Engineering and Technology Journal e-ISSN: 2456-3358

Volume 09 Issue 05 May-2024, Page No.- 4172-4178

DOI: 10.47191/etj/v9i05.38, I.F. – 8.227

Determining of Appropriate Passenger Car Unit Values Due to a Change in Effective Width of Roadway

Egidius Kalogo[1], Don Gaspar N. da Costa[2]

[1,2]Study Program of Civil Engineering, Faculty of Engineering, Universitas Katolik Widya Mandira, Jl. San Juan No.1, Penfui Timur, Kupang, Indonesia

ABSTRACT: Legitimately, the passenger car equivalent value is determined based on the type and width of the road as well as the traffic volume. Interestingly, the effective width of roadway often varies due to land topography conditions and level of side friction. Theoretically, the number of survey posts should be determined based on road geometric and environmental conditions because traffic volume is a reflection of the choice of speed. Unfortunately, due to limited funds, traffic volume, travel speed and ride friction surveys were carried out at 1 survey point. As a result. the recommendations for strategies and/or traffic management and engineering techniques could be bias. This study aims to calculate the impact of differences in the effective road width on the equivalent value of passenger cars using the Speed Method. For this reason, a speed survey was carried out on a number of arterial roads in the Kupang urban area. It was found that changes in the effective width of road lanes have a significant impact on changes in motorbike speed so that the use of passenger car equivalent value for motorcycle should be based on the result of field survey, instead of a standardized value as it was recommended by Indonesian Highway Capacity Guide.

KEYWORDS: Effective carriage width, passenger car equivalent, speed method, urban road link

I. INTRODUCTION

The paradigm of road infrastructure is commonly known as a connecting hub of the centre of strategic socio-economic activities, locally or regionally [1]. The physical connectivity issue know is completed with the functional connectivity issue. This may guarantee the achievement of the development in the prime sectors [2], [3]. Understandably, the orientation of the improvement of accessibility and mobility level is more directed to road preservation programmes in the main connecting road network among such socio-economic zones [2], [4].

Indicators usually used to assess the successfully of the achievement of development's target of road infrastructure is accessibility and mobility index. The accessibility index (AI) is a ratio of total road length within poor category level, and total available road length in a region. Therefore, if the AI closer to 1.0 then it means the level of accessibility is very low, and vice versa.

In the context of traffic management and engineering scope, the increasing number of traffic jam zones represent the low level of accessibility because the travel speed was low. Understandably why a number of riders usually tend to increase their vehicle speed to avoid and/or to be released from such traffic congestion zones [5], [6]. This strongly influences the traffic volume as well as accident risk.

The basic idea of this research are triggered by the following reasons: 1) the presence of an indication of difficulties in the management of right of way occupied by small-scale socio-economic activities along the urban roadway 2) such occupation not only reduce roadway shoulder but also generating the on-street parking which in turn reduce the effective width of roadway, 3) a reduce in the effective width of roadway may reduce travel speed, traffic volume and road capacity as well 4) since the PCE value was determined based on an assumption that the condition of traffic is stable and the minimum effective width of roadway is 3.5 m [7], [8] so that the cumulative impact of a reduce in roadway lane width and travel speed is required to be investigated.

The output of this study is intended to support the determination of public transport policy by local authorities (both public work and transportation departments), during the road network planning and evaluation stages.

Therefore, the aims of this study are: 1) to identify the effect of carriageway width characteristics to the distribution frequency of travel speed 2) to determine the effect of a reduce of roadway width to the fluctuated travel speed measured and its implication on road network analysis or evaluation products.

II. METHOD

As previously mentioned above that the filed observation or survey would be conducted at some urban arterial roadways which suffered a reduce in the effective width of roadway due to topographical or roadside friction conditions.

The type of survey required are: 1) geometrical inventory survey, road environment conditions as well as road functional classification. The data would be used to divide road link into a number of road segments. Only road segment within a reduce width category would be observed 2) a spot speed survey then was conducted on such chosen road segments. The duration of travel between starting to end point then was recorded (around 100 m) to calculated the average spot speed used to determine the PCE values using equation 1.

It should be noted that before the survey began, each of surveyor were told that the sample vehicle is chosen based on their speed. Only vehicle that moving with the similar speed with other vehicles were chosen. Therefore, if the observed vehicle suddenly stops or manoeuvre into another road link then the observed vehicle should be changed.

Subsequently, the research's stages are as follows: 1) compilation data of travel speed intended to produce the average speed at each road segment 2) the average speed data then being used to calculate the passenger car equivalent value for motorcycle and heavy vehicle by using Equation 1 [9] as follow:

$$EMP_i = \frac{V_c/V_i}{A_c/A_i} \qquad (1)$$

Where is:

EMPi = passenger car equivalent for vehicle type "i"

Vc = average speed of light vehicle (km/jam)

Vi = average speed of light vehicle type "i" (heavy vehicle and motorcycle)

Ac = dimension of passenger car

Ai = dimension of the vehicle type "i" (heavy vehicle and motorcycle)

Finally, the effect of a reduce in the effective width of roadway to travel speed represented in the various PCE was analysed by comparing them to the PCE values recommended by IHCM'97 or IHCG'23. Therefore, a number of spot speed survey were carried out at both one-way (divided lane) and two-way (un-divided lane) arterial street.

According to the IHCM'97 and IHCG'23 the PCE values was much influenced by the type of roadway, traffic volume and the width of roadway MKJI'97, neglecting the presence of on-street parking which reduce the effective width of roadway as can be seen in the following tables.

Table 1. PCE for undivided type of urban roadway version IHCM'97 [7]

Undivided roadway type	Total traffic volume (vehicle/hour)	PCE		
		HV	Road Carriage Width W_c (m)	
			≤ 6	≥ 6
Two-way lane (2/2 UD)	0	1,3	0,5	0,4
	≥ 1800	1,2	0,35	0,25
Four-way Lane (4/2 UD)	0	1,3	0,4	
	≥ 3700	1,2	0,25	

Table 2. PCE for divided type of urban roadway version of IHCM'97 [7]

One-way and Divided Roadway	Traffic Volume per Lane (Veh/hour)	PCE	
		HV	MC
Two-way lane (2/1) and Four-way Lane (4/2 D)	0	1,3	0,40
	≥ 1050	1,2	0,25
Three-way lane (3/1) and Six-way Lane (6/2D)	0	1,3	0,40
	≥ 1100	1,2	0,25

Table 3. PCE for undivided type of urban roadway version of IHCG'23 [8]

Type of Roadway	Tot traffic volume (Veh/hour)	PCE_{HV}	PCE_{MC}	
			L lane ≤ 6 m	L lane ≥ 6 m
2/2 TT	< 1800	1,30	0,50	0,40
	> 1800	1,20	0,35	0,25

Table 4. PCE for divided type of urban roadway version of IHCG'23 [8]

Type of roadway	Traffic volume per lane (Veh/hour)	PCE_{HV}	PCE_{MC}
4/2-T or 2/1	< 1050	1,30	0,40
	≥ 1050	1,20	0,25
6/2-T or 3/1	< 1000	1,30	0,40
8/2-T or 4/1	≥ 1100	1,20	0,25

It shows that the PCE values of the IHCM'97 and IHCG'23 are similar and as previously mentioned, the effect of a change in roadway's width was neglected, whereas it may affect the travel speed which in turn may decrease the road performance [10], [11].

It is assumed that a reduce in roadways 'width may reduce the travel speed and resulting in the lower traffic volume. Since the IHCM'97 and IHCG'23 only organized the PCE values based on general roadway's width, i.e., whether it was greater or lower than 6 m then this phenomenon clearly indicated that the recommended PCE values was built based on an assumption that the width of roadway is constant or there is no change in their width.

Accordingly, the determination of study locations was conducted based on the result of initial field observation (visual observation) intended to identify the presence of a reduce in the effective width of roadways due to roadside friction activities, especially due to on-street parking. In addition, the condition of traffic volume was also investigated. The chosen roadways characteristics are as follows:

1. A total of 4 secondary arterial road was chosen i.e., El Tari Street (one-way lane width of > 6 m; 3/1; both on the east-west way and west-east way), Sam Ratulangi Raya Street (lane width of > 6 m; 2/2 un-divided lane (UD)), Soekarno Street (lane width of > 6 m; 2/2 UD), and Achmad Yani Street (lane width of > 6 m; 2/2 UD).
2. The width of all of the chosen roadway was greater than 6 m. However, the general picture of a reduce of effective width of roadway due to on-street parking vehicles can be drawn as follows: a) on-street parking at the El tari Street was triggered by market activities (East-West way) and street vendors (West-East way) b) on-street parking at Sam Ratulangi Raya Street was triggered by street vendors activity adjacent the public space of Taman TAGEPE c) on-street parking at Soekarno Street was triggered by mosque, government office and street vendors activities d) on-street parking at Achmad Yani Street was triggered by educational and trade activities.
3. A significant change in travel speed was occurred on each road segment located nearby the on-street parking activities. This confirms the accuracy location of this of study.

III. RESULT AND DISCUSSION

A. Road geometry and Environment Characteristics

The effective width of roadway and roadside friction level can be seen in the following table. It can be seen that a change in the effective width of roadway occurs on the road segment within the high level of roadside friction category. However, it should be noted that the presence of on-street parking at the El tari Street doesn't affect the required minimum width of roadway lane as it was regulated in the IHCM'97 or IHCG'23, i.e., 3.5 m.

Table 5. The effective width roadway and side friction level characteristics

Name / Type of Road	Road Width (m)	Effective Width of Roadway (m)	Side Friction level	Remark
El Tari (arterial roadway, direction of East-West)				
Segment 1	7	7	Very low	Governor Office – Anugerah Church
Segment 2	7	4	Very high	Anugerah Church – HKSN Statue
El Tari (arterial roadway, direction of West - East)				
Segment 1	7	7	Low	HKSN Statue – unsignalized intersection of Anugerah Church
Segment 2	7	5	Medium	Unsignalized intersection of Anugerah Church – unsignalized intersection of Palapa Street
Segment 3	7	5	High	Unsignalized intersection of Governor Residence – Governor Office
Sam Ratulangi Raya (arterial roadway, 2/2 un-divided)				
Segment 1	7	7	Very low	Kelapa Lima Village Office – unsignalized intersection of RTH
Segment 2	7	5	Very high	Unsignalized intersection of RTH – unsignalized intersection of TAGEPE Garden
Segment 3	7	5	Medium	Unsignalized intersection of TAGEPE Garden – Elementary school of Oesapa Selatan

Name / Type of Road	Road Width (m)	Effective Width of Roadway (m)	Side Friction level	Remark
Segment 4	7	5	High	Elementary School of Oesapa Selatan – unsignalized intersection of Puau Indah
Soekarno (arterial roadway, 2/2 un-divided)				
Segment 1	7	6	Very low	Sonbay statue – Police office (road gradient ± 5%)
Segment 2	7	4	High	Police office – Bank BRI
Segment 3	12	10	Medium	Bank BRI –. Selam bridge
Achmad Yani (arterial roadway, 2/2 un-divided)				
Segment 1	7	5	High	Strat A – Merdeka stadium
Segment 2	7	3,5	Very high	Merdeka stadium – unsignalized intersection of Urip Sumohardjo

The characteristic of geometric and road environment at study location are as follows:

a. Segment 2. El Tari Street (eat-west way)

b.**Segment 3. El Tari Street (west-east way)**

c. Segment 2. Sam Ratulangi Raya Street

d. Segment 2 Soekarno Street

Figure 1. Characteristics of Observed Road

B. Speed Characteristics

Table 6 below explicitly shows that the average speed at each road segment was fluctuated. At one-way street, a change in the effective road width doesn't affect the motorcyclist's travel speed, except during entering-exiting manoeuvre from parking space. This may occur due to the available roadway width of 4 m, greater than 3.5 m as previously mentioned above. However, the average speed of light and heavy vehicle tends to decrease due to the increase in roadside friction level. This strongly indicates the risky behaviour of motorcyclist. Such risky behaviour constantly shows in the average speed of motorcyclist in all observed road segment, regardless the fluctuated level of roadside friction. This confirms that the average speed of motorcyclist is relatively constant in any conditions [12]–[14].

This finding strongly indicates the requirement of speed monitoring at risky location, especially roadway within high level of roadside friction category so that the accident risk could be reduce. This issue should be considered seriously because previous concerned studies reported that fatal accident events have been occurred due to speeding, including due to the chosen of inappropriate speed [6], [15], [16].

Table 6. Speed characteristics due to a difference in roadside friction level

Name and Type of Road	Road width (m)	Effective width pf roadway (m)	Side friction level;	Speed (km/hour) MC	LV	HV
El Tari (arterial road, East-West way)						
Segment 1	8	8	Very low	53	51	45
Segment 2	8	5	Very high	45	37	29
El Tari (arterial road, West - East way)						
Segment 1	8	8	Low	52	50	46
Segment 2	8	8	Medium	53	49	38
Segment 3	8	6	High	45	45	42
Sam Ratulangi Raya (arterial roadway, 2/2 UD)						
Segment 1	8	8	Very low	51	49	44
Segment 2	8	6	Very high	49	38	37
Segment 3	8	6	Medium	54	44	37
Segment 4	8	6	High	49	43	34
Soekarno (arterial roadway 2/2 UD)						
Segment 1	8	8	Very Low	55	48	40
Segment 2	8	6	Medium	45	46	40
Segment 3	12	10	Medium	40	40	38
Achmad Yani (arterial roadway, 2/2 UD)						
Segment 1	7	5	High	47	44	34
Segment 2	7	3,5	Very high	34	40	28

Although this paper focuses on the effect of a change in the effective width of roadway to speed choice but from the result of speed measurement it should be noted that the inadequacy in speed management may trigger risky behaviour, especially speeding and other related traffic violence. This should be curiously considered because during the speed survey, it was found that a number of motorcyclists enjoying the high-speed choice reflected on their type of riding. In this case, since speeding for fun [5], [17] or speeding for time saving [18] or for obtaining the other socio-economic advantages from it was reported to be a specific type of riding that usually associated with traffic accident, so that this risky situations should be considered when determining the accident risk management strategy.

C. Determining of Passenger Car Equivalent Values

This PCE values for motorcycle and heavy vehicle were determined based on the result of field measurement. The average speed represents the total vehicle speed measured. Accordingly, the effect of a change in travel speed to the PCE values could be seen clearly.

Table 7. Calculated PCE values for motorcycle and heavy vehicle based on speed characteristic

Name and Type of Road	Width of road (m)	Efective width of roadway (m)	roadside friction level	averae speed (km/jam) MC	LV	HV	PCE MC	HV
El Tari (arterial road, east-west direction)								
Segment 1	8	8	very low	53	51	45	0.43	1.49
Segment 2	8	5	very high	45	37	29	0.37	1.68
El Tari (arterial road, west-east direction)								
Segment 1	8	8	low	52	50	46	0.43	1.46
Segment 2	8	8	Medium	53	49	38	0.42	1.74
Segment 3	8	6	high	45	45	42	0.45	1.44
Sam Ratulangi Raya (arterial roadway, 2/2 TT)								
Segment 1	8	8	very low	51	49	44	0.43	1.50
Segment 2	8	6	very high	49	38	37	0.35	1.38
Segment 3	8	6	Medium	54	44	37	0.37	1.60
Segment 4	8	6	high	49	43	34	0.39	1.70
Soekarno (arterial roadway2/2 TT)								
Segment 1	8	8	very low	55	48	40	0.39	1.62
Segment 2	8	6	Medium	45	46	40	0.46	1.55
Segment 3	12	10	Medium	40	40	38	0.45	1.42
Achmad Yani (arterial roadway, 2/2 TT)								
Segment 1	7	5	high	47	44	34	0.42	1.74
Segment 2	7	3,5	very high	34	40	28	0.53	1.92

D. The difference of PCE values between IHCM'97, IHCG'23 and Calculated version

Table 8 clearly shows that the PCE values for motorcycle and heavy vehicle recommended by IHCM'97 and IHCG'23 are similar. This confirms that it was determined based on assumption that there is no changing in roadway width. However, the result of this study (Table 7, 8) clearly show that it is varied (changeable and fluctuate), depending on the level of roadside friction; especially due to on-street parking vehicle which reduce the effective width of roadway, directly.

In addition, it should be noted that there is a number of interesting and important finding obtained from this study, as also can be seen in Table 8 as follows:

1. As previously mentioned, for the type of one-way road, a reduce in road lane has no significant impact on travel speed because the available road way lane is greater than the ideal width of roadway, i.e., 3.5 m. This strongly indicate the requirement of such minimum width of roadway as recommended in IHCM'97 and IHCG'23.
2. Regardless such finding, it can be seen that, generally, the calculated PCE for motorcycle and heavy vehicle are greater than the standardized one (as it was recommended by IHCM'97 and IHCG'23). It strongly indicates that the factual PCE should be used when evaluating the road network performance, especially

at roadway that suffered a reduce in their width of roadway.

Table 8. A comparison of calculated PCE values and PCE values version of IHCM'97 and IHCG'23

Name and Type of Road	Road width (m)	Effective width of roadway (m)	Traffic volume (Veh/hour)	PCE IHCM'97		PCE IHCG'23		Calculated PCE	
				MC	HV	MC	HV	MC	HV
El Tari (arterial road, 2/1, East-West way)									
Segment 1	8	8	1.191	0.25	0.25	0.25	0.25	0.43	1.4
Segment 2	8	5	1.232	0.25	0.25	0.25	0.25	0.37	1.6
El Tari (arterial road, 2/1, West-East way)									
Segment 1	8	8	1.222	0.25	1.2	0.25	1.2	0.43	1.4
Segment 2	8	8	1.210	0.25	1.2	0.25	1.2	0.42	1.7
Segment 3	8	6	1.332	0.25	1.2	0.25	1.2	0.45	1.4
Sam Ratulangi Raya (arterial road, 2/2 TT)									
Segment 1	8	8	1.791	0.40	1.3	0.40	1.3	0.43	1.5
Segment 2	8	6	1.678	0.50	1.3	0.50	1.3	0.35	1.3
Segment 3	8	6	1.901	0.35	1.2	0.35	1.2	0.37	1.6
Segment 4	8	6	1.787	0.50	1.3	0.50	1.3	0.39	1.7
Soekarno (arterial road, 2/2 TT)									
Segment 1	8	8	2.220	0.25	1.2	0.25	1.2	0.39	1.6
Segment 2	8	6	2.192	0.35	1.2	0.35	1.2	0.46	1.5
Segment 3	12	10	1.982	0.25	1.2	0.25	1.2	0.45	1.4
Achmad Yani (arterial road, 2/2 TT)									
Segment 1	7	5	2.345	0.35	1.2	0.35	1.2	0.42	1.7
Segment 2	7	3,5	1.890	0.35	1.2	0.35	1.2	0.53	1.9

Understandably that a reduce in the effective width of roadway could influence (reduce) travel speed which in turn decrease the maximum traffic volume. This strongly indicates that in order to evaluate road network performance, especially during converting the passenger car unit / PCU value, i.e., from Veh/hour to PCU/hour, the calculated PCE for motorcycle and heavy vehicle should be taken from the result of field survey. This action needed only to accommodate the effect of a change in the effective width of roadway at a certain corridor or certain road segments.

Subsequently, since a decreasing in traffic volume may also influence the capacity of the observed road segment then their impact on the degree of saturation (DS) should also be taken into account. The effect of speed choice to road capacity was reported to be important issue in traffic engineering policy [11]. These findings are in accord with the result of previous study which reported that the PCE values (for motorcycle and heavy vehicle) at different width and/or different classification of road function should be determined based on the result of field observation [9], [19].

E. Implication of Study Result

The finding result is worth to be considered when determining the appropriate model of traffic engineering and management, especially when conducting a traffic impact analysis (TIA) or during evaluating the performance of urban road network. This is an important notification because traffic engineering policy should be suited to specific condition on each road segment. This suitability is required to guarantee the achievement of road network management's effectiveness which is required to increase road user accessibility, mobility and safety needs. The accomplishment of this target may increase road user awareness and reduce their risky behaviour.

The implementation or the use of this PCE model is also recommended for unsignalized intersection, particularly if there is a difference in road function classification in their approaches lane as strongly recommended by previous researcher. The contextualism of traffic volume which is produced confirmed it [19], especially based on the impact of right turning movement [20].

IV. CONCLUSION

Conclusion that could be drawn based on the result and discussion above are:

1. A decreasing in effective width of roadway has a significant impact on travel speed
2. A change in travel speed influencing the passenger car equivalent values.
3. Consequently, the determination of maximum traffic volume value should be converted by using the appropriate PCE values obtained from the field survey, instead of the standardized value as it was recommended by IHCM'97 or IHCG'23, especially for road performance evaluation on corridor with a decreasing of effective width of roadway.

ACKNOWLEDGEMENT

The authors express their gratitude for the Community Engagement and Research Center of Univeritas Katolik Widya Mandira for the relief fund, and also for the Scientific Community of Traffic Engineering, Study Program of Civil Engineering for their support during the data collection stage.

REFERENCES

1. Soefaat, "Hubungan Fungsional Tata Ruang dan Teknik Sipil : Suatu Pengantar (Jilid 2)," no. Jilid 2. 1999.
2. D. G. N. da Costa, R. M. Rayawulan, K. R. Bela, M. I. Naikofi, E. N. B. Seran, and R. Hendrikus, "Use of Train Transport to Bridge Social-Economic Activities Between Indonesia and Timor Leste Along the Northern Coast of the Island of Timor: A Preliminary Study," *Adv. Eng. Res.*, vol. 199, no. ICoSITEA 2020, pp. 6–10, 2021, doi:

https://doi.org/10.14716/ijtech.v9i4.941.

3. N. Bobylev and I. F. Jefferson, "Integration of Urban Physical Infrastructure Into Land Use," *Annu. World Bank Conf. L. Poverty*, no. March, pp. 3–6, 2014, doi: 10.13140/2.1.1563.3603.
4. D. G. N. da Costa, "Aplikasi Pendekatan Kesisteman dalam Pengembangan Konsep Strategi Implementasi Program MP3EI di NTT," *Mayarakat Transp. Indones.*, vol. 1, no. 1, pp. 1–17, 2016.
5. P. Schroeder, L. Kostyniuk, and M. Mack, "2011 National Survey Of Speeding Attitudes and Behaviors," Washington DC, 2013.
6. Y. O. Susilo, T. B. Joewono, and U. Vandebona, "Reasons underlying behaviour of motorcyclists disregarding traffic regulations in urban areas of Indonesia," *Accid. Anal. Prev.*, vol. 75, 2015, doi: 10.1016/j.aap.2014.12.016.
7. Departemen Pekerjaan Umum, *Manual Kapasitas Jalan Indonesia (MKJI) 1997*. 1997.
8. Direktorat Jendral Bina Marga, "Pedoman Kapasitas Jalan Indonesia No. 09 / P / BM/2023." Kementrian Pekerjaan Umum dan Perumahan Rakyat Indonesia, Jakarta, 2023.
9. R. Ramlan, M. Z. Irawan, and A. Munawar, "Revisi Nilai Ekuivalen Mobil Penumpang untuk Sepeda Motor pada Simpang Tak Bersinyal," *J. Transp.*, no. November, pp. 1–8, 2019.
10. D. G. N. da Costa, E. Kalogo, D. Arakian, C. C. Manubulu, and O. E. Semiun, "Effect of the Right Turning Movement to Road Urban Performance," *Adv. Eng. Res.*, vol. 199, no. ICoSITEA 2020, pp. 1–5, 2021.
11. D. M. P. Wedagama, "Time Headway Modelling of Motorcycle - Dominated Traffic to Analyse Traffic Safety Performance and Road Link Capacity of Single Carriageways," vol. 24, no. 1, pp. 27–34, 2017, doi: 10.5614/jts.2017.24.1.4.
12. D. G. N. da Costa, S. Malkhamah, and L. B. Suparma, "Use of Systematic Approach in Accident Risk Analysis for Motorcyclists : A Conceptual Idea," vol. 50, no. 5, pp. 607–623, 2018, doi: 10.5614/j.eng.technol.sci.2018.50.5.2.
13. P. Tankasem, T. Satiennam, and W. Satienanm, "Cross-Cultural Differences in Speeding Intenstion of Drivers on Urban Road Environments in Asian Developing Countries," *Int. J. Technol.*, vol. 7, pp. 1187–1195, 2016.
14. A. K. Jameel and H. Evdorides, "Developing a safer road user behaviour index," *IATSS Res.*, vol. 45, no. 1, pp. 70–78, 2021, doi: 10.1016/j.iatssr.2020.06.006.
15. GRSP, "Speed management: a road safety manual for decision-makers and practitioners.," Global Road Safety Partnership, Geneva, Switzerland, 2008.
16. F. Sagberg, "Characteristics of fatal road crashes involving unlicensed drivers or riders : Implications for countermeasures," *Accid. Anal. Prev.*, vol. 117, no. April, pp. 270–275, 2018, doi: 10.1016/j.aap.2018.04.025.
17. C. F. Chen and C. W. Chen, "Speeding for fun? Exploring the speeding behavior of riders of heavy motorcycles using the theory of planned behavior and psychological flow theory," *Accid. Anal. Prev.*, vol. 43, no. 3, pp. 983–990, 2011, doi: 10.1016/j.aap.2010.11.025.
18. D. G. N. da Costa, S. Malkhamah, and L. B. Suparma, "Motorcyclist risk taking behavior," in *Proceeding of the 19th International Symposium of FSTPT, Islamic University of Indonesia, 11-13 October 2016, ISBN: 979-95721-2-19*, 2016, pp. 77–85.
19. M. L. Blikololong, E. Kalogo, M. I. Naikofi, and D. G. N. da Costa, "Pengaruh Klasifikasi Fungsional Jalan terhadap Nilai EMP Sepeda Motor di Simpang tak Bersinyal," *J. Tek. Sipil*, vol. 11, no. 1, pp. 7–17, 2022.
20. D. G. N. da Costa and E. Kalogo, "Dampak Tarikan dan Bangkitan Perjalanan Pengguna SPBU Oebufu terhadap Kinerja Bagian Jalan di Sekitarnya," *J. Tek. Sipil UAJY*, vol. 15, no. 3, pp. 150–161, 2019.