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EVALUATION OF SIGNALIZED INTERSECTION CAPACITY AND PCE USING LINEAR REGRESSION IN MIXED TRAFFIC

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Abstract

Signalized intersections play a vital role in urban traffic management, especially in areas with mixed traffic characteristics such as Banda Aceh. This study aims to determine the Passenger Car Equivalent (PCE) values based on actual saturation flow data at the AMD Batoh signalized intersection. Data were collected through video recordings over 120 green time cycles across four intersection approaches, with vehicle classifications including Motorcycles (MC), Light Vehicles (LV), Motorized Rickshaws (MR), and Heavy Vehicles (HV). Linear regression analysis produced positive coefficients, indicating that each additional vehicle unit increases the effective green time by 0.14 seconds for MC, 1.12 seconds for LV, 0.73 seconds for MR, and 1.58 seconds for HV. The regression model also yielded an Adjusted R^2 of 0.94, demonstrating a strong model fit. The resulting local PCE values differ from the standard references in PKJI 2023, particularly for informal vehicles. These findings highlight the importance of localized adjustment in intersection capacity analysis to support more accurate and context-sensitive traffic planning.

Keywords:

Signalized intersection; passenger car equivalent (PCE); saturation flow; linear regression; mixed traffic

Abstrak

Persimpangan bersinyal memainkan peran penting dalam manajemen lalu lintas perkotaan, terutama di wilayah dengan karakteristik lalu lintas campuran seperti Banda Aceh. Studi ini bertujuan untuk menentukan nilai nilai Ekivalen Mobil Penumpang (EMP) berdasarkan data aliran jenuh aktual pada simpang bersinyal AMD Batoh. Data dikumpulkan melalui rekaman video selama 120 siklus waktu hijau pada empat pendekatan simpang, dengan klasifikasi kendaraan meliputi Sepeda Motor (MC), Kendaraan Ringan (LV), Becak Bermotor (MR), dan Kendaraan Berat (HV). Analisis regresi linier menghasilkan koefisien positif, yang menunjukkan bahwa setiap penambahan satu unit kendaraan meningkatkan waktu hijau efektif sebesar 0,14 detik untuk MC, 1,12 detik untuk LV, 0,73 detik untuk MR, dan 1,58 detik untuk HV. Model regresi juga menghasilkan nilai Adjusted R^2 sebesar 0,94, yang menunjukkan tingkat kesesuaian model yang sangat baik. Nilai EMP lokal yang diperoleh berbeda dari referensi standar dalam PKJI 2023, khususnya untuk kendaraan informal. Temuan ini menekankan pentingnya penyesuaian lokal dalam analisis kapasitas simpang guna mendukung perencanaan lalu lintas yang lebih akurat dan kontekstual.

Kata Kunci:

Simpang bersinyal; ekivalen mobil penumpang (EMP); aliran jenuh; regresi linier; lalu lintas campuran

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1. INTRODUCTION

Signalized intersections play a crucial role in maintaining the efficiency of urban transportation systems (Eom & Kim, 2020; Reddy et al., 2023), serving as key control points for managing dense and heterogeneous traffic flows (Gholamhosseinian & Seitz, 2022; Khan & Maini, 1999; Shen et al., 2024). In both major and developing cities across Indonesia, signalized intersections function as strategic elements in traffic regulation(Marini et al., 2025; Said & Syafey, 2019; Satria et al., 2020), however, their effectiveness largely depends on the accuracy of capacity calculations and the understanding of local traffic characteristics (Agustan et al., 2025; Matsuyuki & Nakamura, 2025).

A study in Aceh showed that DS rose from 0.51 to 0.79 over five years, shifting the service level from C to D, highlighting the need for locally tuned traffic models (Erliana et al., 2020). Another study using Greenberg's model found that local interventions, such as speed bumps, significantly altered speed–density relationships, reinforcing the importance of context-sensitive traffic modelling (Faradilla et al., 2025). A recent infrastructure study in Banda Aceh also emphasised that technical planning must adapt to actual site characteristics to ensure performance and resilience, especially in high-activity zones like the AMD Batoh intersection (Yusra et al., 2025). Banda Aceh, as one of the cities with distinctive mixed traffic conditions, presents unique challenges in intersection performance analysis (Vieira et al., 2024; Zare et al., 2024). The predominance of motorcycles and informal vehicles such as motorized rickshaws creates flow dynamics that are not fully captured by conventional models (Chalermpong et al., 2025).

Technical guidelines such as MKJI 1997 (MKJI, 1997) and its updated version, PKJI 2023 (PKJI, 2023), have provided a framework for road capacity calculation, including Passenger Car Equivalent (PCE) values as a tool for converting mixed vehicle types into standardized units (Bouhouras et al., 2022; Bouhouras & Basbas, 2021; Lu et al., 2020; Munshi & Patnaik, 2024; Raj et al., 2019). However, generic and non-contextual PCE values often result in capacity estimates that deviate from actual field conditions. This discrepancy becomes more evident when applied to intersections in areas with unique traffic characteristics, such as the AMD Batoh intersection in Banda Aceh. This intersection serves as a convergence point for traffic from multiple directions. It reflects the complexity of movement patterns shaped by the dominance of two-wheeled vehicles and the diversity of vehicle types.

Several studies have highlighted the importance of local calibration of PCE values to improve the accuracy of capacity analysis (Sugiarto et al., 2021) showing that PCE values may vary significantly depending on vehicle composition and intersection geometry (Ahmed et al., 2022; Granà et al., 2020; Makki et al., 2020). Linear regression-based approaches have also been widely used in transportation studies to identify the contribution of each vehicle type to saturation time and intersection capacity (Ahmed et al., 2022; Mondal & Gupta, 2020). In the context of intense mixed traffic, studies in Asian cities have emphasized that capacity models that fail to account for local characteristics tend to produce significant deviations from actual intersection operations (Maitimu et al., 2024; Putrinur & Mahendra, 2025) .

Moreover, advancements in data collection technology, such as the use of drones to observe traffic flow during peak hours, have opened new opportunities for obtaining more accurate and comprehensive data (E. Barmpounakis & Geroliminis, 2020; E. N. Barmpounakis et al., 2019). Such observations enable a deeper understanding of traffic dynamics and interaction patterns among diverse vehicle types at signalized intersections (Bhattarai, 2024; Bisio et al., 2022; Bouassida et al., 2020; Pu et al., 2025). This rich and detailed data is essential for precise PCE calibration and developing capacity models that are more responsive to local conditions.

Based on this understanding, the present study aims to explore the traffic characteristics at the AMD Batoh intersection through locally calibrated PCE values. Data were obtained via drone-based observation during peak hours, allowing for a more precise analysis of saturation flow patterns and the contribution of each vehicle type. This approach seeks to correct numerical discrepancies in capacity calculations and offer new perspectives on model sensitivity to local conditions. Accordingly, this study is expected to contribute meaningfully to developing more adaptive intersection capacity models and to support the refinement of technical approaches in transportation planning for emerging urban areas.

2. RESEARCH METHOD

2.1. Research Location and Period

This study focuses on the AMD Batoh Intersection, a signalized at grade four legged junction without a roundabout located in Banda Aceh City. The site was selected from several intersections with similar characteristics, signalized and four-legged, and represents baseline saturated flow conditions based on observed traffic patterns. In addition to its geometric similarity, AMD Batoh was chosen for its strategic location connecting major activity centers in Banda Aceh. The intersection experiences high traffic volumes dominated by motorcycles and motorized rickshaws, reflecting the distinctive mixed traffic conditions of Banda Aceh. These characteristics make AMD Batoh a representative case for local PCE calibration. When traffic flow typically reaches saturation, surveys were conducted during the morning peak hours (06:45–08:30 WIB) and evening peak hours (16:45–18:30 WIB). This saturation is evident from the signal cycles, where queued vehicles cannot fully clear the intersection during the green phase. To ensure the reliability and representativeness of the observed traffic conditions, the surveys were conducted over two consecutive working days, allowing for consistent data collection across typical weekday traffic variations.

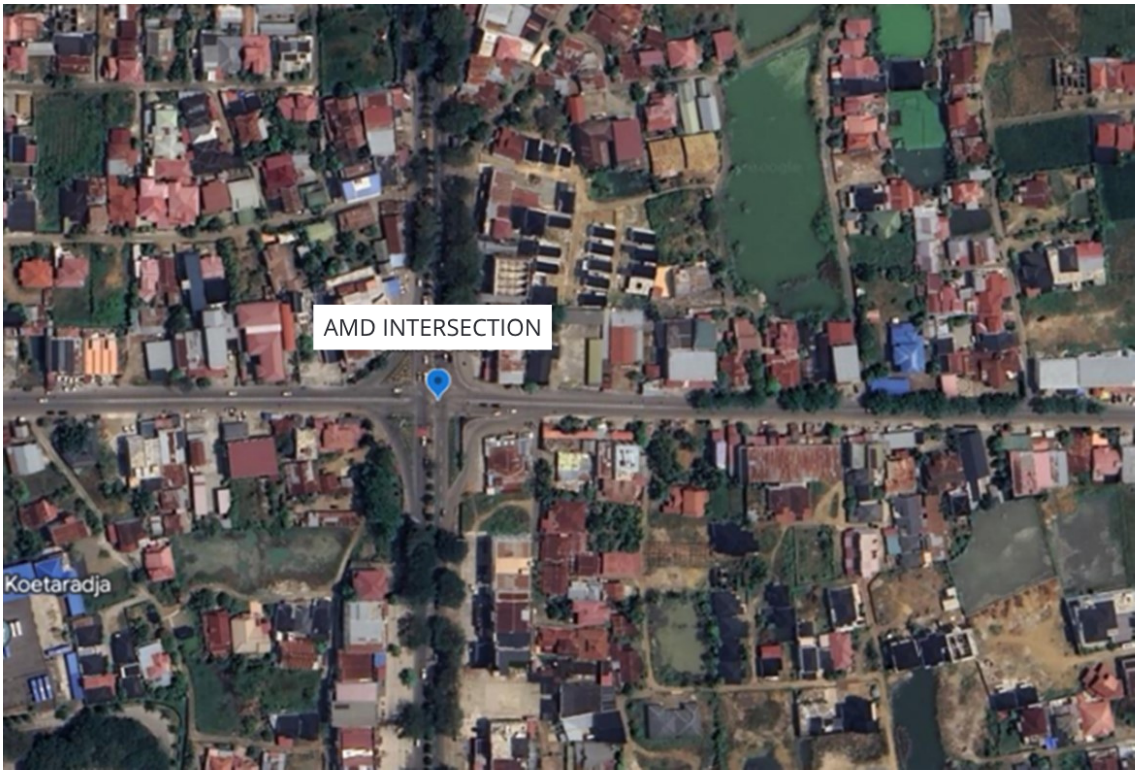

Figure 1. Location of the Study

2.2 Equipment and Research Procedures

The research began with a preliminary survey to understand saturated traffic flow conditions at the studied intersection and to develop an optimal data collection plan. This survey involved identifying various vehicle types and converting them to Passenger Car Units (PCU) based on the latest guidelines. Survey scheduling, observation points, and video camera placement were carefully planned for effective data collection. Geometric measurements were taken during low-traffic periods using measuring tape. Field observations and documentation were conducted over two full days. Traffic flow data were gathered using drone-mounted cameras operating periodically with battery changes every 20 minutes. To avoid observation gaps during battery replacement, recordings were scheduled in rotation and cross-checked with manual notes to maintain continuity of data. Reliability and minimization of potential technical bias were addressed by supervising drone operations to maintain consistent viewing angles, while signal duration measurements with digital stopwatches were conducted by two observers simultaneously. The survey was conducted during morning and evening peak hours, with camera placement supervised to ensure optimal recording of vehicle queues.

2.3 Data Collection Method

The data collection in this study aims to analyze Passenger Car Equivalent (PCE) values, which require supporting information such as intersection geometric conditions, site maps, and other relevant data. The data used to support this research consist of primary and secondary sources.

Primary data refer to information obtained directly through field observation. The primary data collected include:

a. Intersection geometry measured using a measuring tape;
b. Green time duration for each intersection arm;
c. Traffic flow composition.

Secondary data refer to information gathered from previous research references and relevant institutions, including:

a. Indonesian Highway Capacity Manual (PKJI, 2023);
b. Banda Aceh city map;
c. Research site map.

2.4 Data Analysis Method

The data analysis in this study commenced with the processing of video recordings capturing saturated traffic flow conditions at the AMD Batoh intersection. For each approach arm, recordings were conducted over 30 green time cycles, resulting in 120 observed cycles. The collected data encompassed vehicular movements categorized by direction, straight, right turn, and left turn, and vehicle type, namely Motorcycles (MC), Light Vehicles (LV), Heavy Vehicles (HV), and Motorized Rickshaws (MR).

The number of vehicles crossing the stop line during each green phase was counted per cycle. Saturation time was determined by calculating the time difference between the first and last vehicle crossing the stop line within each cycle. These data were tabulated for each approach arm and utilized in linear regression analysis to calibrate Passenger Car Equivalents (PCE). The regression coefficients for each vehicle type were compared against the coefficient for Passenger Cars (PC) to derive PCE values, which were then validated using the Indonesian Highway Capacity Manual (PKJI, 2023)

Correlation testing and calibration procedures were performed using Microsoft Excel. The resulting PCE values were assessed for conformity with national standards and used to identify saturation conditions on each approach arm based on the recorded saturation durations.

3. RESULTS AND DISCUSSION

3.1. Geometric Conditions of the Intersection

The AMD Batoh intersection is a four-legged signalized junction with heavy traffic volumes during peak and off-peak periods. Situated in the economic core of Banda Aceh City, the intersection is surrounded by commercial establishments, educational institutions, office complexes, markets, and a Type A bus terminal. Each approach to the intersection exhibits distinctive geometric attributes. The northern approach toward Batoh Terminal along Dr. Mohd Hasan Road comprises five lanes arranged as two carriageways separated by a median. The western approach via AMD Road consists of four lanes with two carriageways and a median. Similarly, the southern approach toward Simpang Surabaya, along Dr. Mohd Hasan Road, features four lanes divided into two carriageways with a median. In contrast, the eastern approach toward Neusu via AMD Road includes four lanes configured as two-way traffic separated by a median. The detailed geometric configuration of the intersection is illustrated in Figure 2.

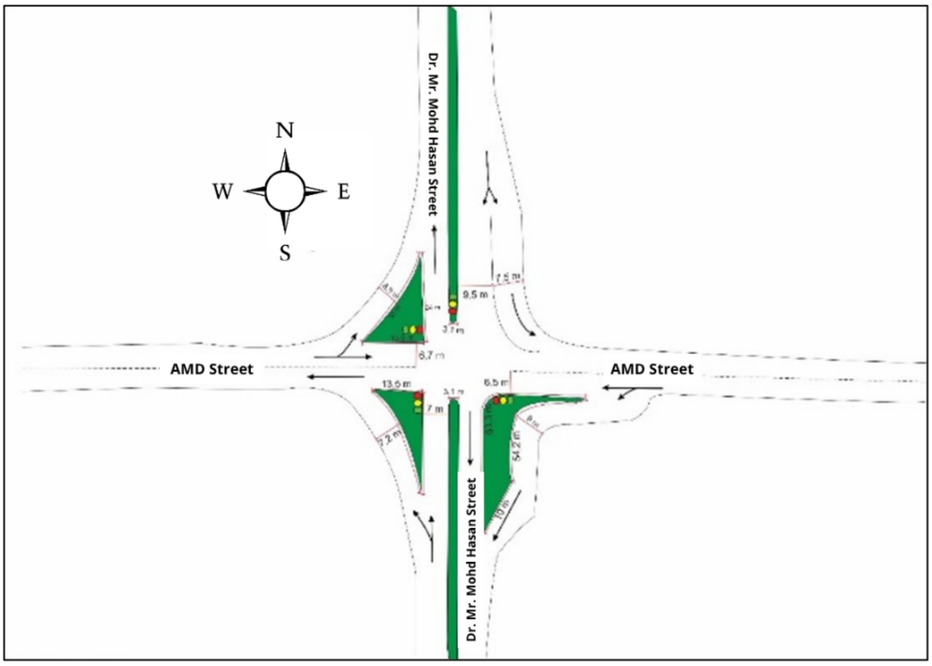

Figure 2. Geometry of the AMD Batoh Intersection

Table 1. Intersection Geometric Data

Approach Type	Approach Direction	Approach Width (m)	Direct Left Turn	Road Median
S	North	9.5	Present	Present
S	West	6.7	Present	Present
S	South	7.1	Present	Present
S	East	6.6	Present	Present

Each approach has a different signal cycle time. The traffic signal timing data (cycle durations) are presented in Table 2.

Table 2. Signal Cycle Times at AMD Batoh Intersection

Approach	Cycle Time (s)	Green (s)	Red (s)	Yellow (s)
Morning				
North	113	29	81	3
West	113	16	94	3
South	113	29	81	3
East	113	16	94	3
Evening				
North	136	39	94	3
West	136	13	120	3
South	136	44	89	3
East	136	13	120	3
Average				
North	124.5	34	87.5	3
West	124.5	14.5	107	3
South	124.5	36.5	85	3
East	124.5	14.5	107	3

3.2. Traffic Flow Composition

North | East | West | South

Figure 3. Traffic Conditions at the AMD Batoh Intersection

The saturation flow analysis utilized traffic data from the AMD Batoh intersection, with vehicles classified into four categories: motorcycles, light vehicles, heavy vehicles, and motorized rickshaws. The observed movements included through traffic and right-turn maneuvers. Data were extracted from drone video recordings using a 4 second time slice to facilitate analysis, particularly due to the dominance of motorcycles in the traffic stream. A total of 240 signal cycles were analyzed across the four intersection approaches.

Figure 3 illustrates real-time conditions during peak hours at the research site, namely the AMD Batoh intersection, across all approach arms. A summary of field-based saturation flow data by traffic movement at the AMD Batoh intersection is presented in Table 3.

Table 3. Summary of Traffic Discharge Data at AMD Batoh Intersection

Approach	**Time**	**Through Movement (TH)**	**Right Turn (RT)**	**TH + RT**
		Morning		
North	06.45-08.30	1,364	605	1,969
West	06.45-08.30	561	250	811
South	06.45-08.30	1,500	515	2,015
East	06.45-08.30	1,367	512	1,879
		Evening		
North	16.45-18.30	1,805	665	2,470
West	16.45-18.30	921	534	1,455
South	16.45-18.30	2,461	1,497	3,958
East	16.45-18.30	924	582	1,506

The highest basic saturation flow at the AMD Batoh intersection occurred on the southern approach, with 2,015 vehicles recorded during the morning peak and 3,958 vehicles during the evening peak. Traffic movement predominantly flowed straight toward AMD Street via the eastern approach. The percentage composition of vehicle flow at the AMD Batoh intersection is illustrated in Figure 4.

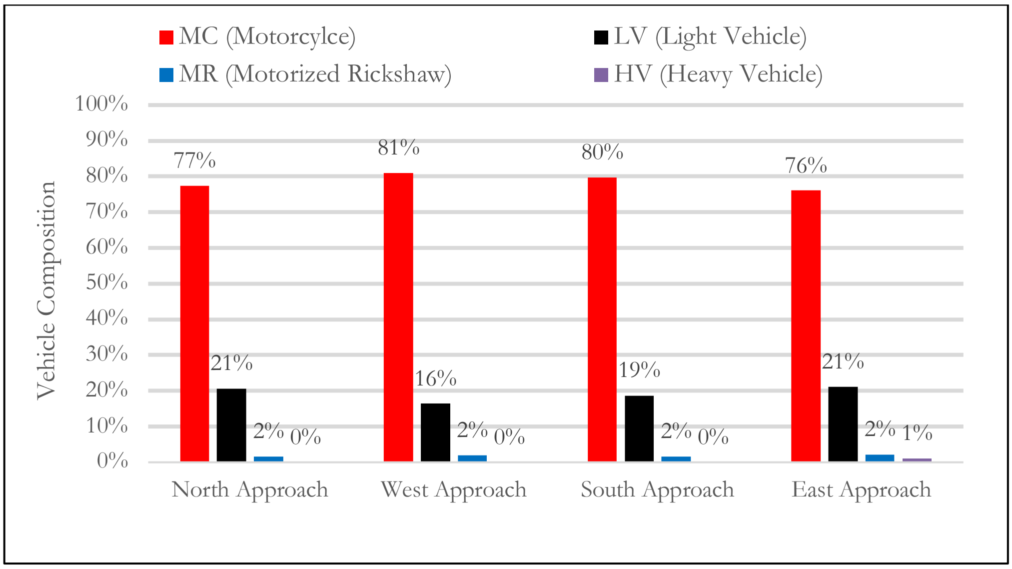

Figure 4. Vehicle Composition at the AMD Batoh Intersection

The figure above presents the percentage composition of vehicles at the AMD Batoh intersection, which is predominantly composed of motorcycles, reaching a maximum of 81% on the western approach. This motorcycle dominance has direct implications for intersection capacity estimation, as reliance on standard PCE values may lead to biased results. In this study, the dominance was explicitly incorporated through locally calibrated regression-based PCE values, ensuring that the analysis accurately reflects traffic conditions in Banda Aceh. A description of traffic movement patterns for each intersection approach is provided in Table 4.

Table 4. Description of Traffic Movement by Intersection Approach

Approach	Through Movement (TH) (%)	Right Turn (RT) (%)
North	71 %	29 %
West	65 %	35 %
South	66 %	34 %
East	68 %	32 %

3.3. Determination of PCE Values Using the Linear Regression Method

Saturation flow and saturation time data at the AMD Batoh intersection were analyzed using linear regression on 240 vehicle counts by type observation cycles during green signals. The model relates saturation time to vehicle count per type, yielding significant EMP coefficients with an Adjusted R^2 of 0.94. Analysis was done using Microsoft Excel, and calibration results appear in Table 5.

Table 5. EMP Model Calibration Results at AMD Intersection

Variable	Regression Coefficient	t-*value*	P-*value*
Intercept (a_o)	7.12	27.80	0.00
MC	0.14	8.94	0.00
LV	1.12	36.93	0.00
MR	0.73	4.57	0.00
HV	1.58	7.03	0.00
***Goodness of Fit* (GoF)**			
Adjusted R *Square*	0.94		
Significance F-test	0.0000		

The EMP value for each vehicle type can be calculated by comparing its regression coefficient to that of Light Vehicles (LV). Additional statistical data from the regression analysis for four vehicle types at the AMD Batoh intersection are presented in Table 6 below.

Table 6. PCE Values Using the Linear Regression Method

Vehicle Type	Intersection Name	New PCE	PCE (PKJI)	PCE (Sugiarto et al., 2021)
	AMD			
MC	0.13	0.12	0.15	0.24
LV	1.00	1.00	1.00	1.00
MR	0.64	0.64	*NA*	0.8
HV	1.40	1.61	1.30	*NA*

Note: *NA = Not Applicable*

3.3.1 Validation of Passenger Car Equivalent (PCE) Values

The PCE values obtained through linear regression analysis, as shown in Table 6, will subsequently be validated against the PCE values provided in PKJI (2023) and those reported by (Sugiarto et al., 2021). The newly analyzed PCE values using the linear regression method are illustrated in Figure 5.

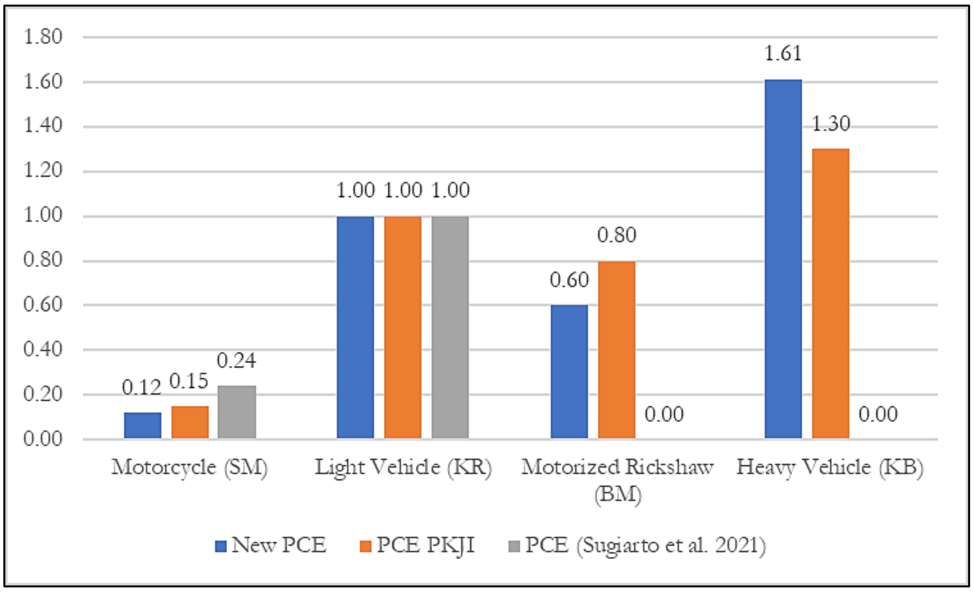

Figure 5. Validation of PCE Analysis Results Against PKJI and (Sugiarto et al., 2021)

3.3.2 Modeling PCE Values Using Linear Regression

The base saturation flow composition of vehicles at the signalized intersection, relative to approach width, is analyzed alongside the observed vehicle composition during saturation time and the composition during the observed initial lost time at the study location. The vehicle composition during saturation and initial lost time periods is presented in Table 7.

Table 7. Vehicle Composition Percentage

Approach	Vehicle Composition			
	MC	LV	MR	HV
North	77%	21%	2%	0%
West	81%	16%	2%	0%
South	80%	19%	2%	0%
East	76%	21%	2%	1%

The vehicle composition during saturation periods at the AMD Batoh intersection predominantly comprises motorcycles (MC). Saturation flow data and approach width were analyzed using linear regression to calibrate Passenger Car Equivalent (PCE) values. The regression model for the AMD intersection is as follows:

$$Y_1 = 7.12 + 0.14\ x_1 + 1.12\ x_2 + 0.73\ x_3 + 1.58\ x_4 \quad (1)$$

The value of a_0 as the intercept in the regression equation for the AMD Batoh intersection represents the ideal saturation time condition, with an average of 7.12 seconds over 120 observation cycles. The resulting regression coefficients are positive, indicating a direct relationship between saturation time and the number and type of vehicles. At the AMD intersection, each additional unit of Motorcycle (MC) increases the adequate green time by 0.14 seconds, Light Vehicle (LV) by 1.12 seconds, Motorized Rickshaw (MR) by 0.73 seconds, and Heavy Vehicle (HV) by 1.58 seconds.

3.4. Saturation Flow Calculation

Saturation flow calculation requires direct observational data, specifically the observed base saturation flow and the newly derived Passenger Car Equivalent (PCE) values for each approach leg of the intersection. The field saturation flow data were obtained through calculations based on on-site surveys conducted at the study location. The observed saturation flow values using the new PCE are summarized in Table 8, presenting the existing conditions at the AMD Batoh intersection.

Table 8. Observed Saturation Flow Based on Updated PCE

Approach	Effective Width (m)	Jo New PCE (pcu/hour)	J New PCE (pcu/hour)
North	9.50	2,807	1,883
West	6.70	2,222	1,875
South	7.06	2,952	1,888
East	6.58	2,279	1,597

As shown in Table 8, the observed saturation flow values calculated using the newly derived PCE are based on the observed base saturation flow for each intersection approach. The highest observed saturation flow using the new PCE at the AMD Batoh intersection was recorded on the southern approach, Jl. Dr. Mohd Hasan, with a value of 1,888 pcu/hour. Saturation flow calculations require direct observational data, specifically the base saturation flow for each leg of the intersection. Saturation flow values calculated using the PCE from PKJI 2023 are presented in Table 9 below.

Table 9. Saturation Flow with PCE PKJI (Auliya et al., 2024)

Approach	Effective Width (m)	**Jo** (Auliya et al., 2024) (pcu/hour)	**J** (Auliya et al., 2024) (pcu/hour)
North	9.50	3,316	2,224
West	6.70	2,338	1,973
South	7.06	2,464	1,576
East	6.58	2,296	1,609

As shown in Table 9, the saturation flow values were calculated using the PCE values from PKJI, based on the corresponding base saturation flow. The highest observed saturation flow at the AMD Batoh intersection was recorded on the northern approach, Dr. Mohd Hasan St, with a value of 2,224 pcu/hour.

3.5. Signalised Intersection Capacity

The calculation of signalised intersection capacity in this study is based on direct field observations conducted at the research location. The observed data are utilised to determine intersection capacity parameters, including green time per cycle, saturation flow rate calculations, and cycle data for each approach width. The saturation flow rate observed at new PCE is employed in the computation of the signalised intersection capacity. Table 10. presents the field data used for this analysis, incorporating the observed saturation flow rate at new PCE and survey results obtained directly from the study site.

Table 10. Intersection Capacity Based on Observed Saturation Flow Using Updated PCE Values

Approach	Effective Width (m)	Jo New PCE (pcu/hour)	J New PCE (pcu/hour)	Observed C New PCE	Total
North	9.50	2,807	1,883	514	1,472
West	6.70	2,222	1,875	218	
South	7.06	2,952	1,888	554	
East	6.58	2,279	1,597	186	

Table 10 presents the results of the signalised intersection capacity analysis at the AMD Batoh Intersection using observed saturation flow values based on updated PCE measurements. The intersection capacity values at AMD Batoh are as follows: the north approach has a capacity of 514, the west approach has a capacity of 218, the south approach has a capacity of 554, and the east approach has a capacity of 186.

Table 11 displays the results of the signalised intersection capacity analysis using PCE values as defined in the PKJI standard.

Table 11. Signalized Intersection Capacity Based on PCE PKJI (Auliya et al., 2024)

Approach	Effective Width (m)	Jo PCE PKJI (pcu/hour)	J PCE PKJI (pcu/hour)	C (Auliya et al., 2024)	Total
North	9.50	3,316	2,224	607	1,487
West	6.70	2,338	1,973	230	
South	7.06	2,464	1,576	462	
East	6.58	2,296	1,609	187	

Table 11 presents the results of the signalized intersection capacity analysis using PCE PKJI and its corresponding saturation flow values. At the AMD Batoh Intersection, the north approach has a capacity of 607, the west approach 230, the south approach 462, and the east approach 187.

The comparison between Table 10 and Table 11 indicates that intersection capacity at AMD Batoh differs when using locally calibrated PCE values versus PKJI standards. For instance, the north approach capacity is 514 pcu/hour with local PCE, compared to 607 pcu/hour with PKJI. This difference highlights that standard PCE values tend to overestimate capacity, potentially leading to biased planning outcomes.

In practical terms, local PCE values can inform signal timing adjustments to better accommodate the dominance of motorcycles. With lower effective capacities, green times on the north and south approaches should be optimized to reduce queues and congestion during peak hours. Furthermore, these findings emphasize the need for intersection planning that incorporates local traffic characteristics, ensuring that traffic management strategies remain adaptive and responsive to real-world conditions in Banda Aceh.

3.6. Determination of Calibrated Base Saturation Flow

A linear regression method was applied using field data on base saturation flow and the approach width of the signalised intersection under study. Vehicles crossing the stop line during the effective green time were recorded and classified into four types: Motorcycles (MC), Light Vehicles (LV), Motorised Rickshaws (MR), and Heavy Vehicles (HV). The base saturation flow was calculated using the PKJI formula multiplied by the approach width. A simple model was developed with saturation flow as the dependent variable and approach width as the independent variable, calibrated using observational data from 30 cycles during morning and evening peak hours at each intersection leg. Calibration was performed using simple linear regression to establish the relationship between saturation flow and approach width.

Table 12. Base Saturation Flow Calibration Results

Model	Parameter	Calibration Parameter		*Adjusted R Square*	*Std. Error*	*Sample*
		α	β			
Saturation Time	Coefficient	-	326	0.97	20.61	16
	t-*value*	-	15.82			

The model calibration using linear regression successfully calibrated all approaches at the intersection. The resulting calibrated base saturation flow value is 326.

The calibrated model shows an Adjusted R Square (coefficient of determination) value of 0.97, which exceeds the threshold of ≥ 0.75, along with an ANOVA significance F-test value of 0.000000000404 and a t-value of 0.000000000978, indicating excellent statistical performance under a 95% confidence level or ≤ 5% margin of error for the developed model. These results were obtained using a linear regression method with the assistance of Microsoft Excel software.

Tabel 13. Indeks Goodness of Fit

Description	Calibration Coefficient Value	t-*value*	P-*value* / Sig. t-*test*
Effective Lane Length (Le)	326	0.0000	0.0000
***Goodness of Fit* (GoF)**			
***Adjusted R Square* / Keofisien Determinasi**	0.97		
Anova test / *Significance* F-*test*	0.0000		

3.6.1 Calculation of Calibrated Saturation Flow

The calculation of saturation flow requires direct observational data, specifically the calibrated base saturation flow values obtained using updated PCE measurements for each intersection approach. Field saturation flow data were derived from base saturation flow calculations based on on-site surveys conducted at the study location. The calibrated saturation flow values using updated PCE observations can be found in Table 14, which summarises the existing conditions at the AMD Batoh Intersection.

Table 14. Calibrated Saturation Flow Based on Updated PCE

Approach	Effective Width (m)	Jo Calibration (pcu/hour)	J Calibration (pcu/hour)
North	9.50	3,097	2,077
West	6.70	2,184	1,843
South	7.06	2,301	1,472
East	6.58	2,145	1,503

As shown in Table 14. the calculation of calibrated saturation flow values using updated PCE is based on the calibrated base saturation flow. The highest calibrated saturation flow at the AMD Batoh Intersection was recorded on the north approach, specifically on Jl. Dr. Mohd Hasan, with a value of 2,077 pcu/hour.

3.6.2 Calibrated Intersection Capacity Analysis

Table 15. presents field data for signalized intersection capacity using newly calibrated PCE-based saturation flow.

Table 15 presents field data for the signalized intersection capacity using calibrated saturation flow based on updated PCE.

Approach	Effective Width (m)	Jo Calibration (pcu/hour)	J Calibration (pcu/hour)	C New PCE Calibration	Total
AMD					
North	9.50	3,097	2,077	567	1,388
West	6.70	2,184	1,843	215	
South	7.06	2,301	1,472	432	
East	6.58	2,145	1,503	175	

Table 15 presents the results of the signalized intersection capacity analysis using PCE PKJI and its corresponding saturation flow values. At the AMD Batoh Intersection, the north approach has a capacity of 567, the west approach 215, the south approach 432, and the east approach 175.

4. CONCLUSSION

This study underscores the critical importance of local calibration of Passenger Car Equivalents (PCE) in achieving accurate intersection capacity estimates within mixed traffic conditions, such as those observed at the AMD Batoh Intersection. By employing a linear regression model that accommodates the characteristics of informal vehicles and the predominance of motorcycles, the resulting capacity calculations more accurately reflect real-world conditions compared to generalized national standards. The analysis was supported by drone-based peak-hour data covering 240 signal cycles, yielding a regression model with an Adjusted R^2 of 0.94. These findings highlight that traffic planning and management must account for local traffic characteristics to optimize signal settings and intersection capacity effectively. Utilizing drone-captured peak-hour data adds valuable depth to the dataset, reinforcing the calibration process and enabling a more adaptive, data-driven technical methodology.

The limitations of this study include its focus on a single intersection, relatively short observation periods, and the absence of detailed driver behavior analysis, such as acceleration patterns, queuing dynamics, and interactions among vehicle types. Moreover, the reliance on peak-hour data may restrict the generalizability of findings to broader daily traffic conditions. Future research should therefore expand to multiple intersections with varying geometric layouts and traffic compositions, extend observation periods to capture temporal and seasonal variations, and incorporate behavioral variables such as lane discipline, signal compliance, and driver responses to congestion. These steps will make PCE calibration more generalizable, enhance external validity, and support traffic management strategies that are more robust and adaptive across diverse urban contexts..

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