

A Study of Footbridge Utilization Behavior in Nakhon Ratchasima

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ABSTRACT

This research studied behavior of pedestrians in Nakhon Ratchasima urban and suburban areas when using footbridge. The data consisted of 1) pedestrian's road crossing behavior, and 2) personal interview using questionnaires. The analysis of the data relied on Logistic Regression Analysis. The study found that factors influencing urban pedestrians in using footbridge comprised 1) the number of pedestrians and 2) the distance between the bus stop and the footbridge. The coefficient of determination $R^2 = 0.763$. The influencing factors for suburban area were 1) self-experience of road accident, 2) proximity to bus stop and 3) know law about pedestrian and 4) the number of co-pedestrians, while $R^2 = 0.470$. Recommended measures to encourage use of footbridge were public relation on pedestrian traffic laws which would help improve ratio of footbridge users by 4.32%, and properly locating footbridges near bus stops.

Keywords: Pedestrian, Footbridge, Behavior, Accident, Crossing the street, Logistic Regression Analysis

1. INTRODUCTION

Global Status Report on Road Safety 2013 revealed that the rate of deaths from road accidents in Thailand is 38.1 per 100,000 populations which was ranked third in the World after the Dominican Republic and Niue. It was also found that 27% of deaths worldwide involved pedestrians and cyclists especially in countries with low-to-moderate income. Pedestrian injuries were largely in urban areas (Híjar, Vazquez-Vela, & Arreola-Risa, 2003) and usually happened to children and elderly (CV Zegeer, Stutts, & Huang, 1996).

In Thailand, a number of pedestrian accidents reached 2,644 in 2011 (Royal Thai Police, 2011). These were caused mainly by behaviors of the pedestrians themselves for example not using a crosswalk or a footbridge and cutting in front of the car in a short distance. The said behaviors became a stimulus for an increasing number of accidents on the roads, resulting in the loss of life and property. The safe alternatives for pedestrians for crossing the roads are for example using the crosswalks and the footbridges. However, at-grade crossing on the crosswalks was still unsafe due to its likely chance for collision with vehicles (Leden, 2002; MacGregor, Smiley, & Dunk, 1999). To make it safe, there must be some safety-assisted facilities around the crosswalks for example road marking (Knoblauch, Nitzburg, & Seifert, 2001; Charles. V. Zegeer et al., 2005), and pedestrian crossing lights (Kennedy & Sexton, 2009; King, Soole, & Ghafourian, 2009; Lambrianidou, Basbas, & Politis, 2013; Lipovac, Vujanic, Maric, & Nesic., 2013). Another alternative for pedestrians which should be made with great attention was the footbridge. It was the safest option as it totally eliminated the chance of conflicts between the vehicles and the pedestrians (Abojaradeh, 2013; Milton, OC, & Ronald R., 2002; Zheng Yang, 2012). Despite its absolute safety, some pedestrians still chose to jaywalk under the footbridges (Híjar et al., 2003). Therefore, the researcher aimed to study the

factors affecting the choices for crossing the roads (in the case of footbridge existence) in order to analyze and understand the roots of problems that shape the pedestrian behaviors. In doing so the research may find ways to protect and promote the pedestrian's decisions for choosing to cross the roads with the most safety crossing alternatives and also creating a positive attitude about safely crossing the roads.

The main objectives of the study were 1) to study the factors affecting the choices of crossing, 2) to develop models of pedestrian's road crossing behaviors in choosing crossing alternatives (in this study, "footbridge" and "on-road" alternatives were available options), to help find solutions or measures to reduce the risk of pedestrian accidents in the future.

2. METHODS

2.1. Studied Locations

The study area was Nakhon Ratchasima Province in the northeastern part of Thailand. The province was the largest in term of area, and the second most populated in Thailand. It was also a gateway to the whole Northeastern region. Pedestrian accidents often occurred in the city areas (Williams, 2013). Accident statistics in Nakhon Ratchasima Province (1/01/2013 - 30/09/2013) shows 5,149 injuries and 231 deaths. The accidents were most often observed in urban areas with a high number of 1,511 times, as shown in Figure 1. The study on behaviors of the pedestrians in the district areas has therefore focused on urban and suburban areas.

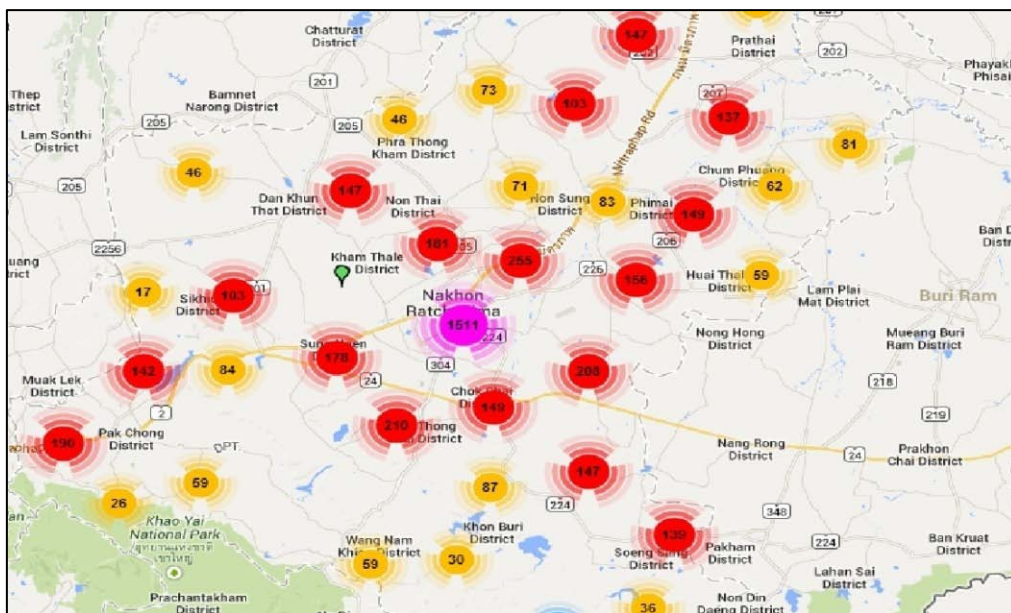


Figure 1 Pedestrian Accident Statistics in Nakhon Ratchasima province since 1/01/2013 - 30/09/2013 (ThaiRsc, 2013)

Data of this study was obtained from a survey at six footbridges in both urban and suburban areas. These included Nakhon Ratchasima Rajabhat University (NRRU), Suranari Wittaya School (SRN), Mary Vithaya School (MV), Pak Thong Chai Three-legged Intersection (PTS), Joho Intersection (Joho), and Bunluawittayanusorn School (BWS).

2.2. Survey Data

Data collection was made by means of a survey on behaviors of the pedestrians crossing the roads on weekdays and weekends with a sample size on weekdays of 3,083 people, and on weekends of 3,168 people. Physical characteristics of the footbridges and environment were observed as shown in Table 1 including number of lanes, presence of bridge roof and traffic

island, parking sign, distance from intersection and bridge vision to represent security and comfort of using it. A face-to-face interview was conducted the pedestrians to find their decision for choosing the crossing patterns with a sample size of 705 people in the city and 435 people in the suburbs.

Table 1: Summary on the physical characteristics of the bridges

| Areas | Communities | Physical Characteristics | | | | | |
|-------|-------------|--------------------------|------|----------------|---------------|----------------------------|----------------------|
| | | Number of Lanes | Roof | Traffic Island | Parking Signs | Distance from Intersection | Vision to the Bridge |
| NRRU | Urban | 6 | Yes | Yes | Yes | No | Transparent |
| PTS | Urban | 8 | Yes | Yes | Yes | No | Opaque |
| MV | Urban | 4 | Yes | Yes | Yes | No | Transparent |
| SRN | Urban | 6 | Yes | Yes | Yes | 10 Meters | Transparent |
| BWS | Suburban | 6 | Yes | No | No | No | Transparent |
| JOHO | Suburban | 6 | No | Yes | Yes | 80 Meters | Transparent |

2.3. Logistic Regression Analysis

2.3.1 Utility theory suggests that individuals will choose to consume or select a preferred alternative which provides them with maximum utility such as satisfaction, cost-saving, etc. This theory can be applied to the pedestrian's road crossing decision. A pedestrian will choose to cross the road by taking various factors into their account such as convenience, safety and security. The utility equation can be expressed as shown in Equation 2.3.1.

$$U_{in} = V_{in} + \varepsilon_{in} \tag{2.3.1}$$

Where U_{in} is utility or satisfaction of an individual n choosing alternative i ;
 V_{in} is observable utility for an individual n choosing alternative i ;
 ε_{in} is random utility reflecting the "taste" for an individual n choosing alternative i .

Part of utility that an n person recognizes and sees V_{in} is mostly defined as a function in Equation 2.3.2

$$V_{in} = \beta_0 + \beta_1 x_{in1} + \beta_2 x_{in2} + \dots + \beta_n x_{ink} \tag{2.3.2}$$

Where X_1, X_2, \dots, X_k are variables associated with utility alternative of i of an individual n ;
 $\beta_0, \beta_1, \beta_2, \dots, \beta_n$ are model parameters.

2.3.2 Logit model was assumed in an analysis of the probability of an individual n in choosing alternative i . The model can be expressed in Equation 2.3.3 as follows:

$$P_n(i) = \frac{e^{V_{in}}}{\sum_{j \in C_n} e^{V_{jn}}} \tag{2.3.3}$$

Where $P_n(i)$ is the probability of a person n choosing alternative i .
 If only two alternatives were available as in this study, the model becomes a "Binary Logit Model" and it can be expressed as

$$\text{Prob}(\text{use footbridge}) = \frac{e^{V_{in}}}{1+e^{V_{in}}} \tag{2.3.4}$$

$$\text{Prob}(\text{not use footbridge}) = 1 - \text{Prob}(\text{use footbridge})$$

Regression Model has been employed in the study on behaviors of the pedestrians (Kong & Yang, 2010; Papadimitriou, 2012; Sze & Wong, 2007). Meanwhile the crossing decision depend on the utility of each individual (Antonini, Bierlaire, & Weber, 2006). This research adopted the Logistic Regression Analysis for analyzing the factors influencing the decision (Willging, 2009) in choosing to cross the footbridges of the pedestrians (Räsänen, Lajunen, Alticafarbay, & Aydin, 2007). The study separate two behavioral models for urban and suburban pedestrians. The data analysis was conducted through PSS 16.0 software package to determine the probability of a person choosing to use the footbridges under associated factors.

3. RESULTS

3.1 Behaviors of the Pedestrians

A survey on behaviors of the pedestrians was made by using the field data from six footbridges of two different places; urban and suburban areas. The urban areas were further classified into two heavy traffic locations (SRN and MV), and two light traffic locations (Rajabhat Nakhon Ratchasima University (NRRU) and Pak Thong Chai Three-legged Intersection (PTS)). The suburban areas consisted of one heavy traffic point (Joho Intersection (Joho)) and one light traffic point (Bunluawittayanusorn School (BWS)). Example the collected data shows in Table 2, showed that the behaviors of crossing patterns in the city with heavy traffic, by comparing the two footbridges in front of Mary Vithaya School (MV) and Suranari Wittaya School (SRN), were rather different. The proportion of pedestrians running/crossing the road by using and not using the footbridge was 47%. This is mainly due to the facts that the road itself has four lanes with an island in between and the traffic is rather heavy, thus causing the vehicles to move slowly. In contrast, the pedestrians appeared to be more aware of the risk of accidents in front of Suranari Wittaya School (SRN). The number of pedestrians using the footbridge at this location an 8-lane road with no island was 98% (Elvik, Sørensen, & Nævestad, 2013).

Table2: Characteristics of Urban Pedestrians in a Heavy Traffic

| Variables | MRV | | | | | | SRN | | | | | |
|---------------------------------|----------|-----|------------|---------|-----|------------|----------|-----|------------|---------|-----|------------|
| | Weekdays | | | Holiday | | | Weekdays | | | Holiday | | |
| | Use | N | % of total | Use | N | % of total | Use | N | % of total | Use | N | % of total |
| Observed pedestrian | 267 | 565 | 47% | 271 | 662 | 41% | 893 | 909 | 98% | 718 | 720 | 100% |
| Gender | | | | | | | | | | | | |
| Male | 126 | 285 | 44% | 114 | 316 | 36% | 368 | 376 | 98% | 469 | 471 | 100% |
| Female | 142 | 281 | 51% | 155 | 347 | 45% | 524 | 533 | 98% | 249 | 249 | 100% |
| Age group | | | | | | | | | | | | |
| Child (less than 12 years) | 46 | 47 | 98% | 25 | 33 | 76% | 174 | 174 | 100% | 0 | 0 | 0% |
| Teen (12-17 years) | 80 | 91 | 88% | 97 | 156 | 62% | 100 | 101 | 99% | 90 | 91 | 99% |
| yong (17-25 years) | 21 | 61 | 34% | 49 | 111 | 44% | 52 | 56 | 93% | 389 | 389 | 100% |
| Adult (25-60 years) | 111 | 343 | 32% | 94 | 347 | 27% | 554 | 566 | 98% | 239 | 240 | 100% |
| Senior (60 years and above) | 4 | 12 | 33% | 3 | 13 | 23% | 12 | 12 | 100% | 0 | 0 | 0% |
| Phone while crossing the street | 0 | 0 | 0% | 1 | 1 | 100% | 18 | 20 | 90% | 20 | 20 | 100% |

It was found that in front of Nakhon Ratchasima Rajabhat University (NRRU) the traffic was heavier during the weekends resulting in a greater number of pedestrians using the footbridges. At Pak Thong Chai Three-legged Intersection (PTS) where there was an 8-lane road and a footbridge with a roof, most people choose to use the footbridge rather than rushing across the road. This may be due to the width of the road and speed of the vehicles. However, some people still chose to run across the road when there are fewer vehicles (Kim, Made Brunner, & Yamashita, 2008; Milton et al., 2002). And The suburban areas, it was found that the footbridge was covered with a roof and was located right in front of the school therefore a majority of students (76%) used the footbridge. This may also be due to the reason that the road itself had six traffic lanes with no traffic island in between, thus making it vulnerable to accidents when running across. For the footbridge at Joho Intersection (Joho), it was found that the bridge was located far from an intersection and without a roof. The road itself was a 6-lane traffic road without an island in between for the runners to rest. Moreover, with the distance of approximately 80 meters between the footbridges (Antonini et al., 2006; Sisiopiku & Akin, 2003; Li, Yang, & Yin, 2010; R. Elvik, 2004), only 23% of the people including the elderly who had difficulty in climbing up and down the bridges decided to take a risk on the road surface (Avineri, Shinar, & Susilo, 2012).

3.2 A Model of Logistic Regression Analysis

A survey on attitudes and factors of individual with questionnaires was carried out by analyzing and dividing the people who live in the city and in the suburbs. A Logistic Regression model was calibrated by using SPSS resulting in the following form:

In the city

$$V_{in} = 3.243 - 0.688(\text{dis_bus}) + 0.300(\text{N_friend}) ; \quad (3.2.1)$$

($R^2=0.763$; Chi-square= 0.017 ;Significance = 0.897)

where

Dis_bus = distance between the bus stop and the footbridge (meters)
 N_friend = number of pedestrians (persons)

In the suburban

$$V_{in} = 0.654 - 0.423(\text{dis_bus}) + 0.209(\text{N_friend}) + 1.787(\text{law}) + 1.483(\text{accident}) ;$$

$R^2=0.760$; Chi-square= 0.830 ;Significance = 0.991 (3.2.2)

Where

Accident = accidents on the road (1 = had accident experience, 0 = no experience)
 Dis_bus = distance between the bus stop and the footbridge (meters)
 N_friend = number of co-pedestrians (persons)
 Law = awareness of the fact that law and regulations and fine are applied to jaywalking (1 = yes, 0 = no)

A test for suitability of the models was presented by the results in the Hosmer and Lemeshow table. Both models contained the Chi-square and the Significance > 0.05, it can be concluded that the models were suitable. The city model had a total percentage of prediction accuracy of 90.6% whereas the suburbs model's was 91.5%.

4. DISCUSSION

The results showed that the pedestrians' decision to use footbridges depended on a set of physical characteristics of the footbridges. When the footbridges were located near schools,

there was a higher percentage of users than it usually was elsewhere especially during the peak hours where the traffic was heavy. Using the footbridges were an alternative that effectively helps reduce risk of accidents to students and parents. A distance from the crossing point to the destination was another key factor. If the distance of the footbridge was far from an intersection and the footbridge itself has no roof, for example the JOHO's, the people would be more likely to run across the road and rest at an in-between island to using the footbridge. Heavier traffic would also result in a higher risk of accidents for someone who crosses the road. Pedestrians are highly aware that crossing the roads with heavy traffic and high speed vehicles was vulnerable to collision with vehicles. More pedestrian in such circumstance chose to use the footbridges for safety. Furthermore, Survey data analysis behaviors of the pedestrians crossing the roads of 6251 person. The most pedestrians using the footbridges are pedestrians of a studying age (86.87 %). Secondary is adult age 77.15 % and the last elderly 55.8%. Elderly were not agile and not conducive to the up-and-down movements. And, female had using the footbridge (80.3 %) was higher than that of Male (74.9%).

From the models, it was found that the factor that affected the footbridge usage for the urban people was a number of accompanied friends ($\beta = 0.300$), and the negative factor was the distance between the bus stop and the footbridge ($\beta = -0.688$). For the suburban people, the factor on law awareness had the most influence on their decisions ($\beta = 1.787$), followed by the past accident experience ($\beta = 1.483$). The number of accompanied friends ($\beta = 0.209$) was the third factor that affects their decisions. Finally the negative factor was the distance between the bus stop and the footbridge ($\beta = -0.423$).

The common factor that affected both the urban and suburban people was the number of accompanied friends. This was due to the reason that going alone always caused anxiety, fear of not being safe, and fear of various crimes. The distance from the bus stop to the footbridge also another key factor that affected the pedestrians' decisions. The negative coefficient means if the distance was far apart, the likelihood of using the footbridges declined.

5. CONCLUSION

Study on behaviors of crossing the roads of the people in both urban and suburban areas of Nakhon Ratchasima province was carried out by collecting data from both the field work and interviews with questionnaires before being analyzed by using the model of logistic regression analysis. Measures to be implemented to encourage more people to use the footbridges can be summarized as follows:

Education and public relation program must be conveyed to people so that they are aware of current law enforcement on footbridge uses. It was estimated from the analysis that the probability of crossing the roads by using the footbridges would increase by 4.32% should all the people realize this fact.

An appropriate location for the footbridge must be close to the bus stop. At a distance of 1 meter between the footbridge and the bus stop, the percentage of probability in choosing to cross the roads with the footbridges in the urban areas was as high as 97.4% while in the suburban areas the probability was 91%. At the distance of 10 meters, the probability was 3.43% in the urban areas and 3.33% in the suburban areas.

Authorities must pay attention on building footbridges that not only serve the real needs but encourage the use by pedestrians. This must focus on pedestrians' behavioral characteristics and attitudes towards the particular factors in order to determine the right, safe, and efficient footbridge designs and locations. In addition, awareness program on law and safety for pedestrians should be conducted for public especially the youths and students who would influence more people in their families.

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