Jurnal Teknik Indonesia

Volume 4 Nomor 3 Juli 2025

https://jti.publicascientificsolution.com/index.php/rp

Safety Zone Facility Needs Study School (Zoss) on Dewi Sartika Street (Case Study: State Middle School 6 and State Senior High School 3 Palu)

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Abstract

Dewi Sartika Street in Palu is home to two major schools SMP Negeri 6 and SMA Negeri 3 which face increasing safety risks due to high vehicle speeds in school zones. To address this, the government proposes the implementation of School Safety Zones (ZoSS), a time-based speed control program designed to minimize traffic accidents by limiting vehicle speed and improving pedestrian safety. This study aims to assess the necessity of ZoSS facilities in the area surrounding the two schools by analyzing pedestrian and escort behavior, vehicle speed, and infrastructure needs. The research method follows the Regulation of the Director General of Land Transportation No: SK.3236/AJ.403/DRJD/2006 and utilizes a normal distribution statistical approach (Z-test) to compare actual field data with national safety standards. The findings reveal that current conditions on Dewi Sartika Street are unsafe for school children, particularly in terms of crossing behavior and vehicle speed. Consequently, the implementation of a School Safety Zone is deemed necessary. The recommended ZoSS design is a 2/2UD-25 configuration with a 2-lane undivided road (2/2-TT), a stopping sight distance of 50–85 meters, a maximum speed of 25 km/h, and a zone length of 150 meters. Essential facilities include school zone markings, zebra crossings, traffic signs, yellow zigzag lines, pedestrian guides, rumble strips, pelican crossing signals, and sidewalks. This study confirms the urgent need for targeted safety infrastructure to reduce accident risk and protect students in urban school areas.

Keywords : *School Safety Zone (ZoSS), traffic safety, pedestrian infrastructure, speed control, urban school areas*

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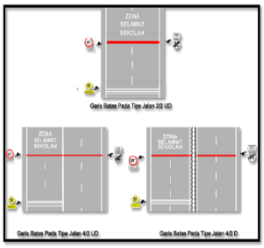
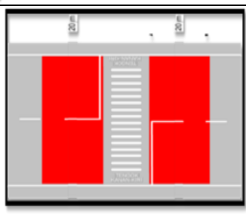
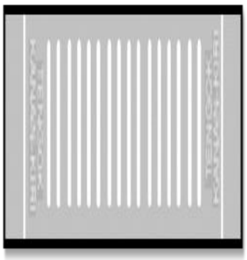
Introduction

School Safety Zone (ZoSS) is a road safety program comprehensively designed by the Indonesian government to create a safe traffic space for school children (Widodo et al., 2021). The main background for the implementation of this zone is the high number of pedestrian accidents involving school-age children, especially during school hours (Suryanto & Hartati, 2020). In an effort to reduce this risk, the Directorate General of Land Transportation issued SK.3582/AJ.403/DRJD/2018, which serves as a technical reference for the provision of road equipment and safety facilities in school areas (Indra et al., 2021). ZoSS comes with an integrated physical infrastructure and traffic management approach, which is systematically designed based on road classification, vehicle volume, and student density levels around the location (Mulyadi & Sari, 2020). The main elements of ZoSS include road markings, sidewalks, traffic signal controllers, signs, crossing guides, and technical drawings of the ZoSS layout based on the type of road crossed (Andriani et al., 2019). These elements are designed to enhance the safety of students and reduce the potential for accidents (Putra et al., 2021). The implementation of ZoSS has also been recognized as an effective method to increase road safety for children in urban areas (Ramadhani & Priyatna, 2020). By improving the infrastructure and traffic management around schools, ZoSS aims to create safer school zones and reduce accidents (Fajar & Fitria, 2021).

Road markings are the first component that is of concern in providing ZoSS facilities (Babić et al., 2022). The markings used serve not only as lane dividers or flow directors, but also as visual warnings that provide a strong signal to drivers that they are entering an area requiring a high level of alertness (Zhao et al., 2020). There are several types of road markings specified, such as red markings as the initial boundary of ZoSS, red carpets around zebra crossings, noise tape to create a vibration effect, zebra crossings with special sizes, and instructional writing such as "SCHOOL SAFETY ZONE" and "LOOK RIGHT AND LEFT" (Chandra & Kumar, 2019). All of these markings are installed with dimensions, colors, and positions that have been arranged in detail (Kurniawan et al., 2021). Studies have shown that these types of markings significantly improve pedestrian safety by increasing driver awareness (Fang et al., 2020). Red markings, in particular, are effective in signaling the transition into a school zone, thus enhancing the effectiveness of the ZoSS (Lee et al., 2021). The application of noise tapes is another innovative approach that improves safety by creating auditory alerts for drivers (Hussain & Khan, 2019). Additionally, properly designed zebra crossings with specific dimensions help in reducing pedestrian accidents at high-risk school zones (Ginting & Sari, 2021). The overall effectiveness of road markings as part of ZoSS has been demonstrated in various urban studies (Mahmoud et al., 2021).

Table 1. Road Markings in the School Safety Zone (ZoSS)

Mark Name	**Image (insert image according to position)**	**Information**
Red Mark		The initial boundary of the ZoSS from both directions is a red transverse line along the width of the road.
Red Carpet		Installed 20 meters to the left and right of the zebra crossing to attract the attention of drivers.
Noisy Tape		Placed 50 meters before ZoSS, in the form of an uneven road surface 1 cm high

Mark Name	Image (insert image according to position)	Information
zebra crossing		Crossing with white-black lines, line width 300 mm and minimum length 2500 mm
The writing "SCHOOL HAPPY ZONE"		Placed after the initial boundary line of the ZoSS as a zone identification reinforcement.
The words "LOOK RIGHT AND LEFT"		Instructional markings on the edge of the zebra crossing for children to pay attention to traffic flow
No Parking Marking		Length 1 meter, width 0.1 meters, angle 45°, thickness 3 mm
Road Nails		Night reflectors to enhance the visibility of road markings

Road nails and night reflectors are used to enhance the visibility of road markings. In addition to markings, sidewalks are also a crucial element that must be available in *ZoSS*. Sidewalks function to separate pedestrian lanes from motorized vehicles, so that children can walk safely and do not come into direct contact with traffic. Sidewalks are designed to have a higher elevation than the road surface, a hard surface, and to be free of obstacles. The latest technical guidelines state that the minimum effective width of the sidewalk is 185 cm, which is sufficient for two wheelchair users to pass each other. Based on SK.Dirjen Hubdat No. SK.43/AJ 007/DRJD/1997, the width requirements for sidewalks vary according to the location and land use around the school, as outlined in the following table.

Table 2. Minimum Sidewalk Width Based on Location

Location	Minimum Width (m)
Roads in urban areas	4.00
Main office area	2.00
Primary Road	2.75
Access Road	2.00

Table 3. Sidewalk Width Based on Land Use

Land Users	Minimum Width (m)	Recommended Width (m)
Settlement	1.50	2.75
Office	2.00	3.00
Industry	2.00	3.00
School	2.00	3.00
Bus Terminal/Stop	2.00	3.00
Shops	2.00	4.00
Bridge/Tunnel	1.00	1.00

In addition to markings and sidewalks, *ZoSS* is also equipped with *APILL* in the form of warning lights or flashing lights. These lights are installed on the right and left sides of the road, flashing during school rush hours to increase driver awareness. The presence of *APILL* has been proven to reduce the average speed of vehicles in the school area by up to 40%. The visualization of *APILL* in this zone can be seen in the following illustration.

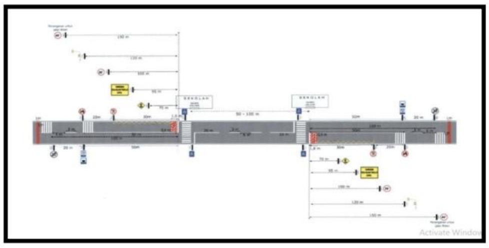


Figure 1. APILL (Warning Light) in the School Safety Zone
(SK.3582/AJ.403/DRJD/2018)

The next component is traffic signs that are designed to provide warnings, prohibitions, directions, and information to road users. Signs used in ZoSS include symbols of children crossing, parking restrictions, speed limits, school location signs, bus pick-up and drop-off points, and school zone signs.

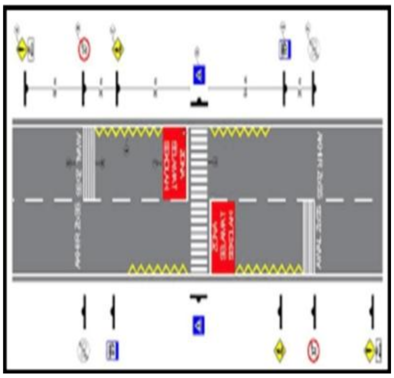


Figure 2. APILL (Warning Light)

Table 4. Types of Traffic Signs in ZoSS

Sign Image	Information
Figure 10	Child pedestrian warning sign
Figure 11	Road crossing warning signs
Figure 12	Speed limit signs in school zones
Figure 13	No Parking Sign

Figure 14	School location signs
Figure 15	Drop-off and pick-up point signs
Figure 16	Bus stop and parking area signs

In addition to physical devices, the implementation of *ZoSS* also involves crossing guide officers. These officers are tasked with stopping the flow of vehicles and ensuring that children cross safely. Officers may come from the police or volunteers with basic traffic safety training. They are equipped with reflective vests, whistles, and command batons. The role of these officers has proven effective in reducing conflicts between pedestrians and vehicles, as well as strengthening safety education from an early age.

The implementation of *ZoSS* is adjusted to the characteristics of the road at each location. There are four main typologies: two-lane two-way undivided (*2/2 UD*), four-lane two-way undivided (*4/2 UD*), two-lane two-way divided (*2/2 D*), and four-lane two-way divided (*4/2 D*). Each configuration has a technical layout drawing that is adjusted to the road width, number of lanes, and vehicle speeds outside the zone.

ZoSS Layout Image on *2/2 D* Road

For special locations, such as intersections and bends, additional *ZoSS* settings are used that emphasize visibility and the completeness of signs. In these areas, *ZoSS* is equipped with special markings and supporting signs so that vehicles slow down and give priority to pedestrians.

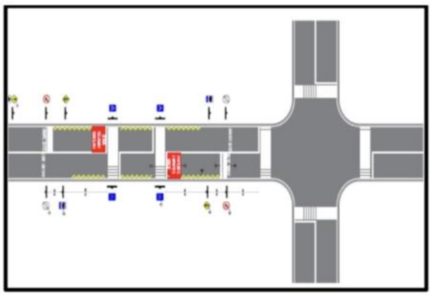


Figure 3 ZoSS at Type 2/2 UD Road Intersection

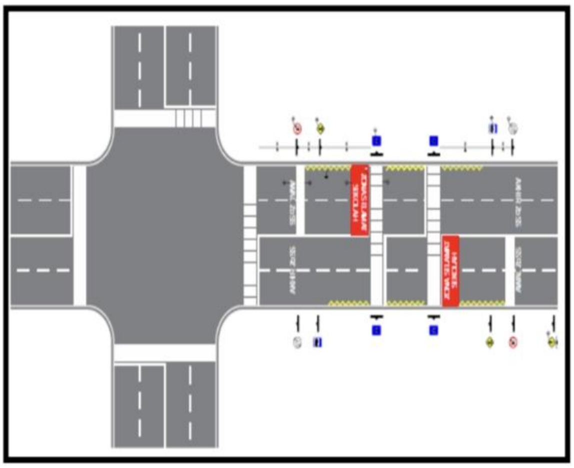


Figure 4 ZoSS at Type 2/2 UD Road Intersection

Overall, *ZoSS* is a form of innovation in area-based road safety policies. This system does not rely solely on infrastructure but also involves education, community participation, and legal policies that regulate traffic behavior around schools. The effectiveness of *ZoSS* in reducing child traffic accidents lies not only in the installation of markings and signs but also in the integration of road design, speed management, and continuous supervision. With cross-sector support and the involvement of the community around the school, *School Safety Zone* can become a new standard in creating safe, orderly, and child-friendly traffic spaces throughout Indonesia.

Previous research by Ellizar et al. (2023) conducted a study in Surakarta City using the *Star Rating for Schools* (*SR4S*) tool from the International Road Assessment Programme (*iRAP*) to evaluate *School Safety Zones*. The research involved youth participation through mapping and traffic surveys to identify infrastructure deficiencies, such as the absence of pedestrian crossings and inadequate road markings, leading to proposals for safer road designs. Although the study innovatively engaged students, it did not assess the implementation of Indonesia-specific *ZoSS* regulations such as SK.3582/2018, nor did it analyze components like *APILL* or standardized crossing officer involvement.

This research aims to evaluate the effectiveness of Indonesia's updated *ZoSS* regulation (SK.3582/2018) in reducing vehicle speed, improving driver compliance, and enhancing pedestrian safety for school children. The benefits include providing evidence-based recommendations for the optimal design and combination of *ZoSS* features (e.g., road markings, *APILL*, sidewalks, and signage), supporting the improvement of national school traffic safety policies, and ensuring safer school environments through comprehensive and context-based interventions.

Research Method

This study uses a quantitative approach with a descriptive analysis method to obtain an accurate picture of traffic conditions, road user behavior, and the feasibility of safety facilities in the school area on *Jalan* Dewi Sartika, Palu City. The main objective of this study is to compile recommendations for traffic safety facility needs that are in accordance with field characteristics, based on primary and secondary data. The design of this research methodology is formulated in the following research flowchart.

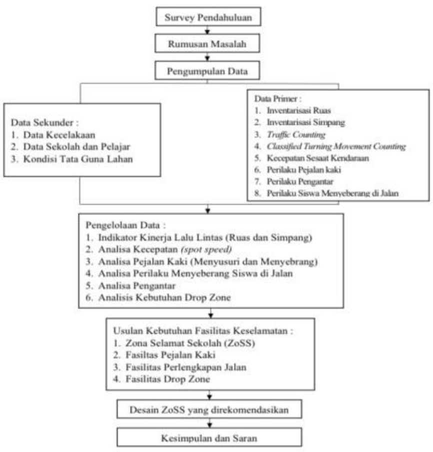


Figure 5. Research Flowchart
Source: Author, 2025

The research began with the formulation of the problem related to the high level of traffic conflict and irregular behavior of road users around SMP Negeri 6 Palu and

SMA Negeri 3 Palu. The next stage is the data collection process. The data collected consists of secondary data in the form of accident data, school and student data, and land use data obtained from agencies such as the Palu City Police, the Palu City Transportation Agency, and the Palu City Education Agency. Meanwhile, primary data was obtained through direct surveys in the field, including inventory of sections and intersections, traffic censuses, observations of instantaneous vehicle speeds, surveys of student behavior when crossing, and surveys of student escorts.

The research location is on Jalan Dewi Sartika in Palu Selatan Village, which is an area dominated by mixed land uses such as residential, office, and commercial. In this location, there are two schools that are the main objects of study, namely SMP Negeri 6 Palu with 846 students and SMA Negeri 3 Palu with 1479 students. The two schools are only about 100 meters apart and are passed by free school transportation route G6, as regulated in the Decree of the Head of the Palu City Transportation Agency Number 870/00.02/Dishub/2023. The activities of drop-off and pick-up drivers who park their vehicles carelessly, as well as the presence of street vendors who trade in front of the school, are the main causes of side obstacles and congestion along this route.

Field surveys were conducted systematically. Inventory surveys of sections and intersections included measuring the length and width of roads, sidewalk widths, shoulders, medians, drainage, and identifying road equipment such as signs and markings. Traffic enumeration surveys were conducted for 12 hours (06.00–18.00 WITA), while turning movement surveys were conducted in three time sessions (morning, afternoon, evening) to determine vehicle flow at major intersections. Measurement of instantaneous vehicle speed was conducted using the stopwatch method at a distance of 50 meters by two surveyors placed parallel. Meanwhile, surveys of pedestrian and student drop-off behavior were conducted to record patterns and characteristics of crossing behavior, walking along the road, and parking methods of drop-offs when dropping off students to school.

After the data is collected, the next stage is data processing and analysis. Traffic performance analysis is carried out based on the Indonesian Road Capacity Guidelines (PKJI 2023) for sections and intersections. The calculation of road section capacity takes into account correction factors such as lane width (FCLJ), direction separation (FCPA), side obstacle conditions (FCHS), and city size (FCUK). The degree of saturation is calculated using the formula $Dj = \frac{q}{c}$, and density is calculated using $k = \frac{q}{v}$. The level of service (Level of Service/LOS) is assessed based on the V/C ratio value and is classified from A (very good) to F (totally congested), as presented in Table 5.

Table 5 Road Service Levels

Level of Service	V/C Ratio	Characteristics
A	0.00–0.20	Free flow, drivers are free to choose their speed
B	0.21–0.44	Current is stable, speed is starting to be limited
C	0.45–0.74	Stable current, tighter speed control
D	0.75–0.84	The current is almost unstable
E	0.85–1.00	Full flow, frequent stops
F	>1.00	Traffic jam, long queue

For intersections, capacity is calculated using a formula that combines basic capacity with median correction, city size, side obstacles, and turning vehicle flow. Intersection delay is calculated based on vehicle interaction and geometric conditions, with separate formulas for major and minor flows. Determination of intersection service levels follows the delay classification from A to F as described in Table 3.15. Analysis of student behavior when crossing using the Z test statistic, assuming that the standard safe crossing behavior follows the 4T procedure (Wait, Look right, left, right again). The formula used is and compared with the Ztable value = 1.645 at a significance level of 5%.Observations on instantaneous vehicle speeds were also tested using the Z-test statistical approach with the average compared to the safe speed threshold in the school area. If the Zhit value ≤ Ztable, then the speed is still within safe limits. Conversely, Zhit > Ztable indicates a high risk to student safety.

$$Z_{hit} = \frac{\bar{P} - 0.5}{\sqrt{\bar{P}(1-\bar{P})/n}}$$

Pedestrian facilities such as sidewalks and crosswalks are assessed based on volume and functional needs using the formula W = (V/35) + N, where W is the sidewalk width requirement and N is an additional constant value depending on the context (commercial, school, etc.). Determining the need for crossing facilities also uses the PV^2 approach, which shows the relationship between pedestrian flow and vehicle volume to determine whether a zebra crossing, pelican crossing, or non-level crossing is needed.

To assess the feasibility of the drop zone, queuing theory is used with parameters λ (vehicle arrival rate), μ (service level), and ρ (arrival intensity). If the value of ρ is close to or more than 1, it means that the queue exceeds capacity and expansion or rearrangement of the drop zone area is needed. Queue data processing is carried out using the standard service system formula M/M/1 and M/M/c from transportation queuing theory.

The final results of this analysis process will be used to design recommendations for the School Safety Zone (ZoSS) design on Jalan Dewi Sartika, which includes the need for road markings, traffic signs, sidewalk facilities, drop zone areas, and the presence of guide officers. All data processing results are presented as the basis for compiling the ZoSS technical design that best suits existing conditions and field needs.

Results and Discussion

Traffic Volume and Composition

The results of the traffic volume survey show that Jalan Dewi Sartika experiences the highest traffic density at 06.45–07.45 WITA with a volume of 1352.60 smp/hour, coinciding with school hours. Meanwhile, at school closing time the highest volume occurs at 14.30–15.30 WITA at 1064.35 smp/hour. Based on Figures 4.6–4.8 which illustrate the composition of traffic for two directions, it is known that the most vehicles are motorcycles, followed by private cars. The dominance of private modes, especially motorcycles, reflects the preference of the people of Palu City who prefer private vehicles to public transportation. The implication of this pattern is the high risk of conflict with pedestrians around schools.

Road Section Capacity

Road capacity calculations are carried out based on the 2023 PKJI guidelines using the formula:

$$C = C_o \times FCLJ \times FCPA \times FCHS \times FCUK$$

With values:

a. Co = 2800 smp/hour
b. FCLJ = 1.14
c. FCPA = 1.00
d. FCHS = 0.98
e. FCUK = 0.90

So the effective capacity of the road section is:

$$C = 2800 \times 1,14 \times 1,00 \times 0,98 \times 0,90 = 2815,34 \text{ smp/jam}$$

The maximum traffic volume recorded was 1352.60 pcu/hour, so the degree of saturation (DS) can be calculated:

$$DS = \frac{q}{C} = \frac{1352,60}{2815,34} = 0,48$$

The DS value of 0.48 indicates that the Dewi Sartika Road section has a service level of C, which means that the flow is still stable but road users are starting to experience limitations in choosing speed and maneuvering.

Traffic Density

With an average speed of 45.24 km/h and a volume of 1352.60 smp/h, the density is calculated as:

$$k = \frac{q}{v} = \frac{1352,60}{45,24} = 29,89 \text{ smp/km}$$

This value indicates that traffic is quite dense but has not yet entered the congestion zone.

Performance of the 4-way intersection of Dewi Sartika Street – Secondary Road – Banteng Street

Intersection Capacity

The type of intersection used is 422 with a basic capacity (Co) of 2900 smp/hour. The correction factor value is:

a. FLP = 0.98145
b. FM = 1.00
c. FUK = 0.88
d. FHS = 0.94
e. FBKi = 1.10426
f. FBKa = 1.00
g. FRMi = 0.94302

So the capacity of the intersection is the peak volume of the intersection is 1448.8 smp/hour, so the degree of saturation is:

$$DS = \frac{1448,8}{2451,697} = 0,591$$

This value indicates that the intersection is at service level B, with stable traffic flow and short queues.

Traffic Delays

The results of the delay calculation are shown in the following table:

Table 6. Results of The Delay Calculation

	Traffic Delay (sec/smp)	Geometric Delay	Major Road Delays	Minor Road Delays	Intersection Delay
1	6.68	3.99	5,042	11,689	10.68

Queue Opportunity

The queue probability is calculated based on the degree of saturation:

a. Lower limit queue probability: 15%
b. Upper limit queue probability: 31.23%

Instantaneous Speed and Safety

The average speed of vehicles in front of the school reaches more than 45 km/h. The results of the Z-test on instantaneous speed:

a. Entry direction: Zhit = 39.44
b. Exit direction: Zhit = 33.77
c. Ztable = 1.645

Since Zhit > Ztable, it can be concluded that vehicle speed is not yet safe for school zones, and intervention is needed.

Pedestrian Crossing Facility Analysis

To evaluate the necessity of pedestrian crossing facilities on Jalan Dewi Sartika, especially in front of SMP Negeri 6 Palu and SMA Negeri 3 Palu, the analysis uses the PV^2 formula, where P is the average number of pedestrians per hour and V is the average number of vehicles per hour. The threshold value recommended for installing a pelican crossing is when PV^2 exceeds 2×10^8.

SMP Negeri 6 Palu

The pedestrian data recorded during peak hours shows an average of 51 pedestrians per hour, while the traffic volume is 2344 vehicles per hour. Using the PV^2 formula:

$$PV^2 = 51 \times (2344)^2 = 2.77 \times 10^8$$

Since the PV^2 value exceeds the threshold, a pelican crossing is recommended in front of SMP Negeri 6 Palu. This facility is necessary to ensure the safety of students crossing the road during school hours.

SMA Negeri 3 Palu

Similarly, pedestrian observations around SMA Negeri 3 Palu indicate an average of 52 pedestrians per hour, with the same vehicle volume of 2344 vehicles per hour. The calculation yields:

$$PV^2 = 52 \times (2344)^2 = 2.82 \times 10^8$$

This value also surpasses the required threshold, confirming the need for a pelican crossing in front of SMA Negeri 3 Palu. The presence of this facility would significantly reduce the risk of pedestrian-related accidents and enhance school zone safety.

Figure 6. Visualization of Junior High School Design

The survey results show that traffic volume on Jalan Dewi Sartika tends to be high during school hours. The highest volume was recorded at 06.45–07.45 WITA at 1352.60 smp/hour, coinciding with the arrival time of students and teachers. Meanwhile, the highest volume in the afternoon was recorded at 14.30–15.30 WITA with a value of 1064.35 smp/hour. This condition indicates that traffic flow is greatly influenced by school activities. The composition of vehicles passing through this road is dominated by motorbikes, followed by private cars. These data show that most students and drop-offs use private vehicles rather than public transportation. This tendency needs to be considered because it has an impact on road capacity, parking facility needs, and passenger drop-off zone management.

The calculation of road capacity based on PKJI 2023 produces an effective capacity of 2815.34 pcu/hour. With the highest volume of 1352.60 pcu/hour, the degree of saturation (DS) value is 0.48. This value is still within safe limits and is classified as service level C. This means that traffic flow is still stable, but road users are starting to experience limitations in choosing speed and maneuvering. The traffic density level is calculated at 29.89 pcu/km, based on the average vehicle speed of 45.24 km/hour. In general, the performance of the Dewi Sartika Street section is still under control, but the high speed level poses a safety risk to pedestrians around the school.

One of the critical points on this road section is the existence of the four-way intersection of Jalan Dewi Sartika – Jalan Sekunder – Jalan Banteng. This intersection is an important link between Palu City and Sigi Regency. The results of the CTMC (Classified Turning Movement Count) survey show that the highest traffic volume occurs at 06.45–07.45 WITA at 1448.8 pcu/hour. After adjustments with correction factors such as approach width, side obstacles, and minor flow ratio, the intersection capacity is calculated at 2451.697 pcu/hour. The intersection saturation degree of 0.591 indicates that the intersection is still operating in a stable condition with a service level of B.

The results of the traffic delay analysis show that the intersection delay is at 10.68 seconds/smp, consisting of a geometric delay of 3.99 seconds/smp and a traffic delay of 6.68 seconds/smp. The delay for the major flow (main road) is 5.042 seconds/smp, while the minor flow is 11.689 seconds/smp. With the possibility of queuing ranging from 15% to 31.23%, it can be concluded that the intersection performance is relatively good, but is susceptible to performance degradation if the volume increases without proper management. The implementation of ZoSS around this intersection needs to be aligned with speed control and traffic flow management.

Based on the results of spot speed measurements, the average vehicle speed in the incoming direction (towards Moh. Yamin) is 45.12 km/h, while the outgoing direction (towards Karanjalemba) is 45.37 km/h. The results of the Z statistical test show that the Zhit values are 39.444 and 33.777, respectively, much greater than the Ztable of 1.645. This proves that the speed of vehicles in front of the school significantly exceeds the safe speed limit for the school area, which is 20 km/h. Thus, the traffic speed in the area is not yet safe, and interventions such as the installation of speed limit signs, rumble strips, and APILL (Traffic Signaling Devices) are urgently needed.

Accident data from the Palu City Police Traffic Unit recorded a total of 937 accidents in Palu City during the 2020–2024 period, with 181 fatalities, 392 serious injuries, and 772 minor injuries. The material losses incurred reached IDR 3.034 billion. Specifically on Jalan Dewi Sartika, there were 6 accidents with 2 fatalities. Although the number is small in absolute terms, the fact that the accident occurred in front of a school with fatalities is a strong indicator of the need to strengthen the traffic safety system in the area.

Pedestrian facility analysis was conducted by calculating the sidewalk width requirement based on the volume of pedestrians walking along the sidewalk on both sides of the road. The average number of pedestrians during peak hours at SMPN 6 is 52 people per hour on the left side and 49 people per hour on the right side. At SMAN 3, the figures are 41.5 and 40.5 people per hour on each side. Based on the standard calculation ($W = Q/35 + 1.5$), the sidewalk width requirement is 1.52 meters on each side. However, referring to the 2023 Pedestrian Facility Technical Planning Guidelines, the minimum standard for a proper sidewalk width is 1.85 meters. Therefore, it is concluded that the existing sidewalk facilities do not meet national standards and must be expanded.

Analysis of crossing facilities using the PV^2 method, which is multiplying the number of pedestrians per hour by the square of the vehicle volume per hour. The calculation results for SMPN 6 show $PV^2 = 2.77 \times 10^8$ and SMAN 3 is 2.82×10^8. This value far exceeds the recommended threshold for installing active crossing facilities such as pelican crossings. Therefore, this area is very suitable for installing pelican APILL to protect students when crossing.

Students' behavior when crossing the road was analyzed based on three indicators: following standard procedures (look right-left-right), how to cross (walking or running), and crossing status (independent/not). The survey results showed that only 46% of students at SMPN 6 and 50.7% of students at SMAN 3 followed the complete crossing procedures. The results of the Z test showed a value of Zhit = -0.761 (SMP) and Zhit = 0.164 (SMA), which means that statistically the students' crossing behavior was not safe. Most students (67–68%) crossed by walking, the rest ran. All students had independent status because they were over 10 years old.

The behavior of students dropping off is also an important aspect to be analyzed. As many as 38% of delivery vehicles stop across from schools (junior high schools) and 34% at senior high schools. Most vehicles (66% of junior high schools and 65% of senior high schools) stop where they are supposed to, but the rest stop carelessly. Regarding the getting off position, 26% of students get off from the right side of the vehicle (junior high schools) and 34% (senior high schools), which is very risky because it is on the side of active traffic. The results of the Z test showed values of -3.464 and -3.681, indicating that the behavior of student drop-offs is not statistically safe and requires design intervention.

Based on the analysis of the number of vehicles arriving during peak hours, the number of service points (drop zones) needed for motorcycles and cars is calculated. For motorcycles, the arrival rate is 137 vehicles/hour (junior high school) and 123 vehicles/hour (senior high school), while the service capacity is 80 vehicles/hour. With 2 drop zone points, the ρ value is 0.86 (junior high school) and 0.77 (senior high school), indicating a fairly good service system. For cars, with 47 arrivals (junior high school) and 39 (senior high school), and a service capacity of 30 vehicles/hour, 2 drop zone points are also needed. The dimensions of the motorcycle drop zone are 4 m × 0.75 m, while the dimensions for cars are 10 m × 2.30 m. So the total recommended drop zone length is 23 meters in each school.

Conclusion

Based on the analysis of *School Safety Zone* (*ZoSS*) needs on *Jalan Dewi Sartika* near *SMP Negeri 6* and *SMA Negeri 3 Palu*, several conclusions can be drawn. Traffic conditions are relatively stable, with a road capacity of 2,815.63 pcu/hour, peak traffic of 1,352.60 pcu/hour, and a saturation degree of 0.48 (service level C). At the nearby intersection, the capacity is 2,451.70 smp/hour, traffic volume 1,448.8 smp/hour, saturation 0.59, and a service level of B with minimal delays. To support *ZoSS*, required facilities include warning, prohibition, and directional traffic signs; longitudinal and red markings; two warning lights (*APILL*); rumble strips; four zebra crossings; four *pelican crossings;* and sidewalks at least 1.85 meters wide. The recommended *ZoSS* design is type *2/2UD–25*, for two-lane undivided roads with a speed limit of 25 km/h and a zone length of 150 meters. Comprehensive implementation of these facilities is expected to significantly enhance the safety of students and road users in the area.

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