Xi'an ShiyouDaxueXuebao (ZiranKexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN:1673-064X
E-Publication:Online Open Access
Vol: 65 Issue 02 | 2022
DOI 10.17605/OSF.IO/QRDT6

INVESTIGATING OF PEDESTRIAN FLOW CHARACTERISTIC ON SHOPPING AREA IN YOGYAKARTA

Muchammad Zaenal Muttaqin[1,2], Ahmad Munawar[1] and Muhammad Zudhy Irawan[1]

[1]Civil and Environmental Engineering, Universitas Gadjah Mada, Jl. Grafika No.1, Yogyakarta, Indonesia.
[2]Civil Engineering Department, Universitas Islam Riau, Jl Kaharuddin Nasution 113, Pekanbaru, Indonesia.

Abstract:
Pedestrians are different from vehicles. Pedestrian has its unique characteristic, especially for its flexibility in traffic. Pedestrians play an important role in supporting sustainable roads as the impact from the vehicle such as pollution, even crowded vehicles create more problems than pedestrians. Pedestrians' characteristics can be divided based on their activity, area, and even based on their behaviour when they are walking. All pedestrian management policies must be started from knowing local and then global characteristics. This will serve more details about pedestrian lanes, and can also be used to derive fundamental parameters for pedestrian operations and to create pedestrian models. In traffic research, one of the volume functions related to speed and density was also used to pre-analyze pedestrian behaviour. The purpose of this study was to introduce the local characteristic of pedestrians in Yogyakarta as a basic term for making regulations or policies as well as better planning for pedestrian lanes. The results showed that pedestrian volume had different characteristics between morning flow and afternoon flow. The characteristic volume of the morning flow tended to decrease due to the difference in temperatures which was lower in the morning and higher temperatures during the day. As for the afternoon flow, pedestrian fluctuations increased due to the temperatures decrease from noon to evening. This was reinforced by an independent T test. Another result showed that pedestrians groups dominated the shopping area, hospital area, as well as public space. Lastly, the characteristics of pedestrians in the sidewalk commercial area also had different characteristics in terms of carrying goods, whereas the shopping areas were more dominated by pedestrians carrying goods than others. These basic terms were expected to be the basic foundation for managing and planning pedestrian lanes based on their local characteristics...

Keywords: Pedestrian, Simulation Model, Viswalk, Microscopic, Indonesia, Capacity, Movement

1. Introduction

Yogyakarta city is one of the biggest destination places in Indonesia. It is located in the middle of Java island-Indonesia by spacious measure 32.5 km2. As a tourism place, Yogyakarta has so many types of tourism such as cultural tourism, mountain resort, beach, and shopping tourism. One of the famous shopping tourisms at Yogyakarta is Malioboro. Malioboro is known as shopping tourism area which often visited by local either international tourists. Besides that, this area is one of the biggest public places in Yogyakarta. Therefore, the travel flow into this area is really big, so it needs supporting facilities according to shopping tourism context in order to attract tourists and makes them comfortable while shopping on that area.

Nowadays, there are revitalization process on the pedestrian path in front of the Jalan Malioboro shops. The revitalization is carried out, among others, for the existence of a revitalization process that is expected to be able to boost the number of tourists in

Xi'an ShiyouDaxueXuebao (ZiranKexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN:1673-064X
E-Publication:Online Open Access
Vol: 65 Issue 02 | 2022
DOI 10.17605/OSF.IO/QRDT6

terms of quantity and quality whom visits Malioboro. It as also takes a control parameter that is able to describe the description of the demand from pedestrians in the Malioboro area. Based on the theories, pedestrians have unique characteristics, where each person has different characteristics such differences in gender, age and even holding the bag. In addition, the direction of pedestrian movement and the condition of pedestrian facilities also affects the characteristics of pedestrian movement. Pedestrian traffic volume was a feature of pedestrian parameters. In traffic research, flow functions was proposed to estimate about maximum volume to do an evaluation and/or monitoring also development planning them. This research was proposed to identify about pedestrian flow and its characteristic to monitoring, maintain also rearrange existing sidewalk in Malioboro.in details, this research review the flow based on the time, direction of travel and the relationship of the flow parameters with the speed and density parameters as the relationship with the pedestrian flow parameters.

2. Theory

Sidewalks are pedestrian paths that are separated from public transport lanes, usually located next to each other or close together. This definition is suitable to the statement of Ogden (1996) who said footpath and sidewalk means that a pedestrian path that takes part of a vehicular road or a separate lane specifically for pedestrians only, where there is a pedestrian path that is used together with a bicycle lane[1].The characteristics of the pedestrian path as a pedestrian facility are shown in the characteristics of the users of the lane, one of which is the pedestrian flow. Previous research noted that pedestrian traffic has different characteristics for various ages, gender [2], [3], cultural difference[4], luggage-carrying[5], dan travel motives [6].]. In addition, the flow of pedestrians is also classified as different from the flow of vehicles. The vehicle driver has minimal knowledge in accordance with the provisions of the driver's license when driving his vehicle. This results in all drivers being able to understand their movements on roads that tend to have uniform lane characteristics. In addition, pedestrians tend to walk with group size rather than alone [7].

Moreover, pedestrians are free to make such a behaviour in their travels anytime and anywhere. Pedestrians are can be seen in the afternoon either in the evening. Besides, Pedestrian paths are needed to avoid conflicts between pedestrians and motorized vehicles[8]. Flexibility moves from people will result more equivalent crowd for the entire area, such as the movement of evacuation from a room (e.g. terminal or station) and sidewalk areas that are more open in open space[9].

The characteristics of pedestrians flow also influenced by pedestrian path characteristics related to the roughness or height difference of the pedestrian path with other lanes. The differences in regional characteristics [10], has also become a variety of variations in the characteristics of pedestrians on the path. The type of pedestrian path, namely indoor or outdoor conditions also affects the characteristics of pedestrians. In the indoor area, pedestrians are only in traffic conditions in the form of unidirectional flow[11]and bidirectional flow [12]. There is no conflict between pedestrians and vehicles on the indoor path because the lane is only for pedestrians, so pedestrian characteristics only depend on the interaction between pedestrians.

Xi'an ShiyouDaxueXuebao (ZiranKexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN:1673-064X
E-Publication:Online Open Access
Vol: 65 Issue 02 | 2022
DOI 10.17605/OSF.IO/QRDT6

Unlike the case with outdoor pedestrian paths such as sidewalks and public spaces which are often placed side by side with traffic lanes or in open places such as pedestrian shopping lanes.

In order to provide effective walking infrastructure, capacity has considered as a main parameter of walking facilities to meet the preferred level of service for operational also used for maintenance for the lane. Procedure for reaching capacity dominated by macroscopic pedestrian model. Oeding[13]started with collect pedestrian volumes, densities and speeds for shopping area and result relationship between them. Others, Tanaboriboon and Guyano[14]did research on sidewalks in Singapore using camera video and collected about pedestrian characteristic and analysed with relationship between pedestrian characteristic. Next, Cheung[15] did analysis with empirically data for effects of bi-directional pedestrian flows on speed, and capacity for walkway in Hongkong. Helbing [16]analyzed more about crowd analysis in Makkah, Saudi Arabia during the Hajj and data has collected by video camera..Recent studies also state that pedestrian flow is closely related to other parameters of pedestrian movement, namely speed and density. Basically, Pedestrian analysis is similar to motor vehicle movement analysis which is based on the fundamental relationship of pedestrian flows. The speed-density relationship along with the pedestrian flow forms a characteristic macroscopic behaviors. The most basic relationship between flow, speed, and density is as in the following equation, [17],

1. Pedestrian walking speed (v) and density (k)

$v = a - b * k$ (1)

2. Pedestrian flow (q) and density (k)

$Q= a * k – b * k2$

3. Pedestrian walking speed (μ) and flow (q)

$Q= v * k = v *(a-v)/b$

Where the values of "a" and "b" denote coefficients for the models which will be based on the characteristics of each pedestrian area. This study focuses on a single regime approach to establishing about flow, speed, and density parameters. Three parameters would be used as main parameters to know about local characteristic of pedestrian. Furthermore, the characteristics of pedestrians on a path have different approaches and cannot be described in general because every pedestrian has an approach in their movement activities [18].The values of a and b are obtained with current and speed data which are entered into a comprehensive table. For example, current and actual speed data are used to describe speed vs. density best fit linear graph. Speed and density data around the best fit line showed about data distribution around the line. The values of model parameters 'a' and 'b' were used to formulate the flow-density and speed-flow equations.

3.Methodology

This research was used a video camera to capture the movement of pedestrians. The use of videos in pedestrian research is supported by[19]which states that the use of

Xi'an ShiyouDaxueXuebao (ZiranKexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN:1673-064X
E-Publication:Online Open Access
Vol: 65 Issue 02 | 2022
DOI 10.17605/OSF.IO/QRDT6

video cameras has a smaller data collection error rate. In addition, the use of video recordings can also reduce the impact of changes in pedestrian movement due to the presence of surveyors or observers in the field. Pedestrian perception consists of two factors, namely before crossing the pedestrian path and when crossing the pedestrian path [20]. The observations were made on weekends for 3 observations, namely at 10.30 a.m. to 13.00 p.m. for morning conditions, 13.00 to 15.30 p.m. for daytime conditions and 16.00 to 18.30 p.m. for afternoon conditions. Each type of time is determined by the busiest hour indicator as the reference time in the pedestrian traffic simulation model. In general, a total of 4446 pedestrians were recorded in five locations during four hours of observation for each location. This is in accordance with the pedestrian standard which states that the observation of pedestrian paths can be carried out for a minimum of four hours In addition, the results from the current data show practically no similar time pattern of the traffic flow event. Traffic growth is generally uneven for each observation location. Survey location also collected about geometric side of the pedestrian lane. Field geometry are done by measuring the overall dimensions of sidewalk lanes, including the position and size of obstacles as well as markers of pedestrian lane in the area. After that, the data was taken according to the planned research time. Data is obtained by uninterrupted traffic movements. This is achieved by placing the camera in a location that does not interfere with pedestrians in carrying out their movement activities. The collecting data will be held by number and type of pedestrians in walking through the research site.

Figure 1. Pedestrian lane measurement survey in Malioboro location

4.RESULT

Pedestrian data obtained as many as 4446 pedestrians during sampling from 10.00 am to 18.30 pm. Pedestrian data was analysed using Microsoft Excel as the main tool to create a graph between them. The values of pedestrian flows, pedestrian speeds, density, and flow were computed at location. Approaching line were plotted between flow and speed, flow and density, and speed and density from the area. Before resulting for the equations between parameter, the flow fluctuations at each study time are shown with the help of graphs which shown in figure 2. In order to plot the graphs, the average of 60 minutes of flow data block was taken. This was dynamic hour. Dynamic hour has the advantage of investigating the dynamics of pedestrian flows based on the time of observation. fluctuations This was then expressed in the unit Ped/hour and bar charts were drawn to represent flow fluctuations. Result showed a spike in pedestrian flow in the afternoon from 1:00 AM to 2:30 PM. Besides, study

Xi'an ShiyouDaxueXuebao (ZiranKexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN:1673-064X
E-Publication:Online Open Access
Vol: 65 Issue 02 | 2022
DOI 10.17605/OSF.IO/QRDT6

experiences a spike in pedestrian flow from 5:00 PM to 6:30 PM in the noon. In the morning, pedestrian flow still stagnant in 300 ped/hour in average. The probable cause for this lies in the study environmental themselves. Malioboro was a communication hub especially at the early portion of the day in Yogyakarta. Hence the spike in pedestrian flow in afternoon rise in flow rate can be attributed to people coming there for shopping. Shops were located all around Malioboro. Tourism or local pedestrians coming in Malioboro from parking place and walking around Malioboro contributes heavily towards the 2:30 to 3:30 PM peak. However, peak flow of pedestrian in Malioboro was sporadic because the area itself is always visited by people around the day.

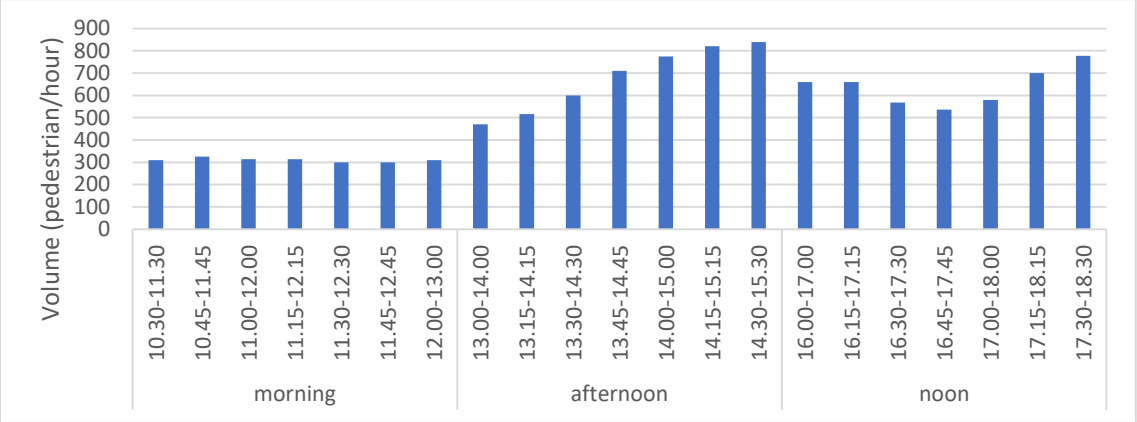

FIGURE 2. FLOW FLUCTUATION AMONG TIME RESEARCH

Characteristic of pedestrian flow shown by the amounts of pedestrians whom do activity in the same time. Pedestrian group were dominated for the entire research time. The increase in the share of pedestrians who walk in groups is getting bigger with time. Pedestrians in the afternoon (4:00 PM to 6:30 PM) are the maximum number of group walkers compared to another. This is supported by [25], in shopping locations, pedestrians need more comfort. This is because there are more diverse types of activities in the shopping area, such as shopping activities, entertainment activities, or just walking activities such as lane functions in urban space, but for office areas, the movement is quite high dominated by individuals who do their own activities, such as workers who enter and exit the office, or self-comfort when in urban space or other activities. In addition, pedestrians tend to walk in groups to protect each other when moving or doing activities in the area. Moreover, the shopping is one of the busiest areas where it will be difficult to direct walking. Thus, walking in groups gave rise to a leadership role to guide the movement of pedestrians along with them. In detail, the characteristics of the pedestrian flow are shown in table 1. Male and female pedestrians do not dominate each other. In the morning to evening conditions, there was a balanced number of the two, as in the morning condition, male pedestrians (51.26%) were greater than female pedestrians (48.76%). On the other hand, in the afternoon and evening conditions, female pedestrians were larger than male pedestrians, although the difference was not that large. In mobility behavior in shopping, female pedestrians have greater travel coverage than men. Shopping habits in women encourage them to spend more on their shopping trips [21]. In addition, in

Xi'an ShiyouDaxueXuebao (ZiranKexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN:1673-064X
E-Publication:Online Open Access
Vol: 65 Issue 02 | 2022
DOI 10.17605/OSF.IO/QRDT6

the flow characteristics related to the habit of carrying goods, it can be seen that at all times of observation, pedestrians who hold bags have dominated than others. In daytime conditions, more than 50% of pedestrians are more likely to hold a bag than to carry or not carry goods. While this value decreased in the afternoon conditions, where the increase in the number of pedestrians who did not carry goods was maximum compared to morning and afternoon conditions, although pedestrians carrying goods were still the highest compared to other types of pedestrians. These results explain the motives of pedestrians where in daytime conditions, shops start to open their shops, and pedestrians tend to shop earlier. The assumption of the availability of a large stock of goods will support more pedestrian movement to carry out shopping activities. On the other hand, in the morning conditions, not all shops have opened so that pedestrians still don't think about shopping at that location. This also applies in the afternoon, where the assumption is that the stock of goods in stores starts to run low due to shopping activities during the day[22].

TABLE 1. PEDESTRIAN CHARACTERISTIC ON SURVEY LOCATION

Pedestrian Characteristic		Morning (%)	Afternoon (%)	Noon (%)
Walking Nature	Private	25,28	19,76	14,38
	Group	74,72	80,24	85,62
Gender (sex)	Man	51,26	49,34	48,63
	Woman	48,74	50,66	51,37
Bring Luggage	No carrying	33,16	24,37	35,31
	Holding bag	45,40	56,71	43,03
	Carrying bag	21,44	18,92	21,66

The next analysis is to investigate pedestrian’s fundamental diagram, e.g. relationship between flow, speed, and pedestrian density. The relationship between speed and density is reviewed in negative exponential relationship. This is stated on research that the negative exponential relationship is one of the velocity-density relationships that is closest to the field data. The graph depicts the velocity-density relationship in the graph below. It can be seen in the graph that the correlation coefficient of R2 is at 0.87. This represents that the graph looks very good to fair fit the data. Therefore, the pattern of data movement in this relationship also shows that there is a possibility related to the pattern of two or three regime models which allows it to produce a better R2 value. Due to the absence of more extensive data, then the designed model cannot be displayed in the current research. However, pedestrians are highly vulnerable as well. The walking speed, flow and density of pedestrians are of prime importance in a study for design and provision of pedestrian facilities. Large proportions of sidewalk users’ need the provision of walk facilities such as exclusive walkways or footpaths on the road for their safe movement. Pedestrians walk differently on different types of walking facilities [12] [14]. Pedestrian characteristics are mainly represented in this study through three parameters, speed, density and flow rate. The speed-density has linear relationship with negative slope. Therefore, as the density increases the speed of the pedestrian decreases. However, this might not always be applicable to pedestrian

Xi'an ShiyouDaxueXuebao (ZiranKexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN:1673-064X
E-Publication:Online Open Access
Vol: 65 Issue 02 | 2022
DOI 10.17605/OSF.IO/QRDT6

movements. The relationships among the variables are expressed through mathematical equations. These equations can be used for macroscopic modeling purposes. It indicates the maximum capacity of the sidewalk as well as provides current level of service for pedestrian movements.

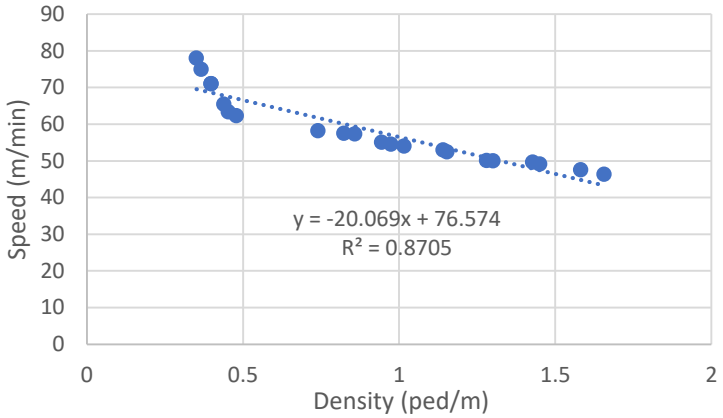

FIGURE 3. FUNDAMENTAL DIAGRAM MODEL

The estimated pedestrian flow characteristics in relation to speed and density are described in the table below. The flow-density and speed-flow graphs formulas are related to the speed-density relationship formulas. The results show that the relationship between these parameters is second order polynomial relation. Single regime models calibrated by least square method can't effectively fit the empirical data because it only describes one phenomenon of pedestrian movement. Based on theory. Speed-density relationship obtained in this study are similar to those reported by [23]for Chinese Central Business Area studies and [24] for Indian Studies. Free flow speed in present study resulted around 76,57 m/min. Some space has been occupied by the shop owners for the display of their material in Malioboro area. Besides, other space used for pedestrian facility, like chair, green space and trash can. The limited pedestrian space increases the pedestrian obstacle potential to the maximum parameter movement. Pedestrian tries to avoid obstacle to move out of this situation as fast as possible and hence, the speeds are higher at this location. Another result shown with maximum flow rates were observed as 292,17 ped/m/min.

TABLE 2. RELATIONSHIP MOVEMENT MODEL

Model relation	Model Equation	R2 value	Free flow speed (m/min)	Optimum flow (ped/m/min)

Xi'an ShiyouDaxueXuebao (ZiranKexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN:1673-064X
E-Publication:Online Open Access
Vol: 65 Issue 02 | 2022
DOI 10.17605/OSF.IO/QRDT6

Speed-Density	V = 76,57-20,07K	0,87	76,57	73,04
Flow-Speed	Q= V(76,57-V)/20,07	0,86		
Flow-Density	Q = 76,57K-20,07K^2	0,99		

The comparison with the pedestrian free flow speed reported in the literature, such as [14] who studied flow characteristic in Singapore, [25] in India or [26] in England. In details shown in table below. Result showed the free-flow speeds computed are higher than those observed in Singapore, India and China but lower than the speed that reported by [26] in England and [27] in Philipines. Meanwhile, current free flow speed also lower than pedestrian standard manual, like US Highway Capacity Manual 2010 in America or HBS in Germany. In general, Eastern Country has lower speed range than western countries. All of speed studies in eastern countries has the speed range between 73-76 m/min which western countries has more value in speed average. This is expected since for differences in cultural values people in the eastern countries tend to walk slower. Recent study stated that western countries, like European countries have highly standard of pedestrian lanes [28]. Traffic jam density in each of these three locations were much less than that of China, Thailand and Singapore and similar to that of India and Saudi Arabia 10. The capacity observed in the present study is found lowest than another reference, even Philipines or Singapore. The highest capacity found in Chinese and India where little obstacle founded in the pedestrian lane. Present study has obstacle that make less width for pedestrian traffic lane. More traffic lane width is making more pedestrian walk in the lane. This supported by [11] with simulation for unidirectional flow with various obstacle and found less obstacle has straight to highest pedestrian flow in the simulation.

TABLE 3. SPEED AND CAPACITY REFERENCE

Xi'an ShiyouDaxueXuebao (ZiranKexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN:1673-064X
E-Publication:Online Open Access
Vol: 65 Issue 02 | 2022
DOI 10.17605/OSF.IO/QRDT6

Reference	Year	Country	Capacity (ped/m/min)	Speed (m/min)
Older	1968	England	76,54	78,64
Khisty	1982	Washington	75,00	60,00
Tanaboriboon	1986	Singapore	89,24	73,90
Yun	1993	Chinese	95,97	75,45
Gerilla	1995	Philipines	74,94	83,20
HBS	2001	Germany	73,20	80,40
HCM	2010	America	83,07	80,47
Parida, Katiyar,Das	2018	India	91,64	75,80
Present Study	2021	Indonesia	73,04	76,57

Pedestrian flow characteristic was taken to reach level of service. Pedestrian level of service describe more about kemampuanjalurpejalan kaki terhadappejalan kaki yang berjalan di atasnya. The US Highway Capacity Manual 2000 referred the different levels of service for maximum speed. Maximum speed describe pedestrian could stay comfort in the lane with their obstacle[29]. Free flow speed consider as basis for LOS classification. On this study Malioborohas a LOS B with speed range between 76,2 – 78 m/min. According to HCM 2000 at LOS B found at Malioboro was sufficient area for pedestrians to select walking speeds freely to bypass other pedestrians, and to avoid crossing conflicts. At this level, pedestrians begin to be aware of other pedestrians, and to response to their presence when electing a pedestrian lane [30].

CONCLUSION

In this paper, we presented more about pedestrian flow characteristic for shopping areas sidewalk in Yogyakarta. Research was focused on fluctuation based on the time characteristics, behaviour and relationship for fundamental diagram. Pedestrian flow showed different characteristics between morning flow and afternoon flow. The increase in the portion of pedestrians who walk in groups is getting bigger from morning to evening. Pedestrians in the afternoon (4:00 PM to 6:30 PM) are the maximum number of group walkers compared to other times. In addition, in the flow characteristics related to the habit of carrying goods, it can be seen that at all times of observation, pedestrian who holding bag have dominated than others. The characteristics of pedestrians in the shopping area Malioborosidewalk have different characteristics in terms of carrying goods, whereas in the shopping areas it is more dominated by pedestrians carrying goods than others. The relationship of pedestrian such as density and speed show results free flow speed around 76,57 m/min.Finally,Pedestrian flow characteristic was taken to reach level of service. According to HCM 2000, Malioborohas a LOS B with speed range between 76,2 – 78 m/min. . At this level, pedestrians begin to be aware of other pedestrians, and to response to their presence when electing a pedestrian lane. It is a suggestion for future research to evaluate pedestrian flow with more than one observation time in order to see volume fluctuations more accurately and to evaluate the volume of pedestrians

ISSN:1673-064X
E-Publication:Online Open Access
Vol: 65 Issue 02 | 2022
DOI 10.17605/OSF.IO/QRDT6

with consideration of peak hour volume for the purposes of further investigation in the future.

Reference

[1] M. Danisworo, *Teori Perancangan Urban*. Bandung: Program Studi Perancangan Arsitektur Pasca Sarjana ITB, 1991.

[2] K. K. Laxman, R. Rastogi, and S. Chandra, “Pedestrian Flow Characteristics in Mixed Traffic Conditions,” *J. Urban Plan. Dev.*, vol. 136, no. 1, pp. 23–33, 2010.

[3] K. K. Laxman, R. Rastogi, and S. Chandra, “Pedestrian flow characteristics in mixed traffic conditions,” *J. Urban Plan. Dev.*, vol. 136, no. 1, pp. 23–33, 2010.

[4] U. Chattaraj, A. Seyfried, and P. Chakroborty, “Comparison of pedestrian fundamental diagram across cultures,” *Adv. Complex Syst.*, vol. 12, no. 3, pp. 393–405, 2009.

[5] S. Huang, R. Wei, S. Lo, S. Lu, and C. Li, “Experimental study on one-dimensional movement of luggage-laden pedestrian,” *Physica A*, vol. 516, pp. 520–528, 2019.

[6] P. M. Kielar and A. Borrmann, “Modeling pedestrians’ interest in locations: A concept to improve simulations of pedestrian destination choice,” *Simul. Model. Pract. Theory*, vol. 61, pp. 47–62, 2016.

[7] Z. Xiao, Z. Zhou, and K. Zhang, “Pedestrians’ violation behavior model based on group decision-making,” *Adv. Mech. Eng.*, vol. 11, no. 4, pp. 1–8, 2019.

[8] U. Intersection, “Analysis of The Effect of Vehicles Conflict on Pedestrian ’ s Crossing Speed In Signalized and Un-Signalized Intersection,” vol. 8, no. October, pp. 502–509, 2014.

[9] J. Wang, L. Nan, and Z. Lei, “Small group behaviors and their impacts on pedestrian evacuation,” *Proc. 2015 27th Chinese Control Decis. Conf. CCDC 2015*, pp. 232–237, 2015.

[10] R. Rastogi, T. Ilango, and S. Chandra, “Pedestrian flow characteristics for different pedestrian facilities and situations,” *Eur. Transp. - Trasp. Eur.*, no. 53, pp. 1–21, 2013.

[11] W. Wang, J. Zhang, H. Li, and Q. Xie, “Experimental study on unidirectional pedestrian flows in a corridor with a fixed obstacle and a temporary obstacle,” *Phys. A Stat. Mech. its Appl.*, vol. 560, p. 125188, 2020.

[12] G. Flötteröd and G. Lämmel, “Bidirectional pedestrian fundamental diagram,” *Transp. Res. Part B Methodol.*, vol. 71, pp. 194–212, 2015.

[13] D. Oeding, “Traffic loads and dimensions of walkways and other pedestrian circulation facilities.,” *Strassenbau and strassenverkehrstechnik*, vol. 22, pp. 160–163, 1963.

[14] Y. Tanaboriboon, S. S. Hwa, and C. . Chor, “Pedestrian characteristics study in Singapore,” *J. Transp. Eng.*, vol. 112, no. 3, pp. 229–235, 1986.

[15] W. H. K. L. C. Cheung, “PEDESTRIAN SPEED/FLOW RELATIONSHIPS FOR WALKING FACILITIES IN HONG KONG,” *J. Transp. Eng.*, vol. 2, no. August, pp. 343–349, 2000.

[16] A. Abdelghany, K. Abdelghany, and H. Mahmassani, “A hybrid simulation-assignment modeling framework for crowd dynamics in large-scale pedestrian facilities,” *Transp. Res. Part A Policy Pract.*, vol. 86, pp. 159–176, 2016.

[17] W. K. Kittelson and R. P. Roess, “Highway Capacity Manual 2000,” vol. 1950, no. 01, pp. 10–16, 2000.

[18] M. Twarogowska, P. Goatin, and R. Duvigneau, “Comparative study of macroscopic pedestrian models,” *Transp. Res. Procedia*, vol. 2, pp. 477–485, 2014.

[19] A. M. Tahsin Emtenan and S. I. Shahid, “Pedestrian Flow Characteristics Under Heterogeneous

ISSN:1673-064X
E-Publication:Online Open Access
Vol: 65 Issue 02 | 2022
DOI 10.17605/OSF.IO/QRDT6

Traffic Conditions," *Am. J. Civ. Eng.*, vol. 5, no. 5, p. 282, 2017.

[20] N. I. Bahari, A. K. Arshad, and Z. Yahya, "Assessing pedestrian profile according to age and gender in Central business district, Kuala Lumpur, Malaysia," *Adv. Mater. Res.*, vol. 905, no. April, pp. 768–772, 2014.

[21] M. Maurer Herter, C. Pizzutti dos Santos, and D. Costa Pinto, "'Man, I shop like a woman!' The effects of gender and emotions on consumer shopping behaviour outcomes," *Int. J. Retail Distrib. Manag.*, vol. 42, no. 9, pp. 780–804, Sep. 2014.

[22] K. Takai and K. Yada, "A framework for analysis of the effect of time on shopping behavior," *J. Intell. Inf. Syst.*, vol. 41, no. 1, pp. 91–107, 2013.

[23] J. H. Ye, X. Chen, C. Yang, and J. Wu, "Walking Behavior and Pedestrian Flow Characteristics for Different Types of Walking Facilities," *Transp. Res. Rec.*, vol. 2048, no. 2048, pp. 43–51, Jan. 2008.

[24] P. Das, M. Parida, and V. K. Katiyar, "Review of simulation techniques for microscopic mobility of pedestrian movement," *Trends Transp. Eng. Appl.*, vol. 1, no. 1, pp. 27–45, 2014.

[25] M. Parida, V. K. Katiyar, and P. Das, "MACROSCOPIC PEDESTRIAN FLOW MODELLING USING SIMULATION TECHNIQUE," *Int. J. TRAFFIC Transp. Eng.*, vol. 8, no. 2, pp. 166–176, 2018.

[26] Older, "Movement of pedestrians on footways in shopping streets," *Traffic Eng. Control*, vol. 10, no. 4, 1968.

[27] G. P. Gerilla, K. Hokao, and Y. Takeyama, "Proposed level of service standards for walkways in Metro Manila," *J. East. Asia Soc. Transp. Stud.*, vol. 1, no. 3, pp. 1041–1060, 1995.

[28] I. A. Ferreira, M. Johansson, C. Sternudd, and F. Fornara, "Transport walking in urban neighbourhoods-Impact of perceived neighbourhood qualities and emotional relationship," *Landsc. Urban Plan.*, vol. 150, pp. 60–69, 2016.

[29] F. D. Pratiwi, "STUDI KARAKTERISTIK PERGERAKAN PEJALAN KAKI DI PEDESTRIANS ROAD STASIUN TUGU YOGYAKARTA," Universitas Sebelas Maret, 2011.

[30] W. K. Kittelson and R. P. Roess, "Highway Capacity Analysis After Highway Capacity Manual 2000," *Transp. Res. Rec. 1776*, vol. 1950, no. 01–2808, pp. 10–16, 2000.