School Safe Route in Sumbersari District, Jember Regency

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Abstract. The number of underage accidents in Jember Regency in 2011-2012 increased from 37 to 190 cases. Therefore, bicycle and pedestrian paths were planned through the School Safe Route program that could encourage students to choose to ride a bicycle or walking. The method of this study was the Level of Service analysis (LOS), student and travel characteristics, cross tabs, bicycle lanes, pedestrians, and road equipment facilities. The results showed that the level of road service on each road section varied, including LOS A, B, D and E. The characteristic and common cross tabs analysis results showed that most transportations used by students were motorcycles. Still, there was a relatively large proportion of students' willingness to change their transportation mode in operational conditions if bicycle and pedestrian path facilities were provided. Cycle path analysis showed that the types of bicycle lanes were planned, specifically type A and C, with a bicycle lane width was 1.44 m for each lane. From the calculation of the minimum effective width of the sidewalk obtained 1.01 m with a crossing facility in the form of a pelican crossing with waiting stalls. Several road equipment facilities were planned, such as traffic signs, road markings and Traffic Signaling Equipment (TSE). Bicycle and pedestrian routes were planned at Tawang Mangu Street, Danau Toba Street, Mastrip Barat Street, Kalimantan Street, Jawa Street, Karimata Street, M.T. Haryono Street, Letjen S. Parman Street, Letjen Panjaitan Street and Letjen Suprapto Street.

Keywords: Bicycle Lane, Pedestrian, School Safe Route

INTRODUCTION

The Jember Police Traffic Unit revealed that the number of underage accident cases in 2011-2012 increased from 37 cases to 190 cases. The National Highway Traffic Safety Administration stated that there were 857 cyclists killed. The number of pedestrians increased >3%, with 6,283 pedestrians in traffic accidents in the United States in 2018. The accident sites at Letjen. Panjaitan Street and Letjen. S Parman Street are categorized as a black spot area in Jember District [1].

The Ministry of Education and Culture made a school zone policy as stated in Article 16 of the Education and Culture Minister No. 14 in 2018 that schools are required to accept students who live in the closest radius to school. The close distance was expected to motivate students to walk or ride bicycles [2]. To reduce traffic accidents, a School Safe Route program was planned [3]. The School, Safe Route program, aimed to encourage students and parents would prefer walking, cycling, or using public transportations to go to schools rather than using motorcycles which could trigger accidents [4].

Therefore, bicycle and pedestrian paths were needed because it could increase students' awareness of switching modes of transportation from motorized vehicles to non-motorized vehicles to reduce traffic congestion and accidents and actualize the School Safe Route program.

This study aims to identify the existing road conditions, analyze student and travel characteristics and plan bicycle and pedestrian paths in actualizing School Safe Route facilities, including signs, markings and traffic signalling devices. The analytical method used were the analysis of the Level of Service (LOS), student and travel characteristics, cross tabs, criteria for bicycle lanes, pedestrians, and road equipment facilities.

METHODOLOGY

Case Study

The case study was in Sumbersari District, Jember Regency. It was divided into several educational zones, including:

- Education zone 1, covering Jawa Street (SMPN 3 Jember & SMAN 2 Jember) and Bengawan Solo Street (SDN Sumbersari 3)
- Education zone 2, covering Mastrip Barat Street (SDS Muhammadiyah 1 Jember & SMA Muhammadiyah 3 Jember) and Danau Toba Street (SDIT Harapan Umat & SMKS Trunojoyo)
- Education zone 3, covering Letjen. Panjaitan Street (SMAN 1 Jember) and Karimata Street (SDN Sumbersari 1 & SDS Al Irsyad Al Islamiyyah)

Data Collection Methods

This study required primary and secondary data. Primary data was obtained from a survey of the existing road conditions and the distribution of questionnaires to students in each of the studied schools. The secondary data were obtained from school location map and vehicle traffic volume data on each studied road in Jember Regency. Sampling was taken by using a non-probability technique, namely purposive sampling and the Slovin's formula, to determine the number of samples required.

$$n = \frac{N}{1+Ne^2} \ldots\ldots\ldots\ldots \tag{1}$$

n   = The sample size
N   = The population size
e   = The margin of error to be decided by the researcher

Data Analysis Methods

Road Service Levels Analysis

Road service level analysis aimed to determine the Level of Service (LOS) on each road segment using the 1997 Indonesian Road Capacity Manual module [5]. The data needed to assess the level of road service included traffic volume (V), road capacity (C) and degree of saturation (DS) or v/c ratio.

Student and Travel Characteristic Analysis

The selection of student and travel characteristics was generated from a questionnaire. It was processed by using a descriptive analysis method with a quantitative approach. Therefore, the socio-economic and students' travel characteristics were known.

Cross Tab Analysis

Cross tab analysis aimed to compare the relationship between the school distance from home and the modes used by the students to go to school and get back home.

Cycle Line Criteria Analysis

Cycle lane criteria analysis aimed to determine the type of bicycle lane needed based on the needs of bicycle lane users. There were three types of bicycles paths; type A bicycle lane (roadway bicycle lane), type B bicycle lane (sidewalk bicycle lane) and type C bicycle lane (road bicycle lane).

Pedestrian Analysis

This analysis aimed to determine facilities for pedestrians needed by the students. They are sidewalks facilities and pedestrian crossing safety like zebra or pelican cross.

Road Equipment Facility Analysis

This analysis aimed to determine the availability of production facilities and the existing condition in the form of traffic signs, marking roads and traffic signaling devices to fulfil the School Safe Route design.

RESULT AND DISCUSSION

School Safe Route Zone Analysis

Based on the regulation of The Transportation Ministry Number 16 in 2016, it is stated that the School Safe Route area's determination refers to the first paragraph of article six. The minimum number of schools in one School Safe Route area is three schools with at least three hundred students for each school. The School Safe Route zone division based on the number of schools and students was divided into three educational zones from the identification results.

TABLE 1. Research Distribution

Education Zone	Location	School	Number of student population
1	Jawa Street	SMPN 3 Jember	795
		SMAN 2 Jember	1066
	Bengawan Solo Street	SDN Sumbersari 3	500
2	Mastrip Barat Street	SDS Muhammadiyah 1 Jember	709
		SMA Muhammadiyah 3 Jember	680
	Danau Toba Street	SDIT Harapan Ummah	541
		SMKS Trunojoyo	362
3	Letjen Panjaitan Street	SMAN 1 Jember	1054
	Karimata Street	SDN Sumbersari 1	371
		SDS Al Irsyad Al Islamiyyah	491

The classification of schools in each educational zone above has fulfilled the requirements of the School Safe Route area criteria based on the rule of Transportation Ministry Number 16 in 2016.

Overview of Respondents and Existing Roads

Existing road conditions were required as road segment inventory data to calculate road segment performances on each road segment.

TABLE 2. Road Inventory Data

No.	Road Section	Type Road	Lane Width (m)	Shoulder/Kereb Road	Side Barrier
1	Jawa Street	2/2 UD	8.7	K	Medium
2	Bengawan Solo Street	2/2 UD	8.5	K	Low
3	Mastrip Barat Street	2/2 UD	8.2	K	Very Low
4	Danau Toba Street	2/2 UD	6	B	Very Low
5	Letjen Panjaitan Street	2/2 UD	13	B	Low
6	Karimata Street	2/2 UD	8	B	Low

The survey results were gained by distributing questionnaires to the students. There were 421 samples. The number of samples was obtained from the results of calculations by using the Slovin's formula.

TABLE 3. Respondent Data

No.	Name of School	Number of Respondents
1	SMPN 3 Jember	48 students
2	SMAN 2 Jember	60 students
3	SDN Sumbersari 3	27 students
4	SDS Muhammadiyah 1 Jember	49 students
5	SMA Muhammadiyah 3 Jember	42 students
6	SDIT Harapan Ummah	26 students
7	SMKS Trunojoyo	47 students
8	SMAN 1 Jember	42 students
9	SDN Sumbersari 1	65 students
10	SDS Al Irsyad Al Islamiyyah	15 students
	Total	421 students

Road Service Level Analysis Results

Road service levels were reviewed based on traffic flow, road capacity and saturation degree by using the 1997 Indonesian Road Capacity Manual Module. The traffic flow data used was in the year of 2022 at 06.00 - 07.00 WIB period. At that hour, the reason was the highest point of traffic volume and the time of students' departure to school. The data was obtained in 2018, so the vehicle volume prediction was calculated by using the formula for vehicle growth per year with the equation:

$$Vn = V0 \; x \; (1 + i)^n \qquad \qquad .(2)$$

Vn = Volume of future vehicles
V0 = Initial vehicle volume
i = Vehicle growth rate (%)
n = Year difference calculated

TABLE 4. Result of Calculation of Level of Service (LOS)

No.	Roads	Traffic Volume (pcu/hour)	Road Capacity (pcu/hour)	V/C Ratio	Level of Service (LOS)
1	Jawa Street	2069.64	2342.58	0.88	D
2	Bengawan Solo Street	990.22	2285.64	0.43	A
3	Mastrip Barat Street	2510.26	2720.01	0.92	E
4	Danau Toba Street	899.15	1379.65	0.65	B
5	Letjen Panjaitan Street	1374.53	3557.77	0.39	A
6	Karimata Street	1710.21	2001.42	0.85	D

The calculation results of the road service level in the period 06.00-07.00 WIB in 2022 showed that the LOS standard on each road segment varied based on the v/c ratio value. LOS A indicated that the traffic flow was free, and the average travel speed was 80 km/h. LOS B indicated that the traffic flow was stable, and the average travel speed was up to 40 km/h. LOS D suggested that the traffic flow became unstable, and the average travel speed dropped to 25 km/h. LOS E indicated that the traffic flow was unstable and the average travel speed was 25 km/h with traffic volume approaching road capacity.

The Results of Student and Travel Characteristics Analysis

The total number of respondents who filled out the questionnaire in google form were 421 students. They were divided into two attribute characteristics, socio-economic and student travel characteristics.
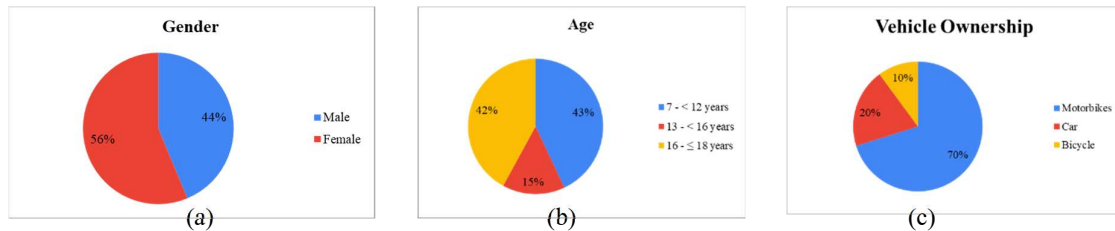

FIGURE 1. Socio-Economic Characteristics
(a) Gender, (b) Age, (c) Vehicle ownership

Most respondents who filled out the questionnaire were female (56%) and at age 7-<12 years (43 %) and at age 16-<18 years (42%), and the majority of vehicle ownership owned by students' parents was motorcycles (70%).
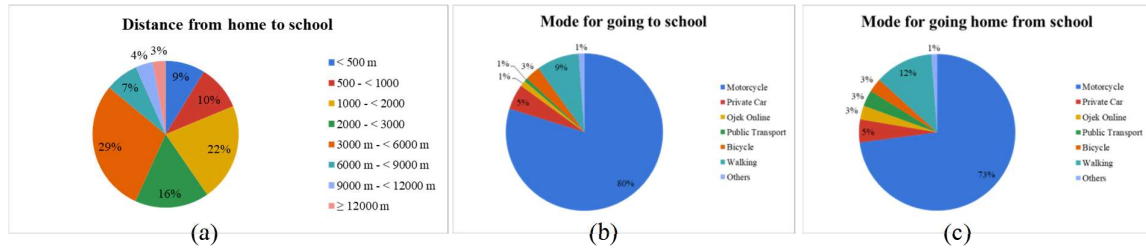
FIGURE 2. Student Travel Characteristic
(a) School distance from home, (b) Mode used to go to school, (c) Mode used to get back home

Based on the regulation of The Transportation Ministry Number 16 in 2016, the maximum distance from home to school by foot is 1 kilometer, whereas by bicycle maximum 5 kilometers. From the survey results obtained distances including <500 m (9%), 500 m-< 1000 m (10%), 1,000 m-< 2,000 m (22%), 2,000 m-< 3,000 m (22%) and 3,000 m-< 6,000 m (29%) etc. The mode of transportation mostly used by students to go to and get back from school was a motorcycle, with the percentages of which were 80% and 73%, respectively.

Results of Cross Tab Analysis

The program used in the cross-tab analysis was the statistical analysis program. It showed the relationship between the variables of the distance from home to school and the mode of transportation used by students to go to school and get back home from school.

TABLE 5. *Cross Tab Analysis* (at School Departure)

Mode of School Departure *Mileage *Crosstabulation*

						Mileage					
			< 500	500 - < 1,000	1,000 - < 2,000	2,000 - < 3,000	3,000 - < 6,000	6,000 - < 9,000	9,000 - < 12,000	>= 12,000	Total
Modes of Leaving for School	Motorcycle	Count	18	27	72	59	110	27	11	12	336
		% of Total	4.3%	6.4%	17.1%	14.0%	26.1%	6.4%	2.6%	2.9%	79.8%
	Private Car	Count	3	2	3	2	5	3	4	0	22
		% of Total	0.7%	0.5%	0.7%	0.5%	1.2%	0.7%	1.0%	0.0%	5.2%
	Ojek Online	Count	0	0	0	0	4	1	0	0	5
		% of Total	0.0%	0.0%	0.0%	0.0%	1.0%	0.2%	0.0%	0.0%	1.2%
	Public Transport	Count	0	0	1	1	1	0	0	0	3
		% of Total	0.0%	0.0%	0.2%	0.2%	0.2%	0.0%	0.0%	0.0%	0.7%
	Bicycle	Count	0	5	7	1	0	0	0	0	13
		% of Total	0.0%	1.2%	1.7%	0.2%	0.0%	0.0%	0.0%	0.0%	3.1%
	Walking	Count	16	8	6	6	1	0	0	0	37
		% of Total	3.8%	1.9%	1.4%	1.4%	0.2%	0.0%	0.0%	0.0%	8.8%
	Others	Count	0	0	2	0	2	0	1	0	5
		% of Total	0.0%	0.0%	0.5%	0.0%	0.5%	0.0%	0.2%	0.0%	1.2%
Total		Count	37	42	91	69	123	31	16	12	421
		% of Total	8.8%	10.0%	21.6%	16.4%	29.2%	7.4%	3.8%	2.9%	100.0%

TABLE 6. *Cross Tab Analysis* (at After School

Mode *Mileage *Crosstabulation*

						Mileage					
			< 500	500 - < 1000	1000 - < 2000	2000 - < 3000	3000 - < 6000	6000 - < 9000	9000 - < 12000	>= 12000	Total
Mode of Going Home	Motorcycle	Count	13	23	52	47	100	23	11	11	280
		% of Total	3.4%	5.9%	13.4%	12.1%	25.8%	5.9%	2.8%	2.8%	72.4%
	Private Car	Count	2	2	3	2	4	3	3	1	20
		% of Total	0.5%	0.5%	0.8%	0.5%	1.0%	0.8%	0.8%	0.3%	5.2 %

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Mode *Mileage *Crosstabulation*											
			Mileage								Total
			< 500	500 - < 1000	1000 - < 2000	2000 - < 3000	3000 - < 6000	6000 - < 9000	9000 - < 12000	>= 12000	
from School	Ojek Online	Count	1	0	1	2	6	1	1	0	12
		% of Total	0.3%	0.0%	0.3%	0.5%	1.6%	0.3%	0.3%	0.0%	3.1%
	Public Transport	Count	2	1	1	1	5	2	1	0	13
		% of Total	0.5 %	0.3%	0.3%	0.3%	1.3%	0.5%	0.3%	0.0%	3.4%
	Bicycle	Count	0	5	6	1	0	0	0	0	12
		% of Total	0.0%	1.3%	1.6%	0.3%	0.0%	0.0%	0.0%	0.0 %	3.1%
	Walking	Count	15	11	13	4	2	0	0	0	45
		% of Total	3.9%	2.8%	3.4%	1.0%	0.5%	0.0%	0.0%	0.0%	11.6%
	Others	Count	1	0	3	0	1	0	0	0	5
		% of Total	0.3%	0.0%	0.8%	0.0%	0.3%	0.0%	0.0%	0.0%	1.3%
Total		Count	34	42	79	57	118	29	16	12	387
		% of Total	8.8%	10.9%	20.4%	14.7%	30.5%	7.5%	4.1%	3.1%	100.0 %

Based on cross – tab analysis of the distance from home to school and the mode used showed that students who rode motorcycles had a larger proportion than other modes with a total of 79.8% when they went to school and 72.9% when they went home from school. However, there was a proportion of 3.1% students riding bicycles and 8.8% students walking to school, while for leaving school there was a proportion of 2.9% students riding bicycles and 12.1% students walking.

Although the results of cross tab analysis showed that the proportion of riding bicycles and walking was small, it did not rule out the possibility of the students who changed modes of transportation. From the survey results, if bicycle lane facilities were provided, 55% of students had the willingness to ride a bicycle on the lane facilities; if sidewalk facilities were provided, 46% of students would use sidewalk facilities. If a zebra cross was provided, 53% of students would use that facility. Therefore, students need special bicycle lanes and adequate pedestrian paths so that they could be safe, secure, and comfortable.

The Results of the Analysis of Determination of Bicycle Path Criteria

Parameters used in determining the criteria for bicycle lanes include topography levels, road functions and standards. Those were the parameters to assess bicycle lanes, whether types A, B or C.
- Assessment based on topography
  Topography which is used in the assessment should be less than 4%, considering the convenience of cyclists because bicycle is transportation that is driven by pedaling.

TABLE 7. Assessment of Roads Based on Topography

No.	Road Sections	Width (m)	Topography	Remarks
1	Jawa Street	8.7	0.14%	-
2	Bengawan Solo Street	8.5	4.17%	>4%
3	Mastrip Barat Street	8.2	3.46%	-
4	Danau Toba Street	6	0.52%	-
5	Letjen Panjaitan Street	13	1.59%	-
6	Karimata Street	8	0.44%	-

The road segment that has a topography > 4% was Bengawan Solo Street, which amounted to 4.17%. It meant that the bicycle lane could not be planned on this road.
- Assessment based on road function
  The criteria for bicycle lanes used in the assessment based on the road functions were for types A and C bicycle lanes. In these types, bicycle lanes were planned on the road. Type A bicycle lanes consisted of secondary arteries, primary arteries, and secondary collectors. Type C bicycle lanes consisted of primary local roads, secondary local roads, secondary collectors, secondary environments and primary environments.

TABLE 8. Distribution of Bike Path Types Based on Road Function

No.	Road Section	Function Road	Type Bike Lane
1	Jawa Street	Secondary Collector	C
2	Mastrip Barat Street	Secondary Collector	C
3	Danau Toba Street	Secondary Collector	C
4	Letjen Panjaitan Street	Secondary Artery	A
5	Karimata Street	Secondary Collector	C

- Assessment based on criteria for type A bicycle lanes
  Details of the moderate roads are at least two lanes for two directions and a minimum width of 7 m [6]. For bicycle lane planning, the bicycle lane width was 1.44 m for one direction and 2.76 m for two directions. Therefore, the width of the road after deducting the bicycle lane design must remain ≥ 7 m.

TABLE 9. Cycle Path Type A Based on Lane Width After Subtracting Cycle

No.	Road Segment	Width of Existing Lane (1)	Width of 2-way Bicycle Lane (2)	(3)= (1)-(2)	Remarks
1	Letjen Panjaitan Street	13	2.76	10.24	Meets

Letjen Panjaitan Street complied with the planned two-way bicycle lanes because the width of the existing road after deducting the bicycle lane was ≥ 7 m.

- Assessment based on criteria for type C bicycle lanes

TABLE 10. Width after deducting bicycle lanes

No.	Road Segment	Width of Existing Lane (1)	Width of 2-way Bicycle Lane (2)	(3)= (1)-(2)	Remarks
1	Jawa Street	8.7	2.76	5.94	Not Meets
2	Mastrip Barat Street	8.2	2.76	5.44	Not Meets
3	Danau Toba Street	6	2.76	3.24	Not Meets
4	Karimata Street	8	2.76	5.24	Not Meets

Two-way bicycle lanes were not planned on Jawa Street, Mastrip Barat Street, Danau Toba Street and Karimata Street. The reason was the width of the road after deducting the width of the bicycle lane is ≤ 7 m, which means that the road width requirement for medium roads will be reduced if two-way bicycle lanes are planned. However, in this study, bicycle lanes were still planned. In increasing the capacity of the road after reducing the bicycle lanes, the steps were as follows:

1. We are reducing obstacles on the road, such as parking and street vendors.
2. Implementing a one-way road that can be planned permanently or temporarily. Temporary one-way road, i.e. if conditions are not peak hours. A two-way road is applied during the morning rush hour. It is made in the same direction and vice versa during the afternoon rush hour.
3. Road widening. In meeting the standard road width of 7 m, the road widening outside the bicycle lanes were recommended as follows:

- Jawa Street, the existing lane is widened by 1.06 m
- Mastrip Barat Street, the existing line is widened by 1.56 m
- Danau Toba Street, the existing line is widened to 3.76 m
- Karimata Street, the existing lane is widened to 1.76 m.

The recapitulation of the bicycle lanes division in each road section is described as follows:

TABLE 11. Type of Bike Lane for Each Road Section

No.	Road Segment	Type Bike Lane
1	Jawa Street	C
2	Mastrip Barat Street	C
3	Danau Toba Street	C
4	Letjen Panjaitan Street	A
5	Karimata Street	C

Pedestrian Analysis Results

The selection of crossing facilities was based on the flow of road crossings and vehicles, while the sidewalk planning was based on the pedestrian volume, the minimum effective width of the sidewalk and additional width according to local conditions.

Therefore, a pedestrian analysis was carried out to see if the existing pedestrian facilities could be used or should be improved by increasing the width of the sidewalk or crossing facilities in the form of a pelican crossing.

- Pavement planning

  It was known from the availability of sidewalks in the existing condition at Mastrip Barat Street, Bengawan Solo Street, Jawa Street, Karimata Street and Letjen Panjaitan Street. However, the sidewalk facilities in those streets were not used as pedestrian facilities but for street vendors along the sidewalks. Based on *The Ministry of Public Works and Housing*[7], the selection of the minimum effective width of the sidewalk using the following formula:

$$W = \frac{V}{35} + N \tag{3}$$

W = Minimum effective width of the sidewalk (m)
V = Pedestrian volume plan/two-way (person/m/min)
N = Additional width according to local conditions (m)

TABLE 12. Planning of Minimum Effective Width of Sidewalks

Roads	Number of Pedestrians (org/meter/minute)	Time (minutes)	Existing Width of Sidewalks (m)		V (org/meter/minute)		N (m)	W (m)	
			Right	Left	Right	Left		Right	Left
Jawa Street	327	60	2	2.4	2.72	2.27	1	1.08	1.14
Bengawan Solo Street	150	60	1.4	1.4	1.79	1.79	1	1.05	1.10
Mastrip Barat Street	60	60	1.5	1.6	0.67	0.63	1	1.02	1.04
Danau Toba Street	60	60	3.7	2.4	0.27	0.41	1	1.01	1.04
Karimata Street	181	60	1.38	1.38	2.19	2.19	1	1.06	1.12
Letjen Panjaitan Street	146	60	2	2	1.21	1.21	1	1.03	1.07

The existing sidewalk width on the left and right lanes had a greater width than the minimum effective width of the sidewalk. It showed that the existing sidewalk width had reached the minimum adequate sidewalk width standard.

- Planning for crossing facilities

  Availability of crossing facilities in existing conditions, such as Danau Toba Street, Bengawan Solo Street, Jawa Street, Karimata Street and Letjen Panjaitan Street, is required. The form of the crossing facility in the existing condition was in the form of a zebra cross. To determine the criteria of crossing facilities, the following formula was used:

$$Crossing\ Facility = PV^2 \tag{4}$$

P = Traffic flow for pedestrians along 100 m (ped/hour)
V = Two-way traffic flow (vehicles/hour)

TABLE 13. Criteria for Determining Crossing Facilities

Road Section	P (ped/hour)	V (vehicle/hour)	PV^2	Recommendation
Jawa Street	275	4888	65.70×10^8	*Pelican* with waiting for a stall
Bengawan Solo Street	163	1791	5.22×10^8	*Pelican* with waiting for a stall
Mastrip Barat Street	64	6852	30.04×10^8	*Pelican* with waiting for a stall
Danau Toba Street	67	2219	3.29×10^8	*Pelican* with waiting for a stall
Karimata Street	244	4084	40.69×10^8	*Pelican* with waiting for a stall
Letjen Panjaitan Street	141	3410	16.39×10^8	*Pelican* with waiting for a stall

The criteria for crossing facilities in the existing condition were in the form of a zebra cross and upgraded to a pelican crossing with waiting stalls.

The Results of Road Equipment Facility Analysis

According to [8], the School Safe Route could be created by providing road equipment facilities in the form of signs, markings and traffic signaling devices.

- Traffic Signs

TABLE 14. Availability of Traffic Signs in Existing Conditions

Equipment Facilities	Mastrip Barat Street	Danau Toba Street	Bengawan Solo Street	Jawa Street	Karimata Street	Letjen Panjaitan Street
signs hint facility location dismissal car public bus	√	-	-	-	-	√
signs hint facility location pedestrian crossings	-	-	√	-	-	√
Signs clues to the location of the school	√	-	-	-	-	-
Signs clues to the location pick-up/delivery	-	-	-	-	-	-
Command signs using bicycle lanes or special lanes	-	-	-	-	-	-
Prohibition Signs for Driving Vehicles at Speeds More Than Written	-	-	-	-	-	-

Source: Survey Results, 2021

There are still many traffic signs needed to fulfil School Safe Route that is not available on every road. Therefore, this study recommended traffic signs on each road segment based on the General Director of Land Transportation Regulation in 2015.

Determining the maximum speed limit was obtained from the 85 percentile speed calculation results. The 85th percentile speed was the speed at 85% of drivers who drive a vehicle on the highway without being affected by slower traffic speeds or lousy weather. The 85th percentile speed was used to determine the ideal speed limit on the studied road section according to the average vehicle speed. An example of a graph for calculating the speed of the 85th percentile on Jawa Street was as follows:
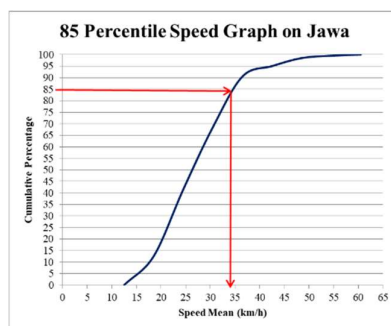

FIGURE 3. 85 Percentile Speed Graph on Jawa Street 2-Way Traffic

Graph of the 85th percentile speed on Jawa Street showed that the 85th percentile speed for 2-way traffic was 34 km/h up to 40 km/h. Then the speed limit used on the signs was 40 km/hour.

- Road Marking

TABLE 15. Availability of Road Marks in Existing Condition

Equipment Facilities	Mastrip Barat Street	Danau Toba Street	Bengawan Solo Street	Jawa Street	Karimata Street	Letjen Panjaitan Street
Road mark for bicycle lanes	-	-	-	-	-	-
Road mark for pedestrian crossings (zebra crossing) without pelican crossing	-	√	√	√	√	√
Road mark for pedestrian crossings (zebra) with a pelican crossing	-	-	-	-	-	-

Many bicycle lanes and pedestrian crossing markings which are needed to fulfil School Safe Route that has not been available yet on each road segment. Therefore, this study recommended road markings on each road section based on [9]
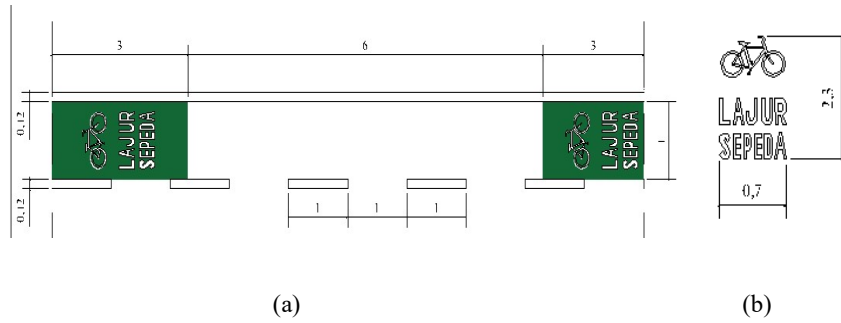
(a)   (b)

FIGURE 4. Details of Bicycle Lane Markings

(a)   Details of markings on road sections, (b) details of symbol markings and writing
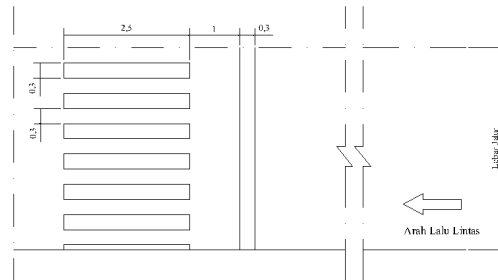

FIGURE 5. Details of Pedestrian Crossing Marking

- Traffic Signaling Equipment (TSE)

TABLE 16. Availability of Traffic Signaling Equipment in Existing Condition

Equipment Facilities	Mastrip Barat Street	Danau Toba Street	Bengawan Solo Street	Jawa Street	Karimata Street	Letjen Panjaitan Street
TSE with light color 1	-	-	-	-	-	-
TSE with lights 2 colors	-	-	-	-	-	-
TSE with lights 3 colors	√	√	-	-	√	√

There were still many things needed to realize School Safe Route that have not been available yet on each road segment. Therefore, this study recommended TSE based on [10] regarding Guidelines for Placement of Road Equipment Facilities.

The 1-color TSE (yellow) is installed at the intersection of Prosalina to be careful when crossing the intersection. The 2-colors TSE is installed at each school at the crossing lane with the purpose of being a light pelican crossing. 3-colors TSE in the existing condition has been installed, such as the Mastrip Barat Street, Danau Toba Street, Karimata Street and Letjen Panjaitan Street. And it is not recommended to be installed on Jawa Street and Bengawan Solo Street because there is a roundabout on the road that is large enough so that there is no need to plan for 3-colors TSE.

Cyclists and Pedestrians

The design of bicycle lane routes was based on the students' distribution map and the Origin-Destination Matrix obtained from the survey results of students' home addresses with their school.
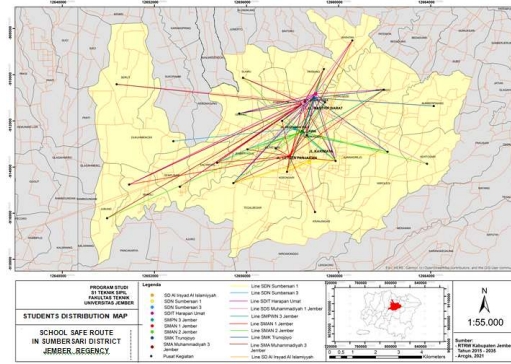
FIGURE 6. Students' Distribution Map

The Origin-Destination Matrix analysis was obtained from the number of students from each village and students going to their respective schools.

TABLE 17. Matrix of Origin and Destination in Sumbersari District

Destination of Origin	SMAN 2 Jember	SMPN 3 Jember	Sumbe rsari 3	SDS Muham madiya h 1 Jember	SMA Muhamm adiyah 3 Jember	SDIT Harapa n People	SMK Trunojo yo	SDN Sumbe rsari 1	SDS Al Irsyad Al Islamiyy ah	SMAN 1 Jember	Total (Oj)
Wirolegi	1	1	-	2	-	-	1	2	-	-	7
Karangrejo	4	3	4	3	2	3	2	1	1	1	24
Sumbersari	14	30	17	11	4	4	4	43	7	17	151
Kebonsari	5	5	-	7	11	5	2	17	5	5	62
Tegalgede	1	1	2	1	-	3	7	-	-	1	16
Antirogo	-	1	-	-	-	1	3	-	-	1	6
Kranjingan	-	-	-	4	-	-	-	-	-	1	5
Total (Dj)	25	41	23	28	17	16	19	63	13	26	271

Source: Results Analysis, 2021

Sumbersari District was the origin zone that has the largest number of students. It had 151 students, and the most destination zone was at SDN Sumbersari 1 with 63 students.

Thus, it was assumed that students in each village of Sumbersari District passed through several roads. The detailed information is described as follows:

TABLE 18. Road Sections in each Village in Sumbersari Subdistrict

No.	Village	Section Street	Number of Students
1	Wirolegi	MT Haryono Street	7
2	Karangrejo	Letjen S Parman Street	31
3	Kebonsari	Letjen Suprapto Street	62
4	Tegalgede	Danau Toba Street	43
5	Sumbersari	Mastrip Street	45
		Kalimantan Street	49
		Bengawan Solo Street	23
		Jawa Street	114
		Letjen Panjaitan Street	87
		Karimata Street	142
6	Antirogo	Tawang Mangu Street	6
		Total	**614**

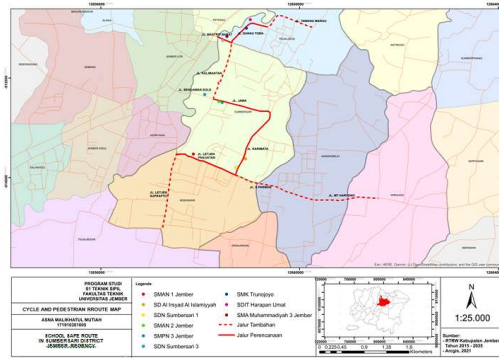Source: Analysis Results, 2021

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FIGURE 7. Cycle and Pedestrian Route Map

The continuous line symbol indicates bicycle and pedestrian paths based on the studied research zone. The dotted line symbol indicates bicycle and pedestrian paths that are added based on the Origin Destination Matrix Analysis results.

CONCLUSION AND RECOMMENDATIONS

Conclusion

1. The existing condition of the road had a road width between 6 m – 13 m. It was divided into two lanes in two directions. There were sidewalks on several roads with a width of 1 m – 3.7 m, except on Danau Toba Street with no sidewalks. Bicycle lanes and other road equipment facilities were not available on all roads. The level of road service on each road segment varied namely Bengawan Solo Street and Letjen Panjaitan Street (LOS A), Danau Toba Street (LOS B), Jawa Street & Karimata Street (LOS D) and Mastrip Barat Street (LOS E).
2. The results of the characteristics and common cross tabs analysis showed that the mostly used transportation mode by students was motorcycles to go to school or go home from school with percentages 80% and 73%, respectively. However, there was a relatively large proportion of students' willingness to change modes in operational conditions if bicycle and pedestrian lane facilities were provided.
3. The design of bicycle and pedestrian paths in Sumbersari District, Jember Regency included:
   - Bicycle lane type A was planned on Letjen Panjaitan Street. Bicycle lane type C was planned on Jawa Street, Mastrip Barat Street, Danau Toba Street and Karimata Street with a bicycle lane width of 1.24 m in each lane. The minimum effective width of the sidewalk was planned to be at least 1.01 m with crossing facilities in the form of a pelican crossing with waiting stalls
   - Several road equipment facilities were planned, such as traffic signs, road markings and traffic signalling equipment
   - Bicycle and pedestrian routes were planned on the Tawang Mangu Street, Danau Toba Street, Mastrip Barat Street, Kalimantan Street, Jawa Street, Karimata Street, MT Haryono Street, Letjen Panjaitan Street, Letjen S Parman Street and Letjen Suprapto Street.

Recommendations

Future studies can use this study results to conduct further research by considering other aspects of bicycle and pedestrian paths. The results of this study can be used for the Transportation Department of Jember Regency as guidelines in the context of developing facilities and infrastructure in realizing the School Safe Routes in Jember.

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