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Optimization of Road Worthiness Assessment Using a Star Rating Scale

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Abstract

The Perintis Kemerdekaan Road serves as a primary arterial road and is a national road, providing access to various public facilities such as offices, schools, places of worship, general hospitals, and shopping centers. A 6/2T-type road located in an area with mixed land use has a high level of service complexity because it must accommodate large traffic flows as well as roadside activities from various land uses. In such conditions, an evaluation of the road's worthiness assessment for purpose is necessary to ensure that the roadway still meets technical and administrative requirements and remains safe for public use. This research objective is to determine the star rating for safe road infrastructure on a 6 lanes 2 lines divided road type and the relationship between the star rating value and the risk factor score for accident types on the road. The research method is the Technical Guidelines for Road Worthiness 11 PBM 2023 as a reference. The assessment of the star rating shows that the Perintis Kemerdekaan Road at KM 12, length 1 kilometer and divided into 100-meter segments, has safer road categories in segments 1, 4 to 10 (Star rating scale rating 4), and segment 2 (Star rating scale rating 5), while segment 3 is included in the safe road category. On urban roads with mixed land uses, the highest risk of property access accidents occurs in lanes less than 3.25 meters wide, with inadequate pedestrian facilities, and the absence of school safe zones. Run-off (driver-side) accidents occur when lane width is insufficient, road surface roughness is inadequate, and delineation are inadequate. For future research, integrating social aspects such as accessibility and economic aspects such as maintenance costs and local economic benefits in assessing the functional worthiness of roads.

Keywords: Infrastructure, Safer Road, Road Worthiness, Star Rating Scale.

I. Introduction

The function of roads and their associated facilities as a means of transportation must ensure comfort and safety for all road users, whether traveling long or short distances. [1]. Road safety management performance is measured by injuries and the number of deaths resulting from traffic accidents that occur. [2], [3]. Traffic accidents experienced by motor vehicle drivers are mostly caused by undisciplined driving behavior [4]. Safe and sustainable road design aims to regulate safe and secure interactions between road users [5], [6]. On heterogeneous traffic roads, many factors can dominate the causes of traffic accidents [7]. The increasing number of accidents globally can be caused by several factors, namely: increasing levels of motorization, many vehicles in poor technical condition, and a lack of adequate traffic knowledge and culture among drivers and pedestrians [4]. Road users need to be more aware of the importance of complying with established regulations, because the cause of accidents is human factors, namely driving and traffic violations committed by drivers [8]. Meanwhile, connectivity between vehicles and infrastructure, as well as traffic information, facilitates the exchange of important information, such as traffic conditions, road hazards, weather updates, avoiding potential hazards so that drivers can make the right decisions.

Proper maintenance of road sections can be assisted by the results of technical roadworthiness tests, in addition, assessment of road safety aspects can be seen from the results of roadworthiness [9]. From a geometric perspective for safer roads, the axle load factor of heavy vehicles on the technical geometric aspects of the road to ensure comfort and safety [10]. Additionally, the angle or visibility while driving can impair road function. Narrow angles or limited visibility are caused by activities that disrupt the smooth flow of traffic, potentially leading to collisions between road users or between road users and road infrastructure ([11]. The components of a road safety system consist of safer speeds, safer vehicles, safer road infrastructure, and safer road user behavior [12].

Star rating scale (SRS) is one of the road safety analysis methods, where the Regulation of the Minister of Public Works of the Republic of Indonesia concerning procedures and requirements for safer roads, technical requirements include technical aspects of road pavement structures, technical structures of road support buildings, technical use of road sections, geometric design of roads, road equipment engineering, and technical implementation of traffic management and engineering [13]. Star Rating Scores/SRS is a safer road rating system from 1 to 5 stars based on physical road inspection data, where 5 stars is the safest (high safety) and 1 star is the worst/unsafe, with 3 stars usually being the minimum threshold for a road to be considered functionally safe (meeting technical and administrative requirements) to operate safely for road users, such as passenger vehicles, motorcycles, bicycles, and pedestrians. The SRS has emerged as an indispensable framework for advancing the environmental, social, and economic sustainability of road infrastructure. [14].

Before this research was presented, many other studies with a similar focus had been conducted, namely a feasibility study of the function of the Suramadu National Road in Bangkalan Regency, based on a star rating scale [15], Weda City road sections based on the 2014 roadworthiness test method [16], including Daud Umar National Road in Tidore City. A comparison of two road safety analysis methods, namely the Roadworthiness Test (ULFJ) adapted to iRAP as an international standard, shows a difference in Star Rating Score (SRS), where the Roadworthiness Test produces a higher score because it only considers operational speed, while iRAP takes into account the maximum speed limit [17], [18], [19]. The study developed a road protection score (SRS) calculation model for national roads based on assessments by drivers of four-wheeled or more motorized vehicles. This SRS model considers 43 (forty-three) road attributes, with two main parameters different from the iRAP model: frontal and rear-end collisions and frontal side collisions during U-turn maneuvers. The results of the study indicate that the Star Rating Score (SRS) model differs significantly from the iRAP SRS model, which is adapted to the characteristics of accidents in Indonesia. This model is expected to form the basis for national road star ratings, improve road safety, and assist decision-making regarding road repairs [20]. Development of a web-based GIS assessment information system for toll road user safety using the Star-Rating method. A case study was conducted on the Cipali toll road, analyzing the safety level of road infrastructure. This system assesses road safety based on five indicators, such as general road conditions, straightness, intersections, rest areas, and toll road facilities. The results show that each segment of the Cipali Toll Road has a star rating between 3 and 4, indicating a moderate to low risk level [21].

The urgency of this research is that the condition of roadside obstructions requires that the assessment of fitness for function consider the interrelation between pavement physical condition, road geometry, road equipment, and land use. Therefore, it is necessary to identify whether the road segment meets safety and operational reliability standards. So far, few studies have examined the assessment of national road infrastructure for safety using a star scale, nor the relationship between star values and risk factor scores for accident types on six-lane roads and two-lane divided roads (6/2D). Theoretically, the urgency of this research lies in its function as a reference for further studies on the functional adequacy of roads in terms of infrastructure completeness and the types of accidents that may occur on 6/2D roads related to infrastructure completeness. Practically, the urgency of this research is to provide input for improving traffic safety, especially on 6/2D roads.

Research gap is that the observed road section is a primary arterial road, class I, with six divided lanes, mixed land use, and no special lanes for public transportation/buses, there is no accident data. Thus, the objective of this research is to determine the safety star rating value for 6/2D roads and the relationship between star rating values and risk factor scores for accident types on 6/2D roads. The hypothesis of this study is that there is a negative correlation between star rating scale scores and accident type; the higher the star rating scale score, the safer it is with respect to traffic accidents.

II. METHOD

The observation location is on Perintis Kemerdekaan street KM 12, Tamalanrea, Makassar, South Sulawesi Province. The research location is divided into 10 segments with a length of 100 m for each segment. Segment division at the research site can be seen on Figure 1.

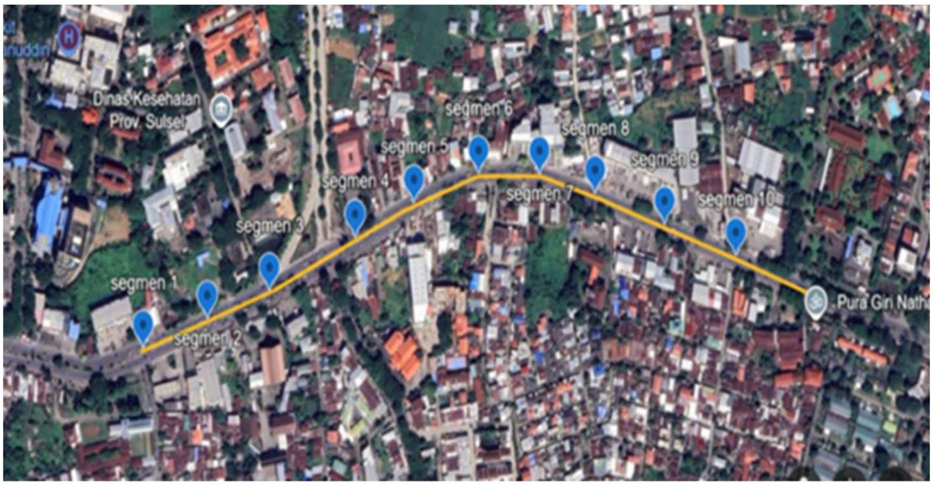

Figure 1. Segment Division

Primary data collection includes recording the availability of facilities and conditions of operational speed, speed limit differentiation, speed limits, road type, speed management engineering, lane width, number of lanes, horizontal curves, median type, curve quality, road pavement condition, gradient, road roughness, visibility, street lighting, delineation, frontage road, distance to objects on the right side of the road, textured center line markings, type of objects on the right side of the road, type of objects on the left side of the road, distance to objects on the left side of the road, width of the paved shoulder on the left side of the road, land use on the right side of the road, textured edge line markings, land use on the left side of the road, pedestrian crossing facilities, area type, availability of pedestrian lanes or sidewalks on the right and left sides of the road, availability of School Safe Zones, intersection quality, intersection type, intersection channelization, number of vehicle volume on minor intersection arms, and property access points. Supporting data includes location maps, road class, road function, and average daily traffic (ADT).

This research uses several tools to facilitate data collection in the field. The tools used in this research include stationery, measuring tape, speed gun, traffic counters, and a camera. Technical assessment refers to the following components: road pavement structure, structure of complementary buildings and road connections, road geometrics, utilization of road sections, traffic management and engineering, and road equipment. The Star Rating Score (SRS) is calculated from a combination of these attributes and accident risk factors; the higher the risk score, the lower the star rating. Technical results are then converted into star categories: 5 stars = safest and 1 star = highest risk. A road is declared fit for service if it meets the required administrative and technical criteria with the minimum required category. For existing non-toll roads in operation, the minimum fitness threshold is 1 star. For new non-toll roads, the minimum is 3 stars, and for toll roads the minimum is 4 stars.

The Star Rating Score assessment was conducted by first dividing the study road into several segments based on the survey area. The attributes collected from each road segment during the field survey were then entered into the Technical Inspection Form Star Rating spreadsheet using Microsoft Excel. The recorded road attributes were subsequently classified into the main assessment components, including speed, road body attributes, road edge attributes, vulnerable road user facilities, intersections, and surrounding land use. For each attribute, the corresponding code and description were selected according to the observed field conditions. Finally, the Star Rating Score for each road segment was calculated based on the cumulative risk score associated with different accident types, providing an overall evaluation of the road's safety performance. Research framework can be seen on Figure 2.

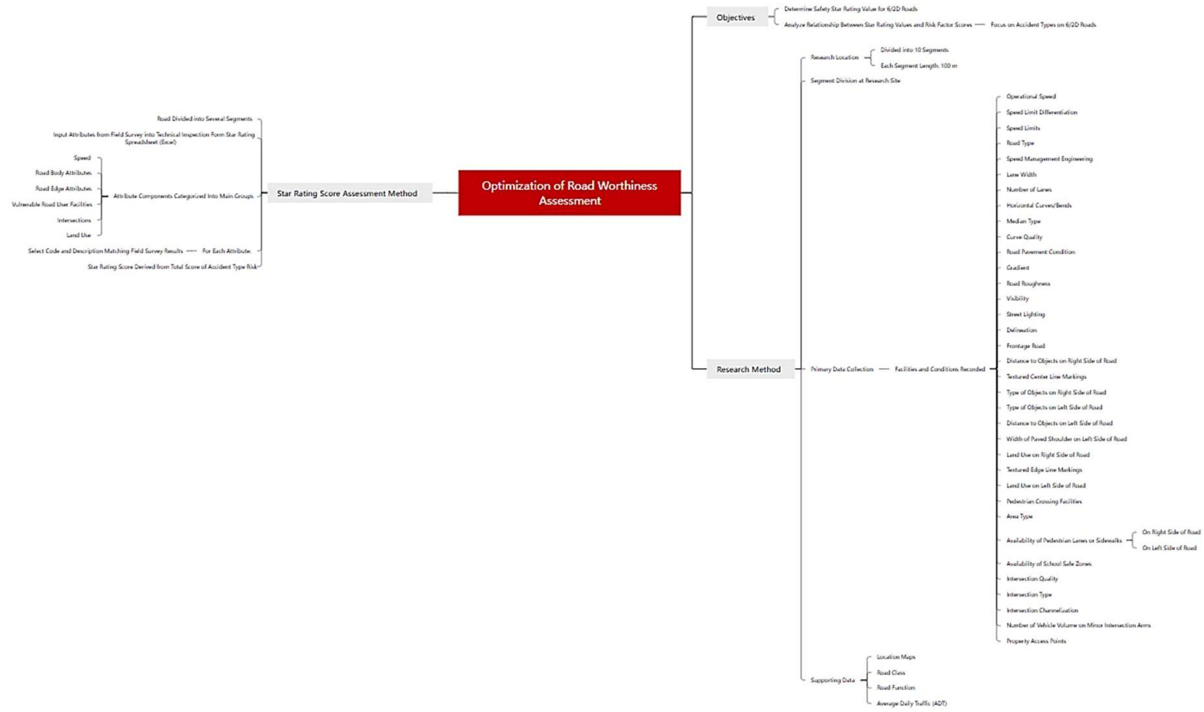

Figure 2. Research Framework

III. Results and Discussion

A. Star Scale Score per Segment on Attributes

This case study conducted a 1,000-meter survey of Perintis Kemerdekaan street KM 12, a national road connecting provinces and central business district. Lane widths of less than 3.25 meters accounted for 50% of all observed segments, with lane widths equal to or exceeding 3.25 meters. Proportion of segments based on lane width can be seen on Figure 3.

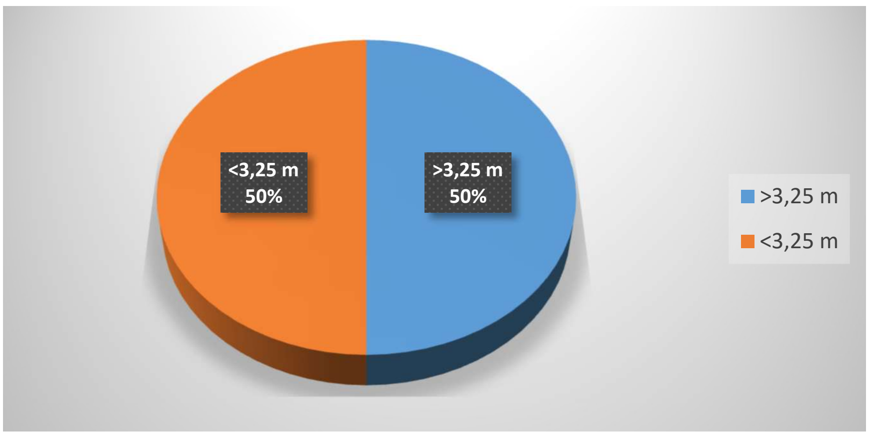

Figure 3. Proportion of Segments Based on Line Width

Table 1. Paired Sample T-test

		Statistic	df	p
>3.25 m	< 3.25 m	0.372	2.00	0.745

Table 1 presents the paired t-test statistical results between star rating scale values for lanes wider than 3.25 meters and those narrower than 3.25 meters. There is no significant difference in star rating scale values between road widths greater than 3.25 meters and less than 3.25 meters.

Table 2. Model Coefficients – Lane Width

Predictor	Estimate	SE	t	p
Run-off (driver side)	-85.3	7.84	10.87	< .001
Run-off (passenger side)	-40.3	2.52	15.97	< .001
Head-on (loss of control)	193.0	15.45	12.49	< .001
Property Access	745.1	152.31	4.89	0.005

The accident type most affected by lane width is run-off (driver side). There is a negative correlation between lane width and the risk of run-off accidents (driver side and passenger side). Meanwhile, there is a negative correlation between lane width and head-on (loss of control) and property access accidents. The accident types and their relationship to lane width as in Table 2.

Table 3. Model Coefficients – Pavement Condition

Predictor	Estimate	SE	t	p
Intercept	44.796	0.2638	169.8	< .001
Run-off (driver side)	0.969	0.0891	10.9	< .001
Run-off (passenger side)	-6.928	0.0287	241.7	< .001
Head-on (loss of control)	9.171	0.1755	52.2	< .001
Property Access	292.557	1.7307	169.0	< .001

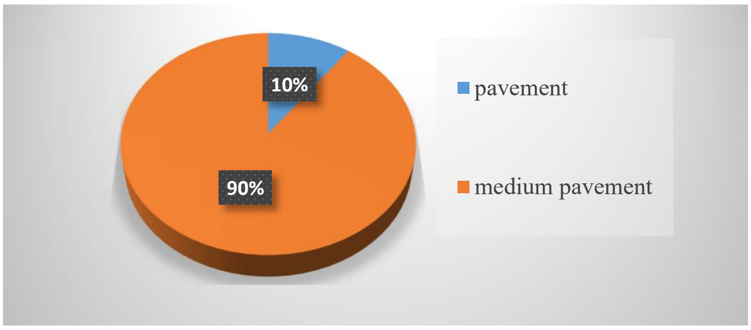

Figure 4. Proportion of Segments Based on Road Surface Roughness

The pavement type in all segments was flexible pavement (asphalt), with good road surface roughness, and only 10% had adequate surface roughness, while the remaining 90% had moderate surface roughness (some segments had cracks and segregation). Proportion of segments based on road surface roughness can be seen on Figure 4. Changes in pavement condition increase the risk of run-off (driver side) by 0.969, the risk of head-on (loss of control) by 9.171, and the risk of property access by 292.557, but decrease the risk factor for run-off (passenger side) by 6.928. Table 3 shows the relationship between accident type and pavement condition.

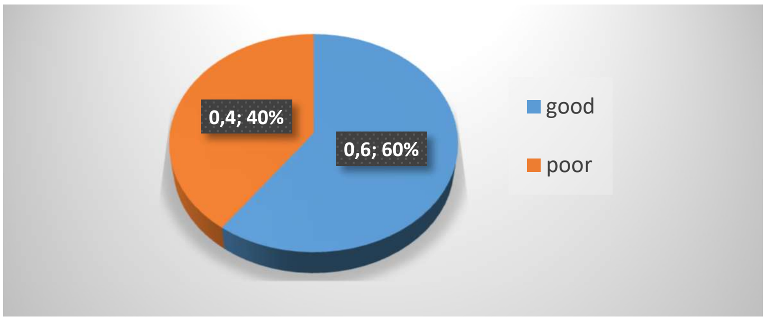

Figure 5. Proportion of Segments Based on Road Delineation

Table 4. Model Coefficients – Delineation

Predictor	Estimate	SE	t	p
Intercept	-57.2	6.727	-8.51	< .001
Run-off (driver side)	24.7	2.273	10.87	< .001
Run-off (passenger side)	23.3	0.731	31.91	< .001
Head-on (loss of control)	-66.1	4.476	-14.78	< .001
Property Access	373.1	44.134	8.45	< .001

Particularly at night, only 60% of segments had good delineation, while the remaining 40% had poor delineation. Previous research has shown that conditions of poor lighting and delineation, especially at night, can limit visibility, which can be dangerous for drivers [22]. Proportion of segments based on road delineation can be seen on Figure 5. The type of accidents most influenced by delineation and lighting conditions are property access, followed by run-off (driver side) and run-off (passenger side). The relationship between accident types and the completeness of delineation and lighting conditions is presented in Table 4.

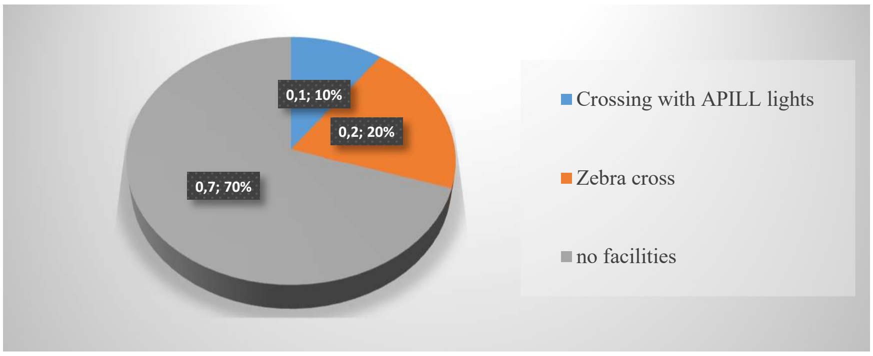

Figure 6. Proportion of Segments Based on Pedestrian Crossing Facilities

Seventy percent of segments lack pedestrian facilities, while only 30% of segments are equipped with pedestrian facilities, including pedestrian crossings (10%), and zebra crossings (20%). Proportion of segments based on pedestrian crossing facilities can be seen on Figure 6.

Table 5. Model Coefficients – Pedestrian Facility

Predictor	Estimate	SE	t	p
Intercept	-114.67	207.3	-0.553	0.0504
Run-off (driver side)	-24.05	70.1	-0.343	0.0745
Run-off (passenger side)	5.37	22.5	0.238	0.0821
Head-on (loss of control)	32.96	138.0	0.239	0.0821
Property Access	178.63	136.0	0.572	0.0500

Based on the p-value, only the property access variable has a significant effect on pedestrian facilities. The type of property access accident significantly affects the availability and condition of pedestrian facilities, while these facilities do not significantly affect other types of accidents. There is no pedestrian facilities can endanger themselves and vehicle drivers. [23]. The relationship between accident types and the completeness of pedestrian facility is presented in Table 5.

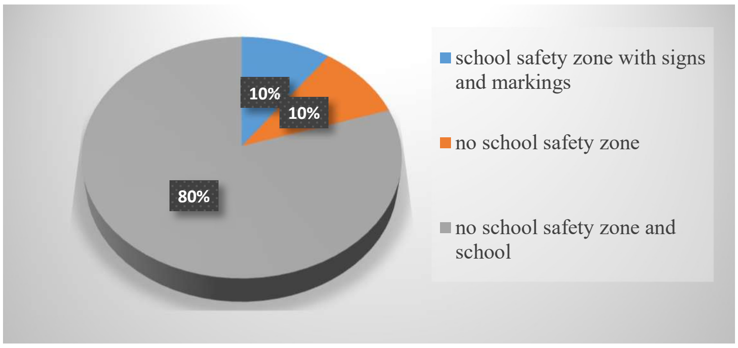

Figure 7. Proportion of Segments Based on School Safe Zones

Table 6. Proportion of Segments Based on School Safe Zones

Predictor	Estimate	SE	t	p
Intercept	-114.67	207.3	-0.553	0.0604
Run-off (driver side)	-24.05	70.1	-0.343	0.0745
Run-off (passenger side)	5.37	22.5	0.238	0.0821
Head-on (loss of control)	32.96	138.0	0.239	0.0821
Property Access	178.63	136.0	0.572	0.0500

There are two schools (20%) at the observation location, but only one school is equipped with School Safe Zone signs and markings. Proportion of segments based on School Safe Zones can be seen on Figure 7. The risk factor for property access accidents has increased due to changes in property access conditions. The type of property access accident significantly affects the availability and condition of school safe zones, while these facilities do not significantly affect other types of accidents. Model coefficients – school safe zone can be seen in Table 6.

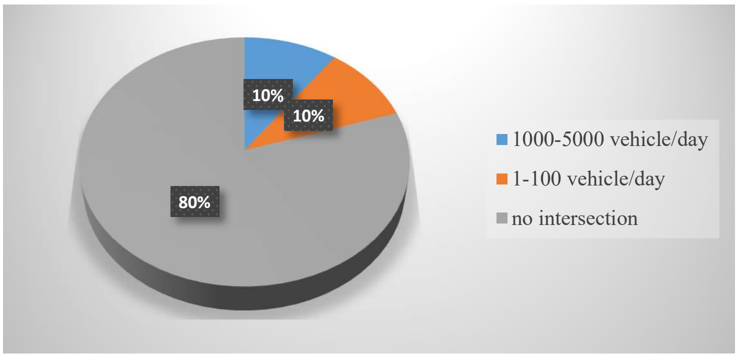

Figure 8. Segments Proportion on the Daily Traffic Volume of the Intersection Minor Arm

Table 7. Model Coefficients – Traffic Volume in Minor Arm

Predictor	Estimate	SE	t	p
Intercept	2.52	284.5	0.008	0.096
Run-off (driver side)	-45.17	96.1	-0.456	0.065
Run-off (passenger side)	-27.70	30.9	-0.895	0.004
Head-on (loss of control)	109.29	189.3	0.577	0.050
Property Access	23.21	186.7	0.012	0.009

Eighty percent of the observation segments do not have intersections. The remaining 20% have intersections, with one intersection having a daily traffic volume of 1-100 vehicles, and the other segment having a daily traffic volume of 1,000-5,000 vehicles on the minor arm. Proportion of segments based on the daily traffic volume of the minor arm of the intersection can be seen on Figure 8. The types of accidents most influenced by the number of vehicles on the minor arm of an intersection are head-on (loss of control) , run-off (passenger side), and property access. The relationship between accident type and traffic volume in minor arm intersections is presented in Table 7.

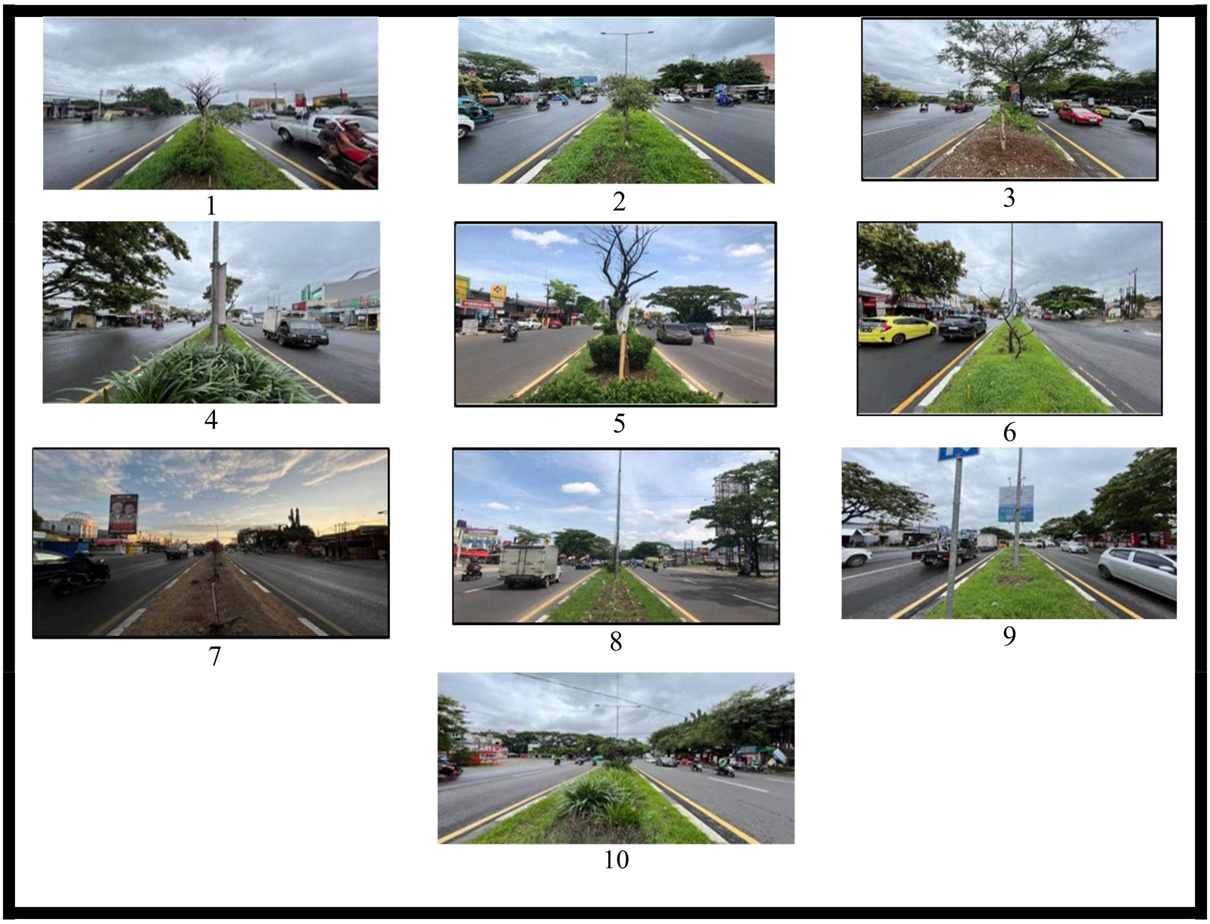

Figure 9. Road Conditions per Observation Segment

Table 8. Star Rating per Segment Based on Attribute

Attribute	Code	Segment									
A.2		1	2	3	4	5	6	7	8	9	10
Operational Speed	A.2.1	2	2	2	2	2	2	2	2	2	2
Speed Limit	A.2.2	2	2	2	2	2	2	2	2	2	2
Speed limit differentiation	A.2.3	1	1	1	1	1	1	1	1	1	1
Speed Control Engineering	A.2.4	1	1	1	1	1	1	1	1	1	1
A.3											
Road type	A.3.1	2	2	2	2	2	2	2	2	2	2
Line number	A.3.2	2	2	2	2	2	2	2	2	2	2
Line width	A.3.3	1	1	1	1	1	2	2	2	2	2
Horizontal curve	A.3.4	1	1	1	1	1	1	1	1	1	1
Intersection quality	A.3.5	3	3	3	3	3	3	3	3	3	3
Median type	A.3.6	6	6	6	6	6	6	6	6	6	6
Road surface roughness	A.3.7	2	1	2	2	2	2	2	2	2	2
Pavement road condition	A.3.8	2	1	2	2	2	2	2	2	2	2
Road gradient	A.3.9	1	1	1	1	1	1	1	1	1	1

Sight distance	A.3.10	1	1	1	1	1	1	1	1	1	1
Delineation	A.3.11	1	1	2	2	2	2	1	1	1	1
Lightning	A.3.12	1	1	2	2	2	2	1	1	1	1
Slow lane	A.3.13	2	2	2	2	2	2	2	2	2	2
textured center markings	A.3.14	1	1	1	1	1	1	1	1	1	1
A.4											
Distance of objects on the side of the road (right side)	A.4.1	2	2	2	2	2	2	2	2	2	2
Type of roadside object (right side)	A.4.2	12	12	12	12	12	12	12	12	12	12
Shoulder width strengthened (right side)	A.4.3	3	3	3	3	3	3	3	3	3	3
Distance of objects on the side of the road (left side)	A.4.4	2	2	2	2	2	2	2	2	2	2
Type of roadside object (left side)	A.4.5	12	12	12	12	12	12	12	12	12	12
Shoulder width strengthened (left side)	A.4.6	3	3	3	3	3	3	3	3	3	3
Textured edge markings	A.4.7	1	1	1	1	1	1	1	1	1	1
A.5											
Land use type (right side)	A.5.1	4	4	4	4	4	4	4	4	4	4
Land use type (left side)	A.5.2	4	4	4	4	4	4	4	4	4	4
Area type	A.5.3	1	1	1	1	1	1	1	1	1	1
pedestrian crossing facilities	A.5.4	7	7	3	7	7	7	7	7	5	5
right sidewalk	A.5.5	5	5	5	5	5	5	5	5	5	5
left sidewalk	A.5.6	5	5	5	5	5	5	5	5	5	5
school safe zone	A.5.7	4	4	4	4	3	4	4	4	2	4
A.6											
Type of intersection	A.6.1	11	11	10	11	11	11	11	11	11	11
Intersection quality	A.6.2	3	3	2	3	3	3	3	3	3	3
intersection canalization	A.6.3	1	1	2	1	1	1	1	1	1	1
property access	A.6.4	1	1	1	1	1	1	1	1	1	1
vehicle volume at minor intersection arms	A.6.5	7	6	4	7	7	7	7	7	7	7
Star Rating Score		**2,71**	**1,67**	**7,31**	**3,22**	**3,22**	**3,37**	**2,84**	**2,84**	**2,84**	**2,84**
Star		**4**	**5**	**3**	**4**	**4**	**4**	**4**	**4**	**4**	**4**

The star scale score assessment is based on 6 main attributes divided into 37 attributes. The main attributes are traffic flow (A.1.1), speed, roadside attributes, road attributes, vulnerable road user facilities, land use, and intersections. The speed attribute consists of operational speed (A.2.1.), speed limit (A.2.2), speed limit differentiation (A.2.3), speed regulation engineering (A.2.4). Road body attributes consist of road type (A.3.1), number of lanes (A.3.2), lane width (A.3.3), horizontal curve/intersection (A.3.4), intersection quality (A.3.5), median type (A.3.6), road roughness (A.3.7), road pavement condition (A.3.8), gradient (A.3.9), visibility (A.3.10), delineation (A.3.11), street lighting (A.3.12), frontage road (A.3.13), textured center markings (A.3.14). Road edge attributes consist of right-hand side object distance (A.4.1), right side object type (A.4.2), left side object distance (A.4.3), left side object type (A.4.4), hardened shoulder width on the left side of the road (A.4.5), textured edge markings (A.4.6). Road user facilities and land use consist of right side land use (A.5.1), left side land use (A.5.2), area type (A.5.3), pedestrian crossing facilities (A.5.4), availability of pedestrian paths or sidewalks on the right and left sides of the road (A.5.5 and A.5.6), availability of School Safe Zones (A.5.7). Intersection attributes consist of intersection type (A.6.1), intersection quality (A.6.2), intersection canalization (A.6.3), property entry and exit access (A.6.4), and vehicle volume at minor intersection arms (A.6.5). Road conditions per observation segment can be seen on Figure 9 and Star rating per segment based on attribute can be seen in Table 8.

In attribute A.2, the operational speed in all observation segments is approximately 40 km/h (code 2). There are speed limit signs for all segments at 40 km/h (code 2). There is no information on speed limit differentiation or speed control measures in any segment (code 1). Furthermore, in attribute A.3 for all observation segments, the road type is divided with a raised median (code 2) with three lanes per lane. Lane widths range from less than 3.25 m (code 2) to more than 3.25 m (code 1). Horizontal curves tend to be straight in all observation segments. Road surface roughness and pavement are in good and adequate condition (code 1) in segment 2, while the other segments have moderate surface roughness (code 2). Road gradients range from 0 to 7.5% (code 1) in all segments. Visibility is good in all segments (code 1). Road delineation and lighting conditions in segments 1, 2, 7, 8, 9, and 10 were adequate, while the other segments were in poor condition. All observed segments do not facilitate with slow lane facilities (code 2) and textured center markings (code 1).

In attribute A.4, there were objects on the right and left sides of the road more than 10 meters from the edge of the road (code 4). The types of objects on the right and left sides of the road were poles, signs, and trees (code 12). The left and right shoulders were 0 to less than 1-meter-wide in all segments (code 3). There were no textured edge markings in any observed segment (code 1). In attribute A.5, vulnerable road user facilities and land use, many commercial activities, offices, restaurants, and schools were located on the left and right sides of the road (code 4) in all segments. The area type for the observed location was an urban road (code 1). Segments 3, 11, and 12 had pedestrian crossing facilities, while the other segments lacked them. There are no sidewalks for pedestrians on either the left or right side of the road (code 5). A school safety zone is only available in one segment, while no information is available on other segments (code 4).

In attribute A.6, almost all observation segments lack intersections, with only one observation segment having an intersection. The quality of intersections in segment 3 is poor (code 2), due to frequent long queues and traffic conflicts. At intersections in segment 3, a canal separates left-turning vehicles from straight-through and right-turning vehicles (code 2). The traffic volume at minor intersections ranges from 1,000 to 5,000 vehicles per day. Indeed, segments 1, 4, and 10 have a 4-star rating, indicating a safer road. Segment 3 received a 3-star rating, indicating a safer road. Segment 2 received a 5-star rating, indicating a safer road.

B. The Relationship Between Star Rating Scale and Risk Factor Scores for Road Accident Type

Accident risk factors based on star rating scores are 5 types of accidents, namely accidents due to leaving the road (run-off), head-on collisions due to overtaking (head-on overtaking), head-on collisions due to loss of control (head-on loss control), accidents due to intersections (intersection), and accidents on property access (property access).

Table 9. Star Rating Based on Accident Risk Factors

Segment	Score						
	***Run-off* (driver side)**	***Run-off* (passenger side)**	***Head-on* (*loss of control*)**	***Head-on* (*over taking*)**	**Intersection**	**Property Access**	**Score**
1	0,96	1,35	0,75	0	0	0,141	3,2
2	0.57	0,57	0,38	0	0	0,15	1,67
3	1,15	1,15	0,77	0	4,1	0,147	7,31
4	1,153	1,15	0,77	0	0	0,147	3,22
5	1,153	1,15	0,77	0	0	0,147	3,22
6	1,203	1,21	0,81	0	0	0,147	3,37
7	1,003	1,01	0,68	0	0	0,147	2,84
8	1,003	1,01	0,68	0	0	0,147	2,84
9	1,003	1,01	0,68	0	0	0,147	2,84
10	1,003	1,01	0,68	0	0	0,147	2,84

The total of each accident value will determine the star rating score in each segment. The star scale assessment for the driver and passenger side of the run-off road type consists of the availability of speed limit differentiation facilities, speed control engineering, curve quality, median, visibility, street lighting, delineation, slow lane, road pavement condition, slope, textured center markings, road roughness, distance of objects on the right roadside, type of objects on the right roadside, width of the hardened shoulder on the right roadside. The star scale assessment for the head-on accident type (overtaking) consists of slope, road roughness, speed limit differentiation, number of lanes, and type of median. The following table summarizes the accident risk factor values. The star scale assessment for the head-on (loss of control) accident type consists of lane width, horizontal curvature, curve quality, delineation, road pavement condition, textured center markings, road roughness, median type, and slope. The assessment of accidents at intersections consists of intersection type, intersection quality, slope, street lighting, visibility, road roughness, speed control engineering, intersection canalization, and intersection type. Accident factors at property access consist of median type, property entrance access, property entrance access and frontage road. Star rating based on accident risk factors can be seen in Table 9.

Table 10. Scale Reliability (1), Model Fit Measures (2), T-test (3)

1	**Scale**	**Cronbach's α**		
		0.657		
2	**Model**	**R**	**R^2**	
		0.592	0.350	
3		**Statistic**	**df**	**p**
	Star Rating Score	7.15	9.00	< .001

Linear regression with an R^2 value of 0.350 means that 35% of the variation in the dependent variable can be explained by the independent variable in the regression model. This value falls within the moderate range; the model is reasonably useful for basic predictions, but additional variables are needed to improve accuracy. The model fit results can be seen in Table 10 (2). The t-test produced a p-value less than 0.001 and a t statistic of 7.15 (greater than the critical value for df = 9, which is ±2.26), indicating a highly statistically significant effect. The t-test result can be seen in Table 10 (3).

Table 11. Model Coefficients – Run Off (Driver Side)

Predictor	Estimate	SE	t	p
Intercept	-0.09792	0.06661	-1.470	0.238
Lane width	0.04639	0.00202	22.968	< .001
Road slippage	0.38774	0.00297	130.426	< .001
Road pavement condition	NaN	NaN	NaN	NaN
Delineation	0.19661	0.00202	97.349	< .001
Pedestrian crossing facilities	3.39e-4	0.00134	0.252	0.817
School safe zone	4.52e-4	0.00143	0.316	0.773
Intersection type	0.00300	0.00649	0.462	0.675
Intersection quality	NaN	NaN	NaN	NaN
Intersection canalization	NaN	NaN	NaN	NaN

Based on p-value, there are three attributes with values less than .001 in the model results of attribute coefficients against the run-off risk factor (driver side). The three attributes are lane width, road slippage, and delineation condition. Road pavement condition in the field is good, with no severe damage. The quality of intersections in all segments is good, and there is no channelization at the intersections. The limited variation in this attribute's data produced NaN results in the statistical test.The model fit measures for run-off (driver side) can be seen in Table 11.

Table 12. Model Coefficients – Run Off (Passenger Side)

Predictor	Estimate	SE	t	p
Intercept	-0.17968	3.8063	-0.0472	0.965
Lane width	-0.14645	0.1154	-1.2690	0.294
Road slippage	0.65097	0.1699	3.8320	0.031
Road pavement condition	NaN	NaN	NaN	NaN
Delineation	0.00645	0.1154	0.0559	0.959
Pedestrian crossing facilities	0.01935	0.0768	0.2521	0.817

Predictor	Estimate	SE	t	p
School safe zone	0.02581	0.0816	0.3162	0.773
Intersection type	1.10e-15	0.3710	2.96e-15	1.000
Intersection quality	NaN	NaN	NaN	NaN
Intersection canalization	NaN	NaN	NaN	NaN

There is only road slippage attribute, with a p-value less than 0.05. Therefore, this attribute has a significant effect on the risk factor for run-off accidents (passenger side). The model coefficients for run-off (passenger side) can be seen in Table 12.

Table 13. Model Coefficients – Head-on (Loss of Control)

Predictor	Estimate	SE	t	p
Intercept	-0.08016	1.0467	-0.0766	0.944
Lane width	-0.01677	0.0317	-0.5285	0.634
Road slippage	0.33452	0.0467	7.1605	0.006
Road pavement condition	NaN	NaN	NaN	NaN
Delineation	0.07677	0.0317	2.4190	0.094
Pedestrian crossing facilities	0.00532	0.0211	0.2521	0.817
School safe zone	0.00710	0.0224	0.3162	0.773
Intersection type	2.36e-16	0.1020	2.31e-15	1.000
Intersection quality	NaN	NaN	NaN	NaN
Intersection canalization	NaN	NaN	NaN	NaN

The road slippage attribute in the model coefficients for the head-on (loss of control) risk factor has a p-value less than 0.05, indicating a significant effect of this variable on the dependent variable. This is supported by research results which also add that head-on accidents (loss of control) increase as vehicle speed increases and the influencing factors are road geometry and road curvature [24]. Model coefficients head-on (loss of control) can be seen in Table 13.

Table 14. Model Coefficients – Property Access

Predictor	Estimate	SE	t	p
Intercept	0.15465	0.05709	2.709	0.073
Lane width	0.00310	0.00173	1.789	0.172
Road slippage	-0.00706	0.00255	-2.772	0.069
Road pavement condition	NaN	NaN	NaN	NaN
Delineation	0.00290	0.00173	1.677	0.192
Pedestrian crossing facilities	-2.90e-4	0.00115	-0.252	0.817
School safe zone	-3.87e-4	0.00122	-0.316	0.773
Intersection type	-2.02e-17	0.00556	-3.64e-15	1.000
Intersection quality	NaN	NaN	NaN	NaN
Intersection canalization	NaN	NaN	NaN	NaN

Model coefficient results for the risk factor property access show no attribute with a p-value less than 0.05. This result differs from research which revealed that environmental factors, mixed land use and the presence of schools, have a high probability of accidents occurring [25]. Model coefficients property access can be seen in Table 14.

C. Discussion

Changes in road slippage increases the risk factor by 0.65097. The road slippage attribute is a factor that greatly influences the type of accidents. This is caused by reduced tire grip and road surface traction, making vehicles difficult to control, especially when turning or braking. These results also reinforce previous research findings that decreased anti-slip surface performance causes vehicles to deviate from their lanes and result in collisions with other vehicles or stationary objects [26], especially during moments when the driver experiences loss of vehicle control [27]. Lack of delineation is the second most influential factor contributing to road accidents. Poor road delineation causes accidents because drivers have difficulty judging curves, lane boundaries, or hazards ahead, especially at night or in bad weather. Other research related to delineation and road safety shows that good delineation, particularly on curves, provides effective information for drivers. [28]. The level of visibility of delineation in the form of markings and signs increases driving speed by 2%. [29]. Delineation also helps drivers reduce speed on sharp and gentle turns. [30]. Each increase in lane width will raise the run-off risk factor (driver side) by 0.0463. Each change in road slippage and delineation will increase the respective accident risk factors by 0.38774 and 0.19661. Lane width is a factor in traffic accidents because it affects speed, driver maneuvers, and the risk of collision.

Changes in lane width have a negative impact on run-off risk factors. Reduced lane width increases the risk of run-off type accidents. Conversely, increased lane width increases the risk of head-on and property access type accidents. Road pavement conditions have a positive impact on the risk of property access, head-on, and run-off (driver side) accidents, while the opposite is run-off (passenger side) accidents. The condition and availability of delineation have a positive impact on run-off (driver side and passenger side) and property access risk factors, while having a negative impact on head-on risk factors.

The availability of pedestrian facilities has a positive impact on property access, head-on (loss of control), and run-off (passenger side) risk factors, while the opposite for run-off (driver side) risk factors. The addition of pedestrian facilities reduces the run-off risk factor (driver side) by 24.05. The availability of school safe zones has a positive impact on property access risk factors, while having a negative impact on run-off (driver side) risk factors. The existence of a school safe zone reduces the risk factor of run-off (driver side) by 24.05.

The amount of traffic volume in minor arm intersections has a positive impact on head-on and property access risk factors, while the opposite is true for run-off risk factors. At intersections, there is a change in the interaction between traffic flows in different directions and destinations. Poorly designed intersections can increase the risk of accidents, congestion, and disrupt traffic flow, thus reducing the safety, smoothness, and comfort of road users. Property access creates side obstacles that disrupt smooth traffic flow. At intersections, the potential for head-on loss control accidents increases if the median separating the lanes is ineffective or crossable, visibility is limited, and road conditions are poor, allowing vehicles to cross into the opposing lane and cause a frontal collision. A head-on overtaking accident is a head-on collision that occurs when a vehicle is overtaking against the flow of traffic, with a high risk of colliding with a vehicle coming from the opposite direction. A road that is safer will meet technical requirements such as sufficient lane width and adequate medians or road dividers to reduce the risk of head-on collisions resulting from dangerous overtaking maneuvers.

IV. CONCLUSION

Safer road categories are found in segments 1, 4, and 10 (SRS rating 4), and segment 2 (SRS rating 5), while segment 3 is included in the safe road category. Attributes that have a positive correlation with run-off risk factors (driver side) are pavement condition and delineation. Meanwhile, lane width, school safe zone, pedestrian facility, and traffic volume in minor arm intersection have a negative correlation. Attributes that have a positive correlation with run-off risk factors (passenger side) are pedestrian facility, school safe zone, and delineation. Traffic volume in minor arm intersection and lane width have a negative correlation with run-off (passenger side). Head on (loss of control) has a positive correlation with lane width and delineation, while it has a negative correlation with school safe zone, traffic volume in minor arm intersection, and pedestrian facility. Property access has a positive correlation with traffic volume in minor arm intersection, pedestrian facility, school safe zone, delineation, pavement condition, and lane width. Indeed, the research gap in this study is that the survey was conducted in clear weather conditions, thus not accounting for rainy weather, and not considering integrating social aspects. For future research, integrating social aspects such as accessibility and economic aspects such as maintenance costs and local economic benefits in assessing the functional worthiness of roads.

REFERENCES

[1] K. F. Tawalujan, T. K. Sendow, and M. R. E. Manoppo, "Uji laik fungsi jalan secara teknis pada ruas jalan Airmadidi–Kairagi," Jurnal Sipil Statik, vol. 8, no. 4, pp. 607–620, Jul. 2020, https://ejournal.unsrat.ac.id/v2/index.php/jss/article/view/29990.

[2] L. Mooren and R. Shuey, "Systems thinking in road safety management", *JRS*, vol. 35, no. 2, May 2024, https://doi.org/10.33492/JRS-D-24-2-2109985.

[3] W. Du, A. Dash, J. Li, H. Wei, and G. Wang, "Safety in traffic management systems: a comprehensive survey", *Designs*, vol. 7, no. 4, p. 100, Aug. 2023, https://doi.org/10.3390/designs7040100.

[4] L. Sejdiu, T. Tollazzi, F. Shala, and H. Demolli, "Analysis of traffic safety factors and their impact using machine learning algorithms", *Civ Eng J*, vol. 10, no. 9, pp. 2859–2869, Sep. 2024, https://doi.org/10.28991/CEJ-2024-010-09-06.

[5] H. Godthelp and A. Ksentini, "Specific road safety issues in low- and middle income countries (LMICs): an overview and some illustrative examples", *TSR*, vol. 8, p. e000068, Nov. 2024, https://doi.org/10.55329/sdtu9515.

[6] S. V. Pandey, J. S. F. Sumarauw, and L. G. J. Lalamentik, "Functional feasibility analysis of Moat – Motongkad road in East Bolaang Mongondow Regency, North Sulawesi Province", *SSRG-IJCE*, vol. 8, no. 11, pp. 24–31, Nov. 2021, https://doi.org/10.14445/23488352/IJCE-V8I11P104.

[7] R. Goel *et al.*, "Effectiveness of road safety interventions: An evidence and gap map", *Campbell Systematic Reviews*, vol. 20, no. 1, p. e1367, Mar. 2024, https://doi.org/10.1002/cl2.1367.

[8] N. Usman, "Roadworthiness test for traffic safety", in *Atlantis Highlights in Engineering (AHE), volume 1*, 2018, pp. 387–391, https://doi.org/10.2991/icst-18.2018.81

[9] A. M. Fitra, "Analisis uji laik fungsi jalan aspek teknis pada ruas jalan nasional Tambu-Tompe provinsi Sulawesi Tengah", *JCEP*, vol. 1, no. 2, p. 130, Dec. 2020, https://doi.org/10.37253/jcep.v1i2.840.

[10] J. Adwang, "Analisa uji laik fungsi jalan pada ruas jalan nasional Tumora (Bts. Kab. Parimo)–Tambrana nomor ruas 31 Km. 157+800 s.d. Km. 168+000 Provinsi Sulawesi Tengah", *TEKNO*, vol. 17, no. 75, pp. 122–138, 2024, https://doi.org/10.35793/jts.v17i74.28339

[11] B. I. Sari, and D. Setiawan, "Analisis keselamatan lalu lintas jalan tol Ngawi-Kertosono studi kasus ruas Madiun-Caruban dan ruas Caruban-Wilangan", *rekayasasipil*, vol. 14, no. 1, pp. 1–9, Feb. 2020, https://doi.org/10.21776/ub.rekayasasipil.2020.014.01.1.

[12] A. Jameel and H. T. Evdorides, "Review of modifying the indicators of road safety system", *jeasd*, vol. 27, no. 2, pp. 149–170, Mar. 2023, https://doi.org/10.31272/jeasd.27.2.1.

[13] Kementerian Pekerjaan Umum dan Perumahan Rakyat, "Pedoman Petunjuk Teknis Uji Laik Fungsi Jalan Pemeringkatan Skala Bintang". Kementerian Pekerjaan Umum dan Perumahan Rakyat, 2023. https://binamarga.pu.go.id/uploads/files/1957/preview_1957-1-5.pdf?

[14] R. A. Mehraban, L. Tsantilis, P. P. Riviera, and E. Santagata, "Comprehensive analysis of sustainability rating systems for road infrastructure", *Infrastructures*, vol. 10, no. 1, p. 17, Jan. 2025, https://doi.org/10.3390/infrastructures10010017.

[15] G. C. Yudhana, N. Hartatik, and Y. D. Prasetyo, "Karakteristik ruas jalan nasional Suramadu Kabupaten Bangkalan STA 7+400 s.d STA 11+400", *JUTIN*, vol. 7, no. 4, pp. 2518–2530, Oct. 2024, https://doi.org/10.31004/jutin.v7i4.37460.

[16] U. H. Mubin, A. Gaus, A. A. Pasri, and Y. Damayanti, "Uji laik fungsi jalan dalam mewujudkan jalan yang berkeselamatan studi kasus jalan utama kota Weda", *Journal of Science and Engineering*, vol. 3, no. 1, Aug. 2020, https://doi.org/10.33387/josae.v3i1.2206.

[17] M. R. F. Amrozi and Raihan Pasha Isheka, "Optimizing the functional performance of road network using vulnerability assessment to cope with unforeseen road incidents", *jcef*, pp. 67–80, Dec. 2021, https://doi.org/10.22146/jcef.3598.

[18] A. Tajudin, N. L. Setyarini, and D. Darmawati, "The influence of CBR value and overloading on flexible pavement mechanistic response", *Proceedings of the 11th Asia Pacific Transportation and the Environment Conference (APTE 2018)*. Atlantis Press, 2019. https://doi.org/10.2991/apte-18.2019.13.

[19] M. Mundung, "Analisis uji laik fungsi jalan pada ruas jalan nasional dengan fungsi arteri primer studi kasus ruas jalan Kawangkoan – Batas Minahasa/Minahasa Selatan", *TEKNO*, vol. 21, no. 85, 2023. https://doi.org/10.35793/jts.v21i85.51055

[20] M. Idris, W. Santosa, and A. Caroline, "Developing road protector score attribute's for Indonesia's national roads from the perspective of four or more wheel motorized vehicle drivers", *Jurnal Jalan Jembatan*, vol. 38, no. 2, pp. 97–109, 2021. https://binamarga.pu.go.id/jurnal/index.php/jurnaljalanjembatan/issue/view/jurnal/index.php/jurnaljalanjembatan/article/view/1023/672

[21] A. Dwiyantara, A. Budiharjo, and D. Suradji, "Sistem informasi penilaian keselamatan jalan tol dengan menggunakan star rating berbasis Webgis (studi kasus : Jalan Tol Cikopo-Palimanan)", *j.keselam.transportasijalan*, vol. 6, no. 1, pp. 37–49, Jun. 2019, https://doi.org/10.46447/ktj.v6i1.40.

[22] P. Kępa, "The issu of road visibility and road traffic safety", *HSS*, 2020, https://doi.org/10.7862/rz.2020.hss.41.

[23] H. Muslim and J. Antona-Makoshi, "A review of vehicle-to-vulnerable road user collisions on limited-access highways to support the development of automated vehicle safety assessments", *Safety*, vol. 8, no. 2, p. 26, Apr. 2022, https://doi.org/10.3390/safety8020026.

[24] M. E. Darkhaneh, M. Effati, and M. Arabani, "Factors affecting the injury severity of head-on crashes on undivided rural roads under different weather conditions", *International Journal of Transportation Science and Technology*, vol. 21, p. 384-398, March. 2026, https://doi.org/10.1016/j.ijtst.2025.02.007

[25] L. Skaug, M. Nojoumian, N. Dang, and A. Yap, "Road crash analysis and modeling: A systematic review of methods, data, and emerging technologies", *Applied Sciences*, vol. 15, no. 13, p. 7115, Jun. 2025, https://doi.org/10.3390/app15137115.

[26] Y. Gao, C. Zhang, M. Ye, and B. Wang, "Identification method of highway accident prone sections under adverse meteorological conditions based on meteorological responsivenes", *Applied Sciences*, vol. 15, no. 2, p. 521, Jan. 2025, https://doi.org/10.3390/app15020521.

[27] E. Kuşkapan, M. Y. Çodur, and M. A. Sahraei, "Investigation of the effect of slope and road surface conditions on traffic accidents occurring in winter months: spatial and machine learning approaches", *Applied Sciences*, vol. 14, no. 24, p. 11629, Dec. 2024, https://doi.org/10.3390/app142411629.

[28] T. J. Triggs, W. G. Harris, and B. N. Fildes, "Delineation as road signing: a study of visual cues on rural roads at night", *Proceedings of the Human Factors Society Annual Meeting*, vol. 23, no. 1, pp. 449–451, Oct. 1979, https://doi.org/10.1177/107118137902300113.

[29] M. Fiolić, D. Babić, D. Babić, and S. Tomasović, "Effect of road markings and road signs quality on driving behaviour, driver's gaze patterns and driver's cognitive load at night-time", *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 99, pp. 306–318, Nov. 2023, https://doi.org/10.1016/j.trf.2023.10.025.

[30] J. Mei, Z. Du, and P. Wu, "Effects of delineation signs on driving behavior in expressway tunnel curves", *Traffic Injury Prevention*, vol. 26, no. 8, pp. 906–914, Nov. 2025, https://doi.org/10.1080/15389588.2025.2470977.