

Assessment of HCM 2010 and HBS 2002 for Pedestrian Lane Quality In Indonesia (Case Study: Sardjito Hospital and Sudirman Office, Yogyakarta)

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Abstract: Transportation was derived demand from primary activities from resident. Transport mobility is used transport modes, including for pedestrian as one of transport modes in the city. Pedestrians mobility are often forgotten on the transport infrastructure, like road. Connectivity between transportation nodes for first and last mile is crucial in encouraging the movement of people by walks. Indonesia still not have special procedures to assess pedestrian lane quality. Performance of road activity is often considered the same as motorized vehicles, like in Manual Kapasitas Jalan Indonesia 1997. On the other hand, several regulations have been issued for the quality of pedestrian lanes, including HCM 2010 in America and the 2002 HBS in Germany. The purpose of this study was to determine the quality of pedestrian lanes using HCM 2010 and HBS 2002 in Indonesia. Research would be located in Sardjito Hospital and Jalan Sudirman Office, Yogyakarta. The results showed that lane width is one of the main components in assessing pedestrian quality from lane characteristic. HCM 2010 is focused on both lane characteristic and pedestrian characteristic on pedestrian location to asses them. On the other side, HBS 2002 just focused on pedestrian characteristic as primary key to asses pedestrian lanes quality The quality of the pedestrian paths for the Sardjito Hospital study is in class C for HCM 2010, but HBS 2002 scored for A class. On the other hand, Sudirman office area has scored A for both HCM 2010 and HBS 2002 assessment. The process and results of the assessment are expected to be a guideline used to develop manuals for the quality of pedestrian services in Indonesia

Keywords: Pedestrian, lane quality, HCM 2010, HBS 2002, Yogyakarta

1. Introduction

Transportation was a daily activity and important for society. Nevertheless, transportation was not a major necessity for citizen, but as a derivative needs from primary needs for citizen. One of the transport activity especially for first and last miles was walking activity. Pedestrians as the object of walking activity was defined as a person walking on a pedestrian path either on the side of the road, on the sidewalk, on a special lane for pedestrians or crossing the road. Pedestrian-only lanes are often included in part of the public road area that functions as a space for pedestrian movement that is separated from motorized vehicles. It is very possible for road users to choose the walking mode to reach their destination quickly, such as people's activity from and to shopping centers after parked their private vehicles or public transportation on their way to the area (Silva Cruz and Katz-Gerro 2016).

The pedestrian characteristics will serve as the foundation for the requirements for pedestrian planning, the amenities required for pedestrian lanes, and can also be utilized to establish baseline parameters for pedestrian operations and to generate pedestrian models (Alexandersson and Johansson, 2013). The volume of pedestrian traffic is one of the pedestrian parameters. In traffic research, one of the functions of volume is to calculate the current traffic flow at a given point in time in order to estimate the busiest flow for the purpose of planning and evaluating traffic lanes. The volumetric parameters, one of which is a rush hour factor, describe the path's volume circumstances during crucial conditions, such as the route's current congestion.

Regulations which related to planning and performance evaluation, especially in urban traffic, are still used as a side barrier in traffic areas. Highway Capacity Manual for Indonesia in 1997 as the only guideline for traffic road evaluation for planning until evaluation made to Indonesian standards. The calculation of the capacity and level of road traffic service is only dominated by the presence of motorized vehicles. Thus, this causes pedestrians to be counted less in the manual. the need for pedestrians is the same obligation as the need for motorized vehicles. On the other hand, pedestrians of all ages and abilities have the same right to be safe, comfortable, and have access to their destination(Hummer et al. 2005). Therefore, a separate traffic performance evaluation review is required specifically for pedestrian lanes. Several regulations for conducting special evaluations of pedestrian lanes include the HBS 2002 issued in Germany and the AHCM 2010 issued in America as a development of the previous AHCM, namely the AHCM 2002.

This study discusses the review of the quality of pedestrian paths in Indonesia, especially on the sidewalks in front of Sardjito Hospital and sidewalks on Jalan Sudirman that located in Yogyakarta, Indonesia. The pedestrian

lane service will focus on applying the HCM 2010 and HBS 2002 regulations for the research study area. The purpose of this study is to evaluate pedestrian pathways related to the characteristics of the path and pedestrian movement. In detail, this study uses the pedestrian service index from HCM 2010 and HBS 2002 with the specific pedestrian lane scoring parameters and movement characteristics in the form of pedestrian volume. The results of this study are expected to provide new insights for making guidelines for pedestrian services in Indonesia. Pedestrian quality services in Indonesia are still based on a qualitative approach, namely in the form of pedestrian perceptions or quantitative based directly on pedestrian characteristic parameters, such as volume, speed and density of pedestrians. even footers, but their headers remain the same.

2.Theory

Pedestrians are an important form of transportation in urban areas. Pedestrians usually do its activity walk on special lanes provided for pedestrians, one of which is sidewalks. Sidewalks are located in the benefit area of the road, which is covered with a surface layer with a higher elevation than the pavement surface, and is generally parallel to the vehicle traffic lane(Romero, et al, 2017). The sidewalk should be placed on the inside of the drainage channel or above the closed drainage channel. The main function of sidewalks is to provide optimal service to pedestrians both in terms of safety and comfort. Sidewalks also serve to increase the smoothness of traffic (vehicles), because they are not disturbed or affected by pedestrian traffic. Especially in urban areas (urban), the space under the sidewalk can be used as space to get utilities and other road additions.

Pedestrian Quality

The definition of the quality of a pedestrian area depends on several different parameters such as accessibility to a destination, connectivity, and the quality of the pedestrian network, security and safety, etc. One of them is the quality of pedestrians, which is defined as a measure of conditions that are measured from a pedestrian activity operation process(Andriani, et al, 2015). Pedestrian quality is one of the assessments in the evaluation of pedestrian activity, especially those in the pedestrian path. Evaluation techniques used to determine the quality of pedestrians are generally divided into 5 types, including evaluation of pedestrian satisfaction (Prijadi et al. 2014; Rohmawati and Natalia 2018; Tyas 2013), pedestrian service levels (FGSV 2002; Kadali and Vedagiri 2016; Krambeck 2008), an assessment evaluation technique in the form of direct assessment to the top field. (Cole et al. 2015; Moura,et al, 2017; Setianto and Joewono 2018). Comparison of the ideal value of a pedestrian facility with field conditions which is also called the pedestrian index (Moeinaddini,et al, 2014), and expert assessments(Martokusumo, Kusuma, and Octaviana 2013).

American Highway Capacity Manual (AHCM) 2010

American Highway Capacity Manual (HCM) was one of the oldest pedestrian service indexes in the world, in details since 1930 until now. Nevertheless, it was significant developed from Fruin in 1971 which compiled six levels of service index based on the occupancy of an area (density) for transport movement(Fruin 1971). Then, the Transportation Research Board (TRB) adopted them and produced a road capacity manual based on the road service index, namely AHCM 1985 which included pedestrian paths in the preparation of the index. This manual continue to developed until in 2010, which had very significant changed especially for pedestrian quality. AHCM 2010 introduced about scoring system from both pedestrian lane characteristic and pedestrian space (Transportation Research Board 2010)

The scoring process in AHCM 2010 based on the characteristics of pedestrian facilities and pedestrian movements. In details, characteristic of pedestrian facilities focused on width of the lane, obstacles pedestrian lane, and shy distance. Shy distance related with perceptual distance for pedestrian when they walks on special lanes. In addition, characteristics for area around special pedestrian lane also affects pedestrian scoring, such as dimensions of outer lanes serving vehicles, road shoulders, curb and median in the area of the road under review. Some of considered parameter that used by AHCM were follows,

- Pedestrian flow data, which in details are Volume pedestrian and average pedestrian speed
- Pedestrian Facilities data, which in details are Proportion of parking on street (decimal), Road shoulder width (ft), Availability of bike lanes, Width of bike path, traffic lane width, curb and barrier along the lane.
- Geometric Characteristics such as Pedestrian lane width, Convenient distance between pedestrian and fixed object on the road side (ft), Convenient distance between pedestrians and objects in the form of display windows, walls buildings, and fences (ft), Effective width of fixed objects in pedestrian facilities adjacent to the road.

HBS Germany 2002

Apart from AHCM 2010, a scoring technique is also applied in Germany by making an evaluation for performance of road facilities which is based on a method with a number of different technical regulations

according to local conditions. Then, the first manual of the German Highway Capacity Manual (Handbuch für die Bemessung von Straßenverkehrsanlagen - HBS) was introduced in January 2002 (FGSV 2002). The evaluation method applied as same as American Highway Capacity Manual (HCM) which level of service quality uses score from A to F. The German HBS guidelines are based on research reports from Brilon, Großmann, Blanke in 1994. These reports were widely used initially by transportation practitioners but were needed approval from the appointed committee, namely Forschungsgesellschaft für Straßen- und Verkehrswesen (FGSV). In this method, the characteristics of specific pedestrian paths are determined through the characteristics of the path and movement without influence from outer lane of the existing pedestrian system. Some parameter that considered in this regulation were following,

- Pedestrian Flow Data, which in details are Pedestrian volume located on the road (p/h) and Average pedestrian speed
- Geometry Characteristics which in details are Total width of pedestrian path, Barrier dimensions, Slope of the pedestrian path (percent) and Width of buffer between road and pedestrian facilities.

3. Methodology

The research was aimed for determining quality of pedestrian path services by scoring index based on AHCM 2010 and HBS 2002 in Indonesia. Its method was taken with quantitative through a field observation to know characteristic pedestrian lane and direct survey to get data from analyze the performance of sidewalk facilities as one of the main pedestrian facilities. This study has limited for the pedestrian area where only for sidewalk where the influence factor of movement outside the pedestrian path, such as the movement of a crossing, was not included in this study.

Types of data used in this research are pedestrian path characteristics and movement characteristics. The characteristics of the pedestrian paths were obtained by field surveys by identification for research locations, both in the Sardjito Hospital Area and the Sudirman Office Area, Yogyakarta. The road characteristics data obtained for this study included with lane width dimensions, dimensions of pedestrian barriers in pedestrian paths such as seats, pedestrian buffers, dimensions of motorized vehicle lanes and other lane characteristics. The survey is carried out by making direct measurements in the field related to all the data required, such as lane characteristics, obstacles, and buffer dimensions that separate vehicle lanes and pedestrian paths.



Figure 1. Pedestrian lane measurement survey

In general, length of the both study area were 50 meters for the Sudirman office area of Yogyakarta and Sardjito Hospital area. In addition, pedestrian movement data were obtained through video cameras which recorded all existing pedestrian activities throughout the study time. Video cameras are also used to record pedestrian speed data using pedestrian boundaries in the area. Pedestrians counted their walking time to determine pedestrian speed by monitoring the number of pedestrians who passed the reference area. On the other hand, the geometric characteristics from location were measured directly in the field. The length of the pedestrian segment used to record on video was 15 meters. This is supported by previous research, such as Hadi (2018); Wibowo, et al (2019) use a reference distance of 10 meters in determining pedestrian speed data.

American HCM 2010 and Germany HBS 2002 had its standard that can be used to assess pedestrian quality through scoring techniques consisting of 6 classes, namely class A to F where class A is the best level and class F is the worst level.

Table 1. Pedestrian path scoring by HCM 2010

Score Pedestrian	LOS via pedestrian average space (ft ² /p)					
	>60	40-60	24-40	15-24	8-15	<=8
<2	A	B	C	D	E	F
2-2.75	B	B	C	D	E	F

2.75-3.5	C	C	C	D	E	F
3.5-4.25	D	D	D	D	E	F
4.25-5	E	E	E	E	E	F
>5	F	F	F	F	F	F

The process in determining the performance of pedestrian facility space based on HCM 2010 used the following formula:

$$I_{p, link} = 6.0468 + F_v + F_s + F_w \tag{1}$$

Where $I_{p, link}$ = Performance of space for pedestrians on the road, F_w = Road cross-section factor, F_s = Vehicle speed factor and F_v = Vehicle volume factor.

While at Germany's HBS 2002, pedestrian quality was assessed from a pedestrian speed, density, and current diagram with the main unit of meters for distance and seconds for time. In determining pedestrian speed, the HBS 2002 guide uses a reference to transportation motives at a review site as one of the considerations. HBS 2002 mentions that for the condition of the pedestrian path that is flat (the slope of the lane is zero percent) or on a uniform sidewalk, hence the internal motivation of pedestrians where one of them is the pedestrian destination.

Table 3. Pedestrian speed based on transportation motives

Transportation Motives	Average speed (m/s)
Mixed use (average)	1.34
Commuter Traffic	1.49
Shopping traffic	1.16
Convenience of traffic (relaxing walk)	1.10

HBS 2002 used pedestrian density as its benchmark to know about level of service. Density would be affected with time which pedestrian reach their destination from the beginning area. Besides, density is affected by current space average that provided by the location. Both of parameter calculated by using the following formula,

$$q_s = q/B \tag{2}$$

Where q_s = quality of flow (Person/m), q = pedestrian flow (Person), B = pedestrian width(m).

Table 2. Pedestrian path scoring by HBS 2002

Level of Service	Quality of flow (Peds/m.s)
A	≤ 0.10
B	≤ 0.25
C	≤ 0.40
D	≤ 0.70
E	≤ 1.80
F	≥ 1.80

This research uses procedures to measure the level of service, namely by using HCM 2010 and HBS 2002 procedures. Input data and calculation procedures of HCM 2010 and HBS 2002 for pedestrians can be seen in Figure 4. Both guidelines have similarities where the characteristics of the pedestrian path are effectively determined by the total path width reduced by the existing obstacles along the path commonly referred to as the lane barrier, and the width of the perception of the object that is next to the pedestrian path commonly called shy distance.

4.Result and Discussion

This research was conducted to find out pedestrian level of service in pedestrian paths for urban area in Indonesia. This research take Yogyakarta for its study case. Based on analysis, it showed that characteristics for pedestrian lane at Sardjito Hospital Area are different from sudirman street office area, Yogyakarta. Sardjito Hospital area has a uniform pedestrian lane width of 2.5 meters, while in Sudirman Area Yogyakarta average has a pedestrian lane width of 7.2 meters. Both locations have characteristic similarities where pedestrians have freedom of movement on the track because there are buffers that limit between the vehicle's path and the

pedestrian path. Sardjito Hospital area has vertical fence as buffer, while Sudirman Street office area has buffer in the form of greening park as a separator of vehicle lanes and pedestrian paths. In addition, pedestrians' perception of objects next to pedestrians.



(a) (b)
Figure 1. Study location Jalan Sardjito (a) and Jalan Sudirman (b)

Result showed that sidewalk width for Jalan Sudirman (7,2 meters)and Jalan Sardjito (2,5 meters) has been fulfilled by local pedestrian policy that minimum width for pedestrian lane is 2 metres(Pekerjaan Umum RI 2014).Besides, both of AHCM 2010 and HBS 2001 also stated that standard lane for convenience about 3 metres or 10 ft(UNESCAP 2016). Thus, Sidewalk width for Sardjitolocation (2,5 metres)cannot be fulfilled by HCM 2010 or HBS 2001, though it fulfilled by local pedestrian policy.Existing pedestrian width on Sardjito location could make impact for pedestrian comfortability. This supported by Sharifi et al. (2016) that pedestrian width would affect for pedestrian behavior and its characteristic like pedestrian volume, speed, and density because of its area to do a walking activity.

Pedestrian level of service has many considered parameter. Both of AHCM 2010 and HBS 2002 measured them by area condition. AHCM 2010 used level of service based from existing pedestrian lane by mixed used activity, which means people and vehicle do together with different side lane and affected one and another like parking activity, traffic vehicle also biking activity (Brinckerhoff 2013). Besides, HBS 2002 consider more about special pedestrian lane that divided from the road activity. HBS 2002 concerned for pedestrian lane as the lane that only based from pedestrian activity that makes independent pedestrian level of services. It is similar with AHCM 2010, HBS 2002 also consider about pedestrian width, obstacle, but HBS did not consider about parking, vehicle activity, or biking activity. In contrast, HBS 2002 given more about pedestrian motives that affected its level of service (Wu 2017).

Calculations of pedestrian service levels show that HCM 2010 Jalan Sardjito location, calculation results showed at service level C class. Besides, Jalan Sudirman location showed service level in A class. Different result for both of them happened with lower value of quality score for Jalan Sudirman than Jalan Sardjito. Lower width of Jalan Sardjito lane gave many impact for the score. Besides, Jalan Sardjito has more pedestrian volume than Jalan Sudirman. This resulted pedestrian space for Jalan Sardjito was lower than Jalan Sudirman. Based from Flötteröd and Lämmel (2015), more pedestrian volume in a pedestrian lane would make people reduce their speed and free area to do pedestrian activity was narrower, even total area in the pedestrian lane was small. Thus people would not convenience to walk there except people has no option to choose another route. This is more due to HCM 2010 considering the characteristic score of the lane other than pedestrian movement.

Table 4. Quality of pedestrians at the research site based from AHCM 2010

Parameter	Jalan Sardjito	Jalan Sudirman
Pedestrian width	2.5	7.2
Pedestrian flow (ped/m)	80	34
Walking average speed (km/h)	1.34	1.34
Parking proportion (%)	0	0
Outside lane width (m)	1	0.2
Bike lane width(m)	0	0
Buffer width(m)	0.8	3.8
Safe width from sidewalk side (m)	0	0
Obstacle width (m)	0	0.15
Pedestrian gradient (m)	0	0
Quality score	2.784	1.249
Pedestrian space (ft ² /s)	2234	8034

Parameter	Jalan Sardjito	Jalan Sudirman
Level of Service	C	A

Similarly, in Sudirman office area, where HCM 2010 shows service level C, HBS 2002 also showed service level was A level. Different result happened in Jalan Sardjito, while HCM 2010 showed service level C, but HBS 2002 valued pedestrian lane for A level. Pedestrian geometry is not considered more in HBS 2002 than HCM 2010. From another point of view, HBS 2002 compiles pedestrian assessments based on pedestrian movement characteristics of speed and density. Final benchmark for pedestrian level of services was quality of flow which talked more about average flow for 15 minutes and 2 minutes. Pedestrian width lane was a considered parameter to divided more pedestrian whether for starting or ending their journey on a lane.

Table 3. Quality of pedestrians at the research site based from HBS 2002

Parameter	Jalan Sardjito	Jalan Sudirman
Pedestrian width (m)	2.5	7.2
Lateral movement width (coefficient)	0.6	0.6
Obstacle width (m)	0	2.5
Pedestrian speed (m/s)	1.34	1.34
Existing pedestrian volume(Person/60 min)	80	34
Volume interval 15 minutes(Person/15 minutes)	25.6	10.88
Volume interval 2 minutes (Person/2 minutes)	4.608	2
Quality of flow for 15 minutes (person/m.s)	0.015	0.003
Quality of flow for 2 minutes (person/m.s)	0.020	0.004
Level of services for 15 minutes	A	A
Level of services for 2 minutes	A	A

CONCLUSION

Based from all description above, this paper conclude that HCM 2010 from America and HBS 2002 from Germany could be used for assessment of pedestrian quality in Indonesia. Effective width from pedestrian path and pedestrian characteristic become primary key to assign level of service for pedestrian area in Indonesia. Study location, whether Sardjito Hospital and Sudirman Office Area in Yogyakarta has different characteristic pedestrian path, where Sardjito Hospital just have width about 3.2 meter and Sudirman Office Area has 7.2 meter for effective width for pedestrian path. The two research locations have different service values, namely Sardjito Hospital area is class C in AHCM 2010 and class A in HBS 2002. On the other hand, Sudirman Yogyakarta office area is in class A for both guides. Both locations have strict separators with vehicle paths, namely using buffers in the form of vertical fences and buffers in the form of separation parks. This research is expected to be a reference in the condition of pedestrian paths in Indonesia to be a reference source in the study of road quality in Indonesia.

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