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The Effect of Structure and Street Characteristics on the Footbridge Usage

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ABSTRACT

Footbridge is one of the safest pedestrian crossing facilities, yet most often people do not use it, and prefer to cross the road on the surface. This behavior is related to many factors which affect the usage of the footbridge. In this study the effect of structure and street characteristics was investigated and analyzed to assess the usage of footbridges. Results showed that the vehicles speed is not supporting the increase of the footbridge usage, and the criteria of traffic volume matched the requirements of providing a footbridge where there is a high volume of vehicles. Also the results showed that the convenience factor for footbridge (no.1) referred to non-satisfaction of saving the time when pedestrian used the footbridge, but was satisfied on footbridge (no.2).The usage will be improved if the safety and convenience of using the footbridge are supported by integrated design of structure and street elements, and provide acceptable loss of time to pedestrians while using the footbridge.

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INTRODUCTION

Accidents between pedestrians and vehicles were studied in terms of minimizing conflict between these two modes while maintaining the continuous free motor traffic flow and the safety environment for pedestrians who are the most vulnerable road users, therefore the classic approach to pedestrian safety improvements is the separation from vehicles either by space or time. A way to achieve that is by grade separation built either above or below the street level, and this has been proposed since 1930s(Fruin, 1971, Ibrahim *et al*., 2005, Robertson, 1993), accordingly such physical changes to the environment can significantly decrease the rate of pedestrian-vehicle crashes (Retting *et al*., 2003).

Footbridge is one of the vertical separation facilities used to segregate pedestrians from vehicular traffic as a method of developing safety (Ribbens, 1996), but it was noticed that although pedestrians have the option of crossing the road using the footbridge, most often they do not use it, rather they prefer to cross the road on the surface (Räsänen *et al*., 2007). This means if a pedestrian can find more direct route and same or less time to cross at street level, the usage of the footbridge will be decreased, and the risk probability will be increased (Zegeer, 2002), which confirms that footbridges should be harmonized with the surrounding factors that affect the safety and convenience movement of pedestrians (Rahman *et al*., 2012), thus an appropriate design can increase quality and quantity of walking (Räsänen *et al*., 2007, Tanaboriboon and Jing, 1994, Sisiopiku and Akin, 2003).

Pedestrian footbridges are popular but often ineffective (Zegeer *et al*., 2006), that was attributed to the appealing impression of complete separation of pedestrian from motor vehicle traffic, which was claimed as a theoretically true, but in practice this rarely occurs for several reasons such as:

- Bridges are so expensive, and cannot be built at most locations where pedestrians may prefer to cross.
- Many pedestrians will not walk extra distance in their trip, and because of the accessible ramps which will increase the distance, they will cross at grade level.

Researchers suggested topography, and fencing along sides of the street or in the median for several hundred feet on either side of the grade-separated crossing to raise the efficiency of the usage (Zegeer *et al*., 2006).

Some pedestrians preferred signalized crossing to bridges and underpasses (Tanaboriboon and Jing, 1994), and that was mainly because of the ascending and descending movements required on these facilities and the effort involved in climbing a grade which is resulted from the vertical dimension of the stairs slope (Cheung and

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Lam, 1998). That stimulated researchers to study solutions such as the installation of an escalator to enhance the usage of the footbridge. This was illustrated in the results of Räsänen *et al*. (2007) who designed a study to find out factors that influence use/non-use of pedestrian bridges. This study showed that the use rate of footbridges varies from 6 to 63% of the users according to the location and the existence or non-existence of an escalator,italso influenced with time saving, safety and familiarity of the area. These findings matched the results obtained by Allos and Mohamad (1983). However, no surveywas done for new suggestions to increase the usage from the respondents' point of view and with enough share of elders. The study also suggested that footbridge use or non-use is a habit and not coincidental behavior. It should be noted, however, from a psychological point of view that a behavior does not necessarily become habitual just because it has been performed many times (Conner and Armitage, 1998).

As it has a great effect on the usage, many researchers studied the structure of the footbridge to enhance safety, and to inform planners and designers in developing new and existing pedestrian footbridges. Researchers examined the design and other parameters such as location and maintenance in order to assess the quality of footbridges function (Renfro, 2007). They also claimed that facility should be attractive to encourage more participation in using it, as found by Joseph *et al*. (2006).Therefore to attract people to use a footbridge, the surrounding environment should has many amenities and activities along the walkway to this footbridge (Cui *et al*., 2013, Ariffin and Zahari, 2013, Joseph and Zimring, 2007).

On the other hand, the characteristics of the road beneath the footbridge have important role in influencing the usage, such as: posted speed limit, the overall width of the cross walkway, the existence of median barrier, fence installation, directional flow, and distance of the facility (Abojaradeh, 2013, Rizati *et al*., 2013). The need of supplying a footbridge in some area was the main goal of investigations about the feasibility of its construction. One of the studies reviewed the police traffic crash records, one year before and one year after the footbridge construction in order to assess the effect of a footbridge on the rates of pedestrian crashes and injuries. The results showed that there were more traffic crashes, and pedestrian injuries, but fewer fatalities after the construction of the footbridge (Mutto *et al*., 2002). To more understanding of such results, behavior studies stated that the risk taking behavior may influence by the volume of pedestrian traffic: it is easier to break the rules as a group rather than alone. Conversely, safety may increase if the pedestrian becomes more conscious of taking risk after experiencing or witnessing a crash (Cambon de Lavalette *et al*., 2009). The study also referred to the footbridge as useless facility beyond the distance of one hundred meters either side, and proposed that cheaper alternatives at more frequent intervals may be more effective (Mutto *et al*., 2002). However, the study suggested a careful investigation in the area before the installation of a new footbridge, but they didn't suggest any procedures to enhance the function of the already existed footbridges.

The objective of this paper is to assess the design factor for the structure and the street beneath it, and how it affects the utilization of the facility, and to identify the suitable characteristics to enhance the usage of the footbridge, thus reducing pedestrian accidents and casualties, and decreasing the social costs in order to create sustainable cities, more vibrant and livable.

1. Methodology:

A. Study Area:

The area of study is in the city of Ipoh, the capital city of Perak state, which is located in the north west of Malaysia, and has a population of about 657,892 according to Department of Statistics Malaysia 2010, and it is the fourth largest city in Malaysia (Malaysia).

Two footbridges were chosen for the study (shown in Fig. 1). The first one (no. 1) is located in the street of Sultan Idris Shah towards the roundabout of Sultan Ismail, and it services an area which includes two secondary schools, one elementary school, shopping mall, bus station, a cemetery, car parking, three petrol stations, and some houses and restaurants. The second footbridge (no. 2) is located in the street of Jalan Hospital towards the roundabout of Sultan Iskandar, and it services an area which includes a general hospital, a private hospital, two bus stations, a mosque, two elementary schools and a construction site. The two sites were fairly typical urban area, and well-used by population in their journeys. The characteristics of footbridges and roads are summarized in Table 1 and 2.

B. Data Collection:

Observation of the pedestrian crossing behavior was conducted in order to observe the footbridge condition, pedestrians' volume survey, pedestrians speed survey and traffic survey. These surveys are believed to give influential data on utilization rate and the characteristics of the traffic movement. Data collection was carried out in August and September 2014. The manual counters were used to count the volumes of pedestrians and vehicles. Besides the counting of people who used the footbridge, the observation of pedestrians who crossed the road in each site was only concerned about the people who were crossing within 100m from the pedestrian bridge (both sides). The volumes were counted every 15 minutes interval and during three periods, each lasting an hour: (10:00-11:00 am),(2:00-3:00 pm), (5:00-6:00 pm), and for one week (including the weekends) for each footbridge. Pedestrians were classified as male, female, children, and physically challenged. For vehicles volumes, the counting was conducted for four continuous hours. A stopwatch was used to calculate the pedestrian time spent in crossing either on the footbridge or on the street level. Dividing the time taken by pedestrians who used the footbridge by the time taken by pedestrians who crossed at grade was calculated and called the convenience ratio. The speed was obtained from dividing the length of the footbridge on the calculated time. The laser gun was used to gauge the vehicle speeds in order to determine the average speed calculated for the total number of vehicles which were surveyed for one hour. These were calculated only for the first vehicle in a queue, or for separate cars with acceptable distance and excluding vehicles following too closely.

Fig. 1: Aerial map and general photo for the two locations. Source: Google Map.

Table 1: Characteristics of footbridges in the study area:

Bridge no.	Characteristics of the Footbridge										
	Type of Area	Height (m)	Length (m)	Width (m)	Number of stairways	Number of steps	Cover existence	Provision of Lighting	Handrail height (m)	Bridge surface	Broken parts
1	Commercial and residential	8.0	21.8	2.5	2	43	Yes	Yes	1.1	Paved	No
2	Commercial and residential	6.7	24.5	1.7	2	30	Yes	No	1.1	Non-paved	Yes

Table 2. Characteristics of the street beneath the footbridge:

Bridge no.	Characteristics of the Street										
	Type of Street	Width (m)	Direction	Number of lanes	Width (m)	Fencing along Sides of the street	Fence height (m)	Spaces in fencing units for (20 m) before and after the bridge	Median Existence and Width (m)	Fencing along Median	Traffic Light existence
1	Minor Arterial One way	12	1	4	3	Yes	1.1	Yes	No	_	No
2	Major collector divided	17	2	2*2	3.4	Yes	1.1	No	Yes 3.4	No	Yes

2. *Results:*

A. *Vehicle speed survey:*

The speed survey was conducted for all vehicle classification including cars, pick-ups, minibuses, busses, light trucks, and medium trucks. The speed was measured by using the speed laser gun, and the average speed for each study area is tabulated in Table 3.

Table 3: Vehicle average speed.

<table>
<tr><th>Bridge no.</th><th>Total Number of calculated vehicles</th><th colspan="2">Average speed Km / h</th></tr>
<tr><td>1</td><td>193</td><td colspan="2">42</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">157</td><td>Towards roundabout direction</td><td>Away from roundabout direction</td></tr>
<tr><td>42</td><td>47</td></tr>
</table>

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Table 4: Vehicles volume for footbridge no (1) and no (2):

Vehicles volume for footbridge No. 1	Time	Number of Vehicles	Vehicles volume for footbridge No. 2	Time	No. of Vehicles towards roundabout direction	No. of Vehicles away from roundabout direction
	11:00 am - 12:00 pm	2785		11:00 am - 12:00 pm	2351	2203
	12:00 pm - 1:00 pm	3074		12:00 pm - 1:00 pm	2409	2322
	1:00 pm - 2:00 pm	3204		1:00 pm - 2:00 pm	2688	2311
	2:00 pm - 3:00 pm	2817		2:00 pm - 3:00 pm	2554	2289

B. Vehicle volume survey:
A continuous counting of vehicles was carried out for four hours and results are presented in Table 4.
C. Pedestrian speed survey:
The stopwatch was used to calculate the pedestrian time spent in crossing, and consequently the results were used to calculate the speed. The survey was done at random and different age groups for both genders. The speed and the average speed for each study area are tabulated in Table 5.

Table 5: Pedestrian speed on footbridge no (1) and no (2):

pedestrian speed on footbridge No (1)	Pedestrian number	Gender	Time seconds	Footbridge length m	Speed m/min	pedestrian speed on footbridge No (2)	Pedestrian number	Gender	Time seconds	Footbridge length m	Speed m/min
	1	Female	23	21.8	56.9		1	Female	23	24.5	63.9
	2	Female	23	21.8	56.9		2	Male	24	24.5	61.3
	3	Male	23	21.8	56.9		3	Female	21	24.5	70
	4	Male	22	21.8	59.5		4	Female	25	24.5	58.8
	5	Female	23	21.8	56.9		5	Female	26	24.5	56.5
	6	Male	19	21.8	68.8		6	Male	21	24.5	70
	7	Male	20	21.8	65.4		7	Male	27	24.5	54.4
	8	Female	20	21.8	65.4		8	Female	29	24.5	50.7
	9	Male	18	21.8	72.7		9	Male	23	24.5	63.9
	10	Female	18	21.8	72.7		10	Male	25	24.5	58.8
	11	Male	27	21.8	48.4		11	Male	22	24.5	66.8
	12	Female	19	21.8	68.8		12	Female	29	24.5	50.7
	13	Male	20	21.8	65.4		13	Male	20	24.5	73.5
	Average		21		62.7		Average		24		61.5

The comparison between the time spent on crossing on the footbridge and the time spent on crossing on the street level was taken in order to calculate the convenience ratio. This ratio should be less than 1.5 in order to increase the usage of the footbridge (Moore and Older, 1965). This is illustrated in Table 6.

Table 6. Street - footbridge (1) and no (2) crossing time.

Street - footbridge No (1) crossing time	Pedestrian number	Gender	Time taken for footbridge crossing in seconds, x	Time taken for grade crossing in seconds, y	Convenience Factor, x/y	Street - footbridge No (2) crossing time	Pedestrian number	Gender	Time taken for footbridge crossing in seconds, x	Time taken for grade crossing in seconds, y	Convenience Factor, x/y
	1	Female	23	10	2.3		1	Female	23	23	1
	2	Female	23	9	2.6		2	Male	24	21	1.1
	3	Male	23	8	2.9		3	Female	21	30	0.7
	4	Male	22	11	2		4	Female	25	28	0.9
	5	Female	23	9	2.6		5	Female	26	33	0.8
	6	Male	19	9	2.1		6	Male	21	25	0.8
	7	Male	20	9	2.2		7	Male	27	30	0.9
	8	Female	20	11	1.8		8	Female	29	36	0.8
	9	Male	18	7	2.6		9	Male	23	21	1.1
	10	Female	18	8	2.3		10	Male	25	26	0.9
	11	Male	27	15	1.8		11	Male	22	26	0.8
	12	Female	19	8	2.4		12	Female	29	29	1
	13	Male	20	8	2.5		13	Male	20	23	0.9
	Average		21	9	2.3		Average		24	27	0.9

D. Pedestrian volume survey:
The manual counters were used to count volumes of pedestrians who used the footbridge or crossed on the street level for one week (including the weekends) for each footbridge. A total of 2261 pedestrians were observed in this study for footbridge (no.1), and 1740 pedestrians for footbridge (no.2). The highest daily volume of people used the footbridge (no.1) was 643 pedestrians on Friday, and 189 pedestrians for footbridge (no.2) on Friday also. Figures 2 and 3 shows the percentage of users and non-users for the whole week.

3. Discussion:
A. Structure Elements:
Usually the preferred angle for the stairs carriage varies from 30^{o} to 35^{o} according to a comfortable design of staircases (Chengalur *et al*., 2004). The angle for footbridge (no.1) was 33^{o}, which is acceptable and

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convenient, but it was 38° for footbridge (no.2) which may contribute in increasing the effort spent on climbing the stairs, hence discouraging users, especially elders, to use the footbridge in their movement, but the existence of level landings will give the pedestrian a chance to catch a breath. Level landings where provided for each stairway in each footbridge. The design of these elements met the requirements stated by WSDOT Guidebook (1997).

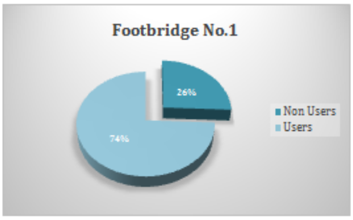

Fig. 2: Percentage of Pedestrians during one Week.

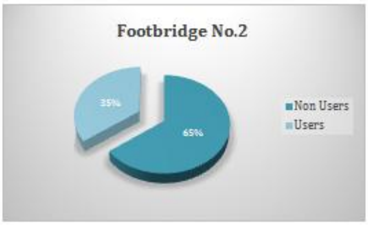

Fig. 3: Percentage of Pedestrians during one Week.

The width of footbridge (no.1) was 2.5 meters, which is acceptable for the movement and in avoiding potential conflicts between users over the footbridge (Officials, 2004). But it was 1.7 meters for footbridge (no.2), which is less than the minimum clear width 2.4 meters recommended by AASHTO, this may result in discomfort movement over the footbridge, and conflict will occur when a large volume of pedestrian will use the footbridge.

To prevent users from toppling over the bridge structure, the handrail was installed with (1.1) meter height for each footbridge, which matches the recommended minimum height 42 inches according to AASHTO. This handrail will give the sense of secure, especially for children.

The surface of the footbridge should be smooth and convenient for users, and materials should be chosen to avoid creating slippery conditions for pedestrians. The exposed concrete surface gave footbridge (no.2) unsuitable view resulted from the cracks in the concrete structure and the non-removable dirt spots which were hard to clean, and the uneven surface caused water ponding after a heavy rain. Conversely, footbridge (no.1) was paved, and the tile floor gave the bridge a good aesthetic appearance and a clean path.

In order to increase the user's sense of security, lighting is requested, and should be provided for the night usage. The lighting is provided for footbridge (no.1), but it isn't available on footbridge (no.2), mainly because of rare usage of the footbridge during the night. Maintenance should be available to keep the function and the aesthetic of footbridges in good condition. The broken parts on the stairs and the holes in the cover of footbridge (no.2) have a bad effect on both of usage and aesthetic view of it, consequently less people will utilize the facility.

B. Street Elements:

The existence of the fence on both sides of the street plays an important role in preventing pedestrians from jaywalking, but its effectiveness will decrease when spaces in the fence's units are existed. Even more, the non-extension of the fence up to a convenience length will encourage pedestrians to turn around the fence and cross on the street, especially in the case of footbridge (no.2) where there is a traffic light that people used to cross on it in spite of non-existence of a marked path for them, and where the fence is ended before the traffic light, giving pedestrians a gap to cross on the road. That will definitely reduce the usage rate as pedestrians will take benefit of stopped traffic flow (Räsänen *et al.*, 2007). On the other hand, the median represented a safe refuge area for pedestrians who jeopardize their lives in crossing the street, although they will spend several minutes waiting the appropriate gap to cross, and this is mainly because of the non-existence of fencing along the median to prevent pedestrian from this action, and this was the situation in the location of footbridge (no.2). Both sites have no way finding tools, either in signage form or in pavement markings form, to orientate the movement of pedestrians towards the location of each footbridge. This led pedestrians, especially who are unfamiliar of the

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area, to cross where ever they found suitable paths along their trip, unaware of the existence of the footbridge or its distance and direction from their position, consequently reducing the feasibility of this structure.

C. Vehicle speed:

The pedestrian footbridge should be provided across streets where the vehicle speed is more than 65 km/h (Axler, 1984), but the obtained speed in each site was less than 65 km/h, "42 km/h for footbridge (no.1), and for footbridge (no.2) was 42, 47 km/h respectively for each direction of movement". Basically, this low speed will not support increasing the usage of the footbridge, because it will give more gaps for pedestrian when decide to jaywalk, and they will be more exposed to be injured during slow traffic flows because of the false sense of safety they will received from the slow vehicular traffic (Mutto *et al*., 2002).

D. Vehicle volume:

The vehicle volumes for footbridge (no.1) and footbridge (no.2) were 11880, 9125vehicles respectively for four continuously hours. These figures are higher than the stated volume of 7500 vehicles in order to make the decision of providing a footbridge in the site, which means that the two footbridges meet the criteria of traffic volume (Axler, 1984). These high volumes will increase the time spent in crossing on the surface of the road, and this may not attract pedestrians to cross it when considering the time saving (Renfro, 2007), and should be a motive to encourage pedestrians to more utilize of the footbridge.

E. Pedestrian speed:

The results indicated that, on average, the pedestrian who crosses on the footbridge (no.1) and footbridge (no.2) takes 21, 24seconds respectively, and walks in average speed 62.7, 61.5 m/min respectively.

The results showed that the convenience factor for footbridge (no.1) is 2.3, which is higher than 1.5 and meansthat the pedestrian will spend on using the footbridge more than twice the time needed in crossing on the street level, and this contributes to non-usage of footbridge by pedestrians, and encourage some pedestrians in crossing at grade. It was found that convenience factor for footbridge (no.2) is 0.9. Obviously the convenience factor is smaller than 1.5which means the pedestrian should be satisfied by using the footbridge more than wasting the time in crossing on the street level.

F. Pedestrian Volume:

Results should match the requirements of providing a footbridge where there is a high volume of pedestrian, That means pedestrian volume should exceed 300pedestrians in the highest four continuous hours, or the pedestrian volume should be more than 100 pedestrians in the four highest continuous hour periods to meet the criteria (Axler, 1984).Obviously the two footbridges met this requirement according to the highest volumes were observed for people used the footbridges in each location.

Conclusion:

The following conclusions are withdrawn from this study about how design factor affects the usage of footbridges:

- The structural design of the footbridge has a great effect on the usage of it; therefore it should comply with the recommended standards designs.
- The angle of the stairs carriage may add effort to the user while ascending the stairs and level landings will give him a chance to catch a breath.
- The small width of the footbridge may result in uncomfortable movement on it, and handrails will prevent pedestrian from toppling over it.
- The good paved surface will protect the user from tripping and slipping, and lighting will give him the sense of secure.
- The existence of the fence on both sides of the street plays an important role in preventing pedestrians from jaywalking, especially if it is built in continually shape with no spaces, and for long and convenient distance.
- The traffic light will decrease the usage of the footbridge, especially if it is located in distance less than 100 meters from the structure.
- The non-existence of fencing along the median will tempt pedestrians to jeopardize their lives in crossing the street.
- Way finding tools are important to orientate the movement of pedestrians towards the location of the footbridge, consequently increasing the feasibility of this structure.
- Gaps created from low vehicle speed will encourage pedestrian to cross on the street level.
- High vehicle volumes will increase the time spent by pedestrians in crossing on the surface of the road, and this may not attract them to cross it when considering the time saving, and this should be a motive to encourage pedestrians to more utilization of the footbridge.
- The usage will be decreased when the footbridge's elements are not well maintained.

- The spent time on crossing from side to another will affect the pedestrian's decision whether she/he will use the footbridge or cross on the street level.

The usage of pedestrian footbridges will be improved if the safety and convenience of using the footbridge are acceptable to pedestrians without taking in mind the loss of time. Future results will be obtained from this study should assist in developing both understanding and awareness of safety.

REFERENCES

Abojaradeh, m., 2013. Evaluation of pedestrian bridges and pedestrian safety in jordan. *Civil and environmental research,* 3: 66-78.

Allos, a., a. Mohamad, 1983. Usage of pedestrian footbridges. *Traffic engineering & control*, 24.

Ariffin, r.n.r., r.k. Zahari, 2013. Perceptions of the urban walking environments. *Procedia-social and behavioral sciences,* 105: 589-597.

Axler, e., 1984. *Warrants for pedestrian over and underpasses*, federal highway administration, office of safety and traffic operations.

Cambon de lavalette, b., c. Tijus, s. Poitrenaud, c. Leproux, j. Bergeron, j.p. Thouez, 2009. Pedestrian crossing decision-making: a situational and behavioral approach. *Safety science,* 47: 1248-1253.

Chengalur, s.n., s.h. Rodgers, t.e. Bernard, 2004. *Kodak's ergonomic design for people at work,* john wiley.

Cheung, c., w.h. Lam, 1998. Pedestrian route choices between escalator and stairway in mtr stations. *Journal of transportation engineering,* 124: 277-285.

Conner, m., c.j. Armitage, 1998. Extending the theory of planned behavior: a review and avenues for further research. *Journal of applied social psychology,* 28: 1429-1464.

Cui, j., a. Allan, d. Lin, 2013. The development of grade separation pedestrian system: a review. *Tunnelling and underground space technology,* 38: 151-160.

Fruin, j.j., 1971. Pedestrian planning and design.

Guidebook, p.f., 1997. Incorporating pedestrians into washington's transportation system. *Sponsored by washington state dot, puget sound regional council, association of washington cities, and county road administration board and prepared by otak*.

Ibrahim, n.i., f.a. Kidwai, m. Karim, 2005. Motorists and pedestrian interaction at unsignalised pedestrian crossing. Proceedings of the eastern asia society for transportation studies, 120-125.

Joseph, a., c. Zimring, 2007. Where active older adults walk understanding the factors related to path choice for walking among active retirement community residents. *Environment and behavior,* 39: 75-105.

Joseph, a., c. Zimring, l. Harris-kojetin, k. Kiefer, 2006. Presence and visibility of outdoor and indoor physical activity features and participation in physical activity among older adults in retirement communities. *Journal of housing for the elderly,* 19: 141-165.

Malaysia, d.o.s., 2010. "population distribution by local authority areas and mukims".

Moore, r.l. S. Older, 1965. *Pedestrian & motor vehicles are compatible in today's world*, traffic engineering.

Mutto, m., o.c. Kobusingye, r.r. Lett, 2002. The effect of an overpass on pedestrian injuries on a major highway in kampala–uganda. *African health sciences,* 2: 89-93.

Officials, T. 2004. *Guide for the planning, design, and operation of pedestrian facilities*, aashto.

Rahman, K., N. Ghani, A. Kamil, A. Mustafa, 2012. Analysis of pedestrian free flow walking speed in a least developing country: a factorial design study. *Research journal of applied sciences, engineering and technology,* 4: 4299-4304.

Räsänen, M., T. lajunen, F. Alticafarbay, C. Aydin, 2007. Pedestrian self-reports of factors influencing the use of pedestrian bridges. *Accident analysis & prevention,* 39: 969-973.

Renfro, R., 2007. Pedestrian/bicycle overcrossings: lessons learnt. *Portland: portland state university*.

Retting, R.A., S.A. Ferguson, A.T. Mccartt, 2003. A review of evidence-based traffic engineering measures designed to reduce pedestrian-motor vehicle crashes. *American journal of public health,* 93: 1456-1463.

Ribbens, H., 1996. Pedestrian facilities in south africa: research and practice. *Transportation research record: journal of the transportation research board,* 1538: 10-18.

Rizati, H., S.Z. Ishak, I.R. Endut, 2013. The utilization rates of pedestrian bridges in malaysia. Business engineering and industrial applications colloquium (beiac), 646-650.

Robertson, K.A., 1993. Pedestrianization strategies for downtown planners: skywalks versus pedestrian malls. *Journal of the american planning association,* 59: 361-370.

Sisiopiku, V., D. Akin, 2003. Pedestrian behaviors at and perceptions towards various pedestrian facilities: an examination based on observation and survey data. *Transportation research part f: traffic psychology and behaviour,* 6: 249-274.

Journal of Applied Science and Agriculture, 9(21) Special 2014, Pages: 52-59

Tanaboriboon, Y., Q. Jing, 1994. Chinese pedestrians and their walking characteristics: case study in beijing. *Transportation research record*.

Zegeer, C.V., 2002. *Pedestrian facilities users guide: providing safety and mobility*, diane publishing.

Zegeer, C.V., l. Sandt, M. Scully, M. Ronkin, M. Cynecki, P. lagerwey, 2006. How to develop a pedestrian safety action plan. University of north carolina, highway safety research center, pedestrian and bicycle information center.