvement in traffic accidents had no impact on the use of the footbridge, and this matches the results from previous studies about pedestrians who actually have been hit by a vehicle but are no more likely to use footbridges (Sabet 2013). The study confirmed that being in a hurry is an important factor of not using the footbridge. The study by Sabet (2013) found that hurriedness causes the lack of pedestrians' adherence to the legal crossing and offers a good predictor of the footbridge use. In the case of the low rate of usage, some studies suggested the zebra and signalized crossings to be the replacements for the footbridge (Mutto, Kobusingye, and Lett 2002, Rizati, Ishak, and Endut 2013, Sisiopiku and Akin 2003). The strategic location of the footbridge was cited in some studies as a major cause of not using the footbridge (Rizati, Ishak, and Endut 2013, Sabet 2013). The fear of using the footbridge because of its height was found to be statistically significant factor associated with non-using of the footbridge (Opdyke, Williford, and North 1995, Juan and Pérez 2009). On the other hand, it was found that fence and barrier installation will decrease the road death rate by 10% if these elements were built in sufficient length to block people of getting around it (Arias Gallegos 2012). Many studies have shown that pedestrians are susceptible to pay efforts while climbing stairs, making them feel tired and lazy when they use the footbridge in the future (Mutto, Kobusingye, and Lett 2002, Rizati,

Ishak, and Endut 2013). In such a case, the escalator represents the best solution (Cheung and Lam 1998, Räsänen et al. 2007). From the social viewpoint, the role of parents in educating their children about safety was stated to be essential for making their choices when crossing the street. This corresponds with pedestrians' studies about the role of parents which begins from the early stages of accompanying and supervising the children while walking to the school, until the time when children are ready to walk on their own (Morrongiello and Barton).

The multiple linear models showed that the traffic volume has predicted the usage rate. For instance, the first model can be interpreted as an increase of one vehicle per hour in the traffic volume will be associated with 1.5% increment in the usage rate. A study by Rizati, Ishak, and Endut (2013) found that providing footbridges should consider the factor of high vehicle volume with two directional flows as an influential one. The posted speed limit and lanes number also predicted the usage rate. One of the studies has related the percentage use of the footbridges with the existence of median barrier and the speed on the street (Abojaradeh 2013).

Conclusions:

This study analysed Malaysian pedestrians' perceptions toward the use of footbridges with the consideration of different types of structure elements, traffic situations and traffic treatments. It was concluded that the most influential factor cited by pedestrians in making a decision to use the footbridge is the existence of the escalator. The zebra crosswalk was chosen as the pedestrians' most preferred alternative of the footbridge. The main reasons given by the Malaysian pedestrians for shunning the footbridge are the hurriedness and the fear of heights. Installation of fence and barriers was proposed as a procedure to prevent jaywalking. For considering the building of footbridges in the future, the study suggests making the decision based on the traffic volume, posted speed limit and lanes number, as these are the most influential factors to predict the usage rate.

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Figure.1. Photos of the footbridges in Ipoh city

Table.1. Characteristics of footbridges in Ipoh city

Bridge no.	Characteristics of the Footbridge					Characteristics of the Street beneath the bridge			
	Height (m)	*Length (m)*	*Width (m)*	*Number of stairways*	*Number of steps*	*Width (m)*	*Direction*	*Number of lanes*	*Traffic light existence*
1	8.0	21.8	2.5	2	43	12	1	4	No
2	6.7	24.5	1.7	2	30	17	2	2*2	Yes
3	5.1	23.2	1.85	3	36	19	2	2*2	No
4	5.0	12.9	2.75	2	36	11.75	1	3	Yes

Table.2. Characteristics of footbridges in the four cities

Bridge Location	Characteristics of the Footbridge					Characteristics of the Street beneath the bridge			
	Height (m)	*Length (m)*	*Width (m)*	*Number of stairways*	*Number of steps*	*Width (m)*	*Direction*	*Number of lanes*	*Traffic light existence*
Chow Kit	5.0	23.4	2.0	4	43	9.5	1	3	Yes
George Town	5.75	19.4	1.55	4	34	13.3	1	4	No
Kajang	5.4	35.2	2.6	2	32	19.6	2	3*3	Yes
Seremban	5.4	35.1	1.7	2	39	16.9	2	3*2	Yes

Table.3. Usage rates of footbridges in Ipoh city

Bridge no.	Pedestrians' volume			Street under the bridge	
	n	**Users (%)**	**Non-users (%)**	**Volume (Vehicles/h)**	**85th percentile speed (km/h)**
1	2261	74	26	2964	49
2	1740	35	65	2295	54
3	2842	60	40	1354	55
4	4928	19	81	1482	33

Table.4. Usage rates of footbridges from the four cities

Bridge Location	Pedestrians' volume			Street under the bridge	
	n	Users (%)	Non-users (%)	Volume (Vehicles/h)	85th percentile speed (km/h)
Chow Kit	17458	22	78	1243	31
George Town	1141	55	45	2955	54
Kajang	1813	75	25	2655	55
Seremban	1400	59	41	2810	57

Table.5. The regression models

Model Number	Regression Model	R^2	Adjusted R^2	F value	P value
1	$Y_{Usage\ rate}$= -19.905+ 0.015*$X_{Traffic\ volume}$	0.784	0.748	21.824	0.003
2	$Y_{Usage\ rate}$= 43.217+ 0.017*$X_{Traffic\ volume}$ – 1.722* $X_{Posted\ Speed\ Limit}$	0.925	0.895	30.821	0.002
3	$Y_{Usage\ rate}$= 27.337+ 0.014* $X_{Traffic\ volume}$ – 1.612* $X_{Posted\ Speed\ Limit}$ + 6.546*$X_{Lanes\ Number}$	0.975	0.956	51.269	0.001