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Research Article

Safety Road Improvement on Kedu-Parakan Street, Temanggung Regency

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Abstract: The kedu-Parakan arterial road is a national road that has the second-highest number of accidents in Temanggung Regency. Traffic accident data in 2014-2018 as many as 80 times. The purpose of the study is to identify the causative factors of the accident and evaluate the suitability and analysis of Kedu-Parakan Road as a safe road to improve it. Data analysis uses correlation with SPSS Program and collision diagram. The main cause of the accident (75%) is human, and the type of collision that often occurs is front-to-front collisions (42.5%), as well as the type of vehicle often involved is motorcycles (65.2%). The accident time often occurs at 06.00 WIB-12.00 WIB (45%), wherein this section there are 3 blackspots, namely: STA 01+050-STA 01+350 (4 events), STA.03+900-STA 04+300 (5 events), and STA 07+500-STA 07+800 (4 events). Recommended types of person crossings suitable for STA 01+050-STA 01+350 and STA 07+500-STA 07+800 with PV2 values of 3 x 108 in the form of zebra cross, renewal of signs and markings, and the creation of a single School Safe Zone (ZOSS) at STA 03+900-STA 04+300.

Keywords: Accident, Blackspot, Road.

1. Introduction

Transportation is the lifeblood of the economy so that efforts to improve people's welfare through development are highly dependent on transportation infrastructure (Cooley, 1894; Hodge, 1990; Rondinelli & Berry, 2000). The definition of transportation is the process of moving people, animals, or goods from one place to another by using a vehicle driven by humans or machines. Transportation is also defined as the process of moving people or goods from one place to another using land, sea, air, both public and private, using machines or not. (Steenbrink, 1974; Miro, 2005; Adisasmita, 2011).

Transportation has many functions in human life. Some of the transportation functions include;

- Helping economic growth and development of a region/country (Bravo & Vidal, 2013).
- Increase population mobility services and other resources to support economic and social growth in the community.
- Community facilities to interact with each other (Jara-Diaz, 1982).
- Transportation can avoid isolation and stimulate development in all areas of life, be it trade, industry, or agriculture.

With the availability of adequate transportation facilities, the people's economy is increasingly developing, both in urban and rural areas. Service to the community is also maximized using transportation.

Meanwhile, the benefits of transportation fall into four classifications, namely:

- Economic Benefits

The economic activity aims to meet human needs by creating benefits. Transportation is one type of activity that involves increasing human needs by changing the geographic location of goods and people to lead to transactions (Weisbrod & Reno, 2009).

- Social Benefits

Transportation provides various conveniences, including:

1. Services for individuals or groups
2. Exchange or delivery of information
3. Travel to relax
4. Shorten the distance
5. Spread the population.

- Political Benefits

Transportation creates unity, wider service, national security, overcomes disasters, etc.

- Territorial Benefits

Meet the needs of residents in cities, villages, or inland areas, especially those related to circulation and mobilization as well as development stimulants (Gaunthier, 1970).

Land transportation is the process of moving people or goods by land. The means of transportation commonly used on land routes are cars, motorbikes, trains, bicycles, rickshaws, bajaj, and so on, while the infrastructure used

is roads or railways. Land transportation is often used due to several factors, including distance, cost, convenience, safety, and flexibility (Bouwman & Moll, 2002; McNally & Kulkarni, 1997).

Temanggung Regency is one of the districts in Central Java Province. With most of its territory in the form of highlands. It is geo-economically traversed by 3 central economic activities, namely Semarang, Yogyakarta, and Purwokerto (Temanggung Regency Government, 2015).

The activity centers are in two sub-districts, namely Temanggung District and Parakan District. Government, education, and economic activities are in the Temanggung District, while other activities are in the Parakan District. The existence of two activity centers increasing access to and out of the sub-district and movement within the sub-district (Temanggung Regency Government, 2017).

Economic movement is connected through roads that are spread over 114 sections. Consisting of national roads, provincial roads, and district roads. The high level of movement also causes transportation problems in the Temanggung Regency in many accidents.

Jalan Kedu-Parakan is a national road with arterial function, which has the second-highest number of Temanggung Regency accidents. Based on data obtained from the Traffic Unit (Satlantas) of the Temanggung Resort Police in 2019, there were 80 traffic accidents in this section in 2014-2018 (Temanggung Resort Police, 2019).

Jalan Kedu-Parakan has a road length of 8800 m with the road type 2/2 UD. Has a difference in lane width, namely 3.2 m and 3.5 m along the 3900 m and 4900 m. This condition is exacerbated by poor infrastructures, such as the absence of road lighting equipment (APJ) and damaged road signs so that road users cannot see it clearly. This section's performance is indicated by a VC Ratio of 0.634, speed of 65.56 km / h, and a density of 161.34 pcu / km.

2. Literature review

Road Definition

Based on the Republic of Indonesia Law No. 38 of 2004 concerning Roads, it defines roads as land transportation infrastructure which includes all parts of the road, including complementary buildings and equipment intended for traffic, which are on the ground level, above ground level, below ground level and/or water, as well as above the water level, except for railways, lorries, and cable roads (State Secretariat, 2004).

Meanwhile, based on RI Law No. 22 of 2009 concerning Road Traffic and Transportation, which was promulgated after Law No. 38 defines roads as all parts of the road, including complementary buildings and equipment intended for public traffic, which are on the ground level, above ground level, in below the surface of the land and/or water, as well as above the water level, except rail and cable roads (State Secretariat, 2009).

Road traffic and transportation infrastructure is traffic space, terminals, and road equipment, including markings, signs, traffic signaling devices, road user control and safety devices, road surveillance and security devices, and supporting facilities (Munawar, 2004; Mulyono et al. 2009).

Road infrastructure is an essential part of people's lives to serve people and goods' movement, which must be accompanied by the provision of adequate road network infrastructure (supply) for smooth distribution (Pandey, 2013). The provision of road infrastructure is the key to national economic growth and as a link between regions to positively impact regional development and is the government's responsibility (Pandey, 2013). Meanwhile, quality road infrastructure affects the accessibility and mobility of a region's development (Pandey, 2013).

3. Highway Safety

Road safety is an effort to reduce road accidents by paying attention to the factors that cause accidents, such as human factors, vehicle factors, road factors, and environmental factors, and comply with established regulations (Sujanto & Mulyono, 2010; Tjahjono, 2016).

In law number 14 of 1992 concerning road traffic and transportation, article 22 paragraph 1 states that the safety, smoothness, and orderliness of road traffic and transportation stipulates provisions regarding traffic engineering and management. According to law No. 14 of 1992, the definition of traffic management includes planning, regulation, supervision, and control of traffic with the aim of safety, security, order, and smoothness of traffic.

4. Road Safety Engineering

To realize safe roads, it is necessary to have road safety engineering to ensure every road user can improve safety through the national road safety general plan program. Even if an accident occurs, it will reduce the risk of severity for negligent road users who experience an accident. Roads must be equipped following provisions such as signs, markers, safety fences, and other complementary buildings related to road conditions and situations (Sugiyanto & Fadli, 2017; Wicaksono et al., 2014).

5. The concept of the Safe Way

According to Djoko Muryanto (2012), technical guide I road safety engineering, the Ministry of Public Works of the Republic of Indonesia explains that a safe road is a road that is designed and operated in such a way that it informs, warns, and guides drivers through a road segment that has unusual elements.

realize safe road sections, three aspects need to be fulfilled by a road section following Law Number 22 the Year 2009 concerning Road Transportation Traffic. The three aspects are Self-explaining, Self-enforcing, and Forgiving road.

Self-explaining (article 25) means that every road used by traffic must be equipped with road equipment. The goal of providing road infrastructure is expected to guide road users without direct communication with road operators. The road designer uses the maximum safety aspects in geometric road design and easily digestible road elements to help road users know the situation and condition of the next road segment.

Self-enforcement (article 8), namely road management activities in the form of regulation, development, construction, and road infrastructure supervision. This activity is expected to be able to create compliance from road users without warning road users. The road designer meets the maximal road equipment design. Road equipment such as signs and markings can control road users to stay on track. Besides, it must also control road users to meet safe speeds and distances between vehicles.

Forgiving-road (article 22), a road that is operated, must fulfill the road operator's proper technical and administrative function, which must be implemented by the road operator, both before and after the road is operated. This aims to minimize road user errors to minimize the severity of victims due to accidents. The road designer fulfills the geometric aspects and road equipment and complies with road complementary buildings and safety devices. The design of road safety fences and other road safety devices can direct road users to stay on track. Even if an accident occurs, it does not cause fatal casualties—the design of road safety devices can remind road users / minimize road user errors.

6. Method

In the research on the improvement of the safe road sections of the two-part road in Temanggung, several surveys were carried out to obtain some existing data, the causes, the number of accidents per year, and other types of accidents in the Kedu-Parakan road section of Temanggung Regency. The data obtained were analyzed the characteristics and traffic accidents to determine the relationship between the accident variables using the correlation method using the SPS program.

A safe road analysis was also carried out from this data, which included pedestrian analysis, Self Regulating Road analysis, and Self Enforcing Road analysis. This study also still refers to the Indonesian Road Capacity Manual (MKJI) in 1997 and the Road Safety Inspection (IKJ) in 2007.

7. Result and discussion

1. Characteristics Analysis and Traffic Accidents

To determine the relationship and linkages between accident variables, the statistical analysis method used is a correlation. In doing these calculations, the authors use the SPSS program. This program really helps the analysis process because it does not require manual calculations, making it more effective and efficient.

Here we will discuss correlation, namely whether the available sample data provide sufficient evidence that there is a relationship between variables. And if there is a relationship between variables, how strong is the

relationship between these variables. The variables tested were the type of accident, the cause of the accident, the type of vehicle, the time the accident occurred. This data can be seen in the table below:

Table 1. Data on the number of accidents with causative factors

Year	Causes of Accidents			
	Human	Road	Vehicles	Environment
2014	13	2	2	1
2015	12	2	1	0
2016	10	1	1	1
2017	12	2	2	0
2018	13	3	2	0

Source: Traffic Police of Temanggung Police

Table 2. Data on the number of accidents with hit type

Collision Type	Accident					Total
	2014	2015	2016	2017	2018	
Single	3	4	2	3	3	15
Front-Front	8	6	5	7	8	34
Front back	3	2	1	3	3	12
Front-Side	1	1	2	2	2	8
Side-by-Side	1	1	0	1	0	3
Hit Humans	2	1	3	0	2	8

Source: Traffic Police of Temanggung Police

Table 3. Data on the number of accidents with vehicles

Year	Type of Vehicle Involved				
	Motor cycle	Private Vehicle	Good Vehicle	Bus	Non-Motorized Vehicle
2014	16	4	2	0	1
2015	15	4	2	1	2
2016	13	2	3	0	1
2017	15	4	3	0	2
2018	18	5	4	0	1

Source: Traffic Police of Temanggung Police

Table 4. Data on the number of accidents by the time of the incident

Year	Time of the incident			
	00.00-06.00	06.00-12.00	12.00-18.00	18.00-24.00
2014	3	8	4	3
2015	3	7	3	2
2016	3	5	3	2
2017	2	8	4	2
2018	3	8	4	3

Source: Traffic Police of Temanggung Police

Then the above data are correlated using the SPSS program; the following results are obtained:

Table 5. Correlation of the number of accidents with the causative factors

Number of Accidents			
Parameter	Pearson Correlation	Sig. (1-Tailed)	N
Number of Accidents	1		5
Human Factor	.962	0.004	5
Road Factor	.833	.040	5
Vehicle Factors	.861	.031	5
Environmental factor	-.215	.364	5

Table 6. Correlation of the Number of Accidents by Collision Type

Number of Accidents			
Parameter	Pearson Correlation	Sig. (1-Tailed)	N
Number of Accidents	1		5
Single	.333	.292	5
Front-Front	.994	.000	5
Front back	.922	.013	5
Front-Side	.-215	.364	5
Side-by-Side	.215	.364	5
Hit Humans	-.207	.369	5

Table 7. Correlation of Number of Accidents with Vehicles

Number of Accidents			
Parameter	Pearson Correlation	Sig. (1-Tailed)	N
Number of Accidents	1		5
Motorcycle	.908	.016	5
Private vehicle	.861	.031	5
Goods Vehicles	.141	.411	5
Bus	-.264	.334	5
Non-Motorized Vehicles	-.215	.364	5

Table 8 Correlation of Number of Accidents and Time of Event

Number of Accidents			
Parameter	Pearson Correlation	Sig. (1-Tailed)	N
Number of Accidents	1		5
00.00-06.00	.000	.500	5
06.00-12.00	.904	.018	5

12.00-18.00	.861	0.31	5
18.00-24.00	.861	0.31	5

From the correlation data above, the strongest correlation results are as follows:

Table 9 Correlation of the Number of Accidents with the Variables

		Factors Causing	Type of Vehicle Involved	Collision Type	Occurrence
		Human	Motor Cycle	Front-front	06.00-12.00
Number of Accidents	Pearson Correlation	.962	.908	.994	.904
	Sig. (1-Tailed)	0.004	.016	.000	.018

2. Safe Road Analysis

Pedestrian Analysis

Table 10 Analysis of Blackspot Crossers STA 01 + 050-STA 01 + 350

No.	Time	P (Person/hour)	V (pcu/hour)	V^2	PV^2	PV^2 Highest
1	06.15-07.15	143	1,498	2244004	320,892,572	√
2	06.30-07.30	151	1,476	2178576	328,964,976	√
3	11.15-12.15	131	1,355	1836025	240,519,275	
4	11.30 - 12.30	135	1,425	2030625	274,134,375	-
5	15.15-16.15	138	1,492	2226064	307,196,832	√
6	15.30 - 16.30	147	1,514	2292196	336,952,812	√

Based on the analysis on blackspot STA 01 + 050-STA 01 + 350, it can be seen that the four busiest hours are 06.15-07.15, 06.30-07.30, 15.15-16.15, and 15.30-16.30. Then the next step is to determine recommendations for crossing facilities following the results of the analysis, namely:

P = 579/4
= 144
V = 5,980 / 4
= 1,495
PV^2 = 1,294,007,192/4
= 323,501,798
= 3 x 108

So the recommendation for the provision of crossing facilities is pelican crossing with dividers. According to Government Regulation Number 34 of 2006 concerning Roads, fast traffic should not be disturbed by slow traffic. So that the crossing facility at that point can be a zebra cross with a divider.

Table 11 Analysis of Road Crossers for STA 07 + 500-STA 07 + 800

No.	Time	P (Person/hour)	V (pcu/hour)	V^2	PV^2	PV^2 Highest
1	06.00-07.00	163	1,529	2,337,841	381,068,083	√
2	06.15-07.15	165	1,547	2,393,209	394,879,485	√
3	11.45-12.45	159	1,431	2,047,761	325,593,999	√

4	12.00-13.00	155	1,408	1,982,464	307,281,920	-
5	15.00-16.00	137	1,462	2,137,444	292,829,828	-
6	15.15-16.15	142	1,472	2,166,784	307,683,328	√

Based on the analysis on blackspot STA 07 + 500-STA 07 + 800, it can be seen that the four busiest hours are 06.00-07.00, 06.15-07.15, 11.45-12.45, and 15.15-16.15. Then the next step is to determine recommendations for crossing facilities following the results of the analysis, namely:

P = 629/4
= 157
V = 5,979 / 4
= 1494
PV^2 = 1,409,224,895/4
= 352,306,224
= 3 x 108

So the recommendation for the provision of crossing facilities is pelican crossing with dividers. According to Government Regulation Number 34 of 2006 concerning Roads, fast traffic should not be disturbed by slow traffic so that the crossing facility at that point can be a zebra cross with a divider.

Self Regulating Road Analysis
Vertical Alignment

Table 12 Vertical Alignment STA 01 + 050-STA 01 + 350

STA 01+050-STA 01+350					
Vertical Alignment					
NO	STA (M)	Distance	Elevation(M)	Δ elevation	Sluggishness (%)
1	0+00		613		
2	0+050	50	615	2	4%
3	0+100	50	616	1	2%
4	0+150	50	617	1	2%
5	0+200	50	618	1	2%
6	0+250	50	620	2	4%
7	0+300	50	621	1	2%

Calculation:
Elevation (Δ) = Elevation (m1) – Elevation (m2)
Sluggishness (%) = Elevation (Δ) : Distance
Based on the data above on STA 01 + 050-STA 01 + 350, the elevation angle and slope values for vertical alignment on the road are obtained at STA 01 + 050-STA 01 + 350 with elevations 0 to 2 and road slopes of 0% to 4 % does not really affect the function of the road and is not a factor causing accidents.

Tabel 1 Alinyemen Vertikal STA 03+900-STA 04+300

STA 03+900-STA 04+300					
Vertical Alignment					
NO	STA (M)	Distance	Elevation(M)	Δ elevation	Sluggishness (%)
1	0+00		644		
2	0+050	50	644	0	0%
3	0+100	50	646	2	4%

4	0+150	50	647	1	2%
5	0+200	50	647	0	0%
6	0+250	50	647	0	0%
7	0+300	50	648	1	2%
8	0+350	50	649	1	2%
9	0+400	40	649	0	0%

From the above data on STA 03 + 900-STA 4 + 300, the elevation angle and slope values for vertical alignment on the road are obtained at STA 03 + 900-STA 4 + 300 with an elevation of 0 to 2 and a slope of 0% to 4 % does not really affect the function of the road and is not a factor causing accidents.

Table 14 Elevation of STA 07 + 500-STA 07 + 800

STA 07+500-STA 07+800					
Vertical Alignment					
NO	STA (M)	Distance	Elevation(M)	Δ elevation	Sluggishness (%)
1	0+00		720		
2	0+050	50	721	1	2%
3	0+100	50	722	1	2%
4	0+150	50	724	2	4%
5	0+200	50	726	2	4%
6	0+250	50	727	1	2%
7	0+300	50	728	1	2%

Based on research data on STA 07 + 500-STA 7 + 800, the elevation angle and slope values for vertical alignment on the road are obtained at STA STA 07 + 500-STA 7 + 800 with elevations 1 to 2 and 2% to 2% slope. 4% does not really affect the function of the road and is not a factor causing accidents.

Self Enforcing Road Analysis

Self-enforcing road analysis includes analysis of stopping visibility and preparing visibility.

Table 15 Visibility to Stop STA 01 + 050-STA 01 + 350

Data Type	Motor In	Motor Out	Car In	Car out	Pick up in	Pick up out
Percentile Speed 85	80.00	75.00	78.00	73.95	69.00	70.00
D 85 km/hour	131.95	119.23	126.79	116.64	104.76	107.11
Data Type	Public Trans in	Public Trans out	Bus in	Bus out	Truck in	Truck out
Percentile Speed 85	45.60	40.00	76.55	70.00	45.80	45.60
D 85 km/hour	56.50	46.89	123.11	107.11	56.86	56.50

Table 16 Visibility to Stop STA 03 + 900-STA 04 + 300

Data Type	Motor In	Motor Out	Car In	Car out	Pick up in	Pick up out
Percentile Speed 85	80.00	75.00	78.00	73.95	69.00	70.00
D 85 km/hour	131.95	119.23	126.79	116.64	104.76	107.11

Data Type	Public Trans in	Public Trans out	Bus in	Bus out	Truck in	Truck out
Percentile Speed 85	45.60	40.00	76.55	70.00	45.80	45.60
D 85 km/hour	56.50	46.89	123.11	107.11	56.86	56.50

Table 17 Visibility to Stop STA 07 + 500-STA 7 + 800

Data Type	Motor In	Motor Out	Car In	Car out	Pick up in	Pick up out
Percentile Speed 85	80.00	75.00	78.00	73.95	69.00	70.00
D 85 km/hour	131.95	119.23	126.79	116.64	104.76	107.11
Data Type	Public Trans in	Public Trans out	Bus in	Bus out	Truck in	Truck out
Percentile Speed 85	45.60	40.00	76.55	70.00	45.80	45.60
D 85 km/hour	56.50	46.89	123.11	107.11	56.86	56.50

Table 18 Visibility Preparing to Enter STA 01 + 050-STA 01 + 350

Type of Vehicle	Vehicle speed km/hour	Preparing Viewing Distance (m)	Viewing distance prepared min (m)
Motor	78.00	425.26	327.91
Car	75.00	405.38	312.45
Pick Up	73.00	392.35	302.32
MPU	58.00	300.37	230.88
Bus	70.00	373.14	287.39
Truck	60.00	312.05	239.95

Table 19 Visibility Preparing to Exit STA 01 + 050-STA 01 + 350

Type of Vehicle	Vehicle speed km/hour	Preparing Viewing Distance (m)	Viewing distance prepared min (m)
Motor	75.00	405.38	312.45
Car	73.50	395.59	304.84
Pick Up	70.25	374.73	288.62
MPU	50.00	255.46	196.06
Bus	73.25	393.97	303.58
Truck	59.00	306.19	235.40

Table 20 Visibility Preparing to Enter STA 03 + 900-STA 04 + 300

Type of Vehicle	Vehicle speed km/hour	Preparing Viewing Distance (m)	Viewing distance prepared min (m)
Motor	76.00	411.96	389.46
Car	80.00	438.74	338.39
Pick Up	69.00	366.83	282.49
MPU	41.40	210.41	161.16
Bus	74.00	398.84	307.37

Truck	48.40	246.83	189.37

Table 21 Visibility Preparing to Exit STA 03 + 900-STA 04 + 300

Type of Vehicle	Vehicle speed km/hour	Preparing Viewing Distance (m)	Viewing distance prepared min (m)
Motor	80.00	438.74	338.39
Car	80.00	438.74	338.39
Pick Up	70.75	377.90	291.09
MPU	40.00	203.39	155.73
Bus	70.50	376.31	289.86
Truck	45.60	232.00	177.88

Table 22 Visibility Preparing to Enter STA 07 + 500-STA 7 + 800

Type of Vehicle	Vehicle speed km/hour	Preparing Viewing Distance (m)	Viewing distance prepared min (m)
Motor	80.00	438.74	338.39
Car	78.00	425.26	327.91
Pick Up	69.00	366.83	282.49
MPU	45.60	232.00	177.88
Bus	76.55	415.60	320.40
Truck	45.80	233.04	178.69

Table 26 Visibility Preparing to Exit STA 07 + 500-STA 7 + 800

Type of Vehicle	Vehicle speed km/hour	Preparing Viewing Distance (m)	Viewing distance prepared min (m)
Motor	75.00	405.38	312.45
Car	73.95	398.51	307.11
Pick Up	70.00	373.14	287.39
MPU	40.00	203.39	155.73
Bus	70.00	373.14	287.39
Truck	45.60	232.00	177.88

8. Conclusion

Based on the study in the study area, the Kedu-Parakan road section has the highest causes of accidents caused by humans with a correlation value of 0.962. The Kedu-Parakan road section has not fulfilled the 4 aspects of a safe road, namely self-regulating road, self-explaining road, self-enforcing road, and self-forgiving road. Based on the analysis that has been done, handling can be done to improve safety on Jalan Kedu-Parakan by improving the factors that cause accidents both in terms of humans, facilities, and infrastructure so that the road can become a safe road.

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