# ANALYSIS OF VEHICLE ACCIDENT POTENTIAL AND SAFETY ROAD PLANNING IN MADIUN CITY

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ABSTRACT

Based on the traffic accident data from the Madiun City Police for the years 2018, 2019, and 2020 on 13 (thirteen) national roads in Madiun City, traffic accidents are classified into the categories of Minor Injuries, Serious Injuries, and Fatalities. The largest total weight of accident victims are 59, which occurred on the national road section of D.I. Panjaitan road, while the second-largest is 50, which occurred on the national road section of Yos Sudarso road. The national road section to be tested for road functionality is D.I. Panjaitan Road and Yos Sudarso Road. The Average Daily Traffic Volume (ADTV) survey conducted on the national road section of D.I. Panjaitan Road in 2021 showed an ADTV of 12,221 pcu/day. The ADTV survey on the national road section of Yos Sudarso Road showed an ADTV of 9,892 pcu/day. The condition of road flatness is assessed based on the International Roughness Index (IRI). The IRI survey results for D.I. Panjaitan Road showed an IRI of 1.88, which meets the flatness requirement of IRI ≤ 4. Meanwhile, the IRI survey results for Yos Sudarso Road showed an IRI of 1.56. The road functionality test on D.I. Panjaitan Road found that some road elements meet technical road requirements but still pose safety problems, such as narrow road shoulders (20-50 cm), trees on the road shoulders, and open roadside ditches that need to be covered. On the other hand, some road elements do not meet technical requirements but do not pose safety problems, such as the width/dimensions of the side drains, the width of the Roadway Ownership Space and Roadway Surveillance Space, zebra cross markings, and completeness of hectometer poles. The road functionality test on Yos Sudarso road found that some road elements meet technical road requirements but still pose safety problems, such as narrow road shoulders (20-40 cm), especially along the 550-meter section parallel to the Pertamina tank train rails, and damaged covered roadside ditches that need to be repaired. On the other hand, some road elements do not meet technical requirements but do not pose safety problems, such as the width/dimensions of the side drains, the width of the Roadway Ownership Space and Roadway Surveillance Space, zebra cross markings, and completeness of hectometer poles.

## INTRODUCTION

Traffic accidents are one of the biggest causes of death in Indonesia. The high number of victims significantly impacts the economy and society. Annual accident data from Jasa Marga showed that the biggest cause of accidents is human factors (drivers), followed by vehicle factors and lastly road geometry factors. The factors causing traffic accidents involve human factors, vehicle factors, road factors, and the environment. These factors are interconnected.

Data from Traffic Accidents in the Madiun City Police Station from 2018 to 2020 showed that there were 385 cases of traffic accidents in 2018, 402 cases in 2019, and 297 cases in 2020 (a drastic decrease due to COVID-19 PSBB/PPKM). The material losses were IDR 185.650.000 in 2018, IDR 211.700.000 in 2019, and IDR 168.300.000 in 2020.

The number of traffic accident victims in Madiun City in 2018 was 480 people with minor injuries, 0 with severe injuries, and 36 deaths. In 2019, there were 522 victims with minor injuries, 0 with severe injuries, and 43 deaths. In 2020, there were 363 victims with minor injuries, 0 with severe injuries, and 21 deaths (source: Madiun City Police Station accident data).

The highest number of accident victims occurred in 2019 with 522 people with minor injuries, 0 with severe injuries, and 43 deaths. The highest number of deaths occurred in August 2019 with 7 people. Motorcycle accidents resulted in 5 deaths, and motorcycle-car accidents resulted in 2 deaths. Motorcycle accidents often result in fatalities, while road planners focus primarily on

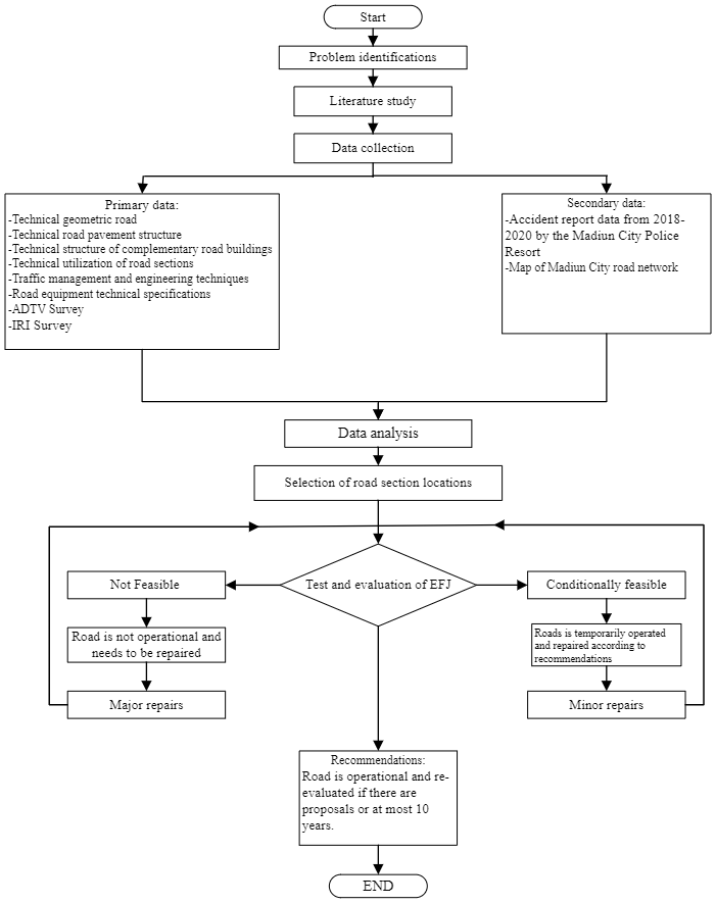


Figure 1 Research Flowchart Diagram

cars in road design.

## METHODOLOGY

### *A. Problem Identifications*

The realization of traffic safety begins with the interaction between humans, vehicles, and roads. Good road user competencies (humans), functional vehicles, and safe roads and environments can prevent various incidents of traffic errors and conflicts from ending up as accidents. This study identifies the problem of high accident rates and potential accidents caused by road function feasibility.

Based on the existing problem formulation, the objectives of this study are:

1. Identifying accident victims on national roads in Madiun City from 2018 to 2020.
2. Identifying road sections that are prone to accidents based on the weighting of traffic accident victims.
3. Conducting Road Function Feasibility Tests (RFFT) on two road sections that are prone to accidents based on the Minister of Public Works Regulation No. 11/PRT/M/2010 [1] and,
4. Recommending measures to minimize the number of traffic accidents.

To achieve the above objectives, a research flowchart is proposed in Figure 1.

### *B. Data Collection*

1). Secondary Data.

Secondary data is data obtained from external sources, not from surveys. The secondary data needed for this study is the report of road traffic accidents in Madiun City that occurred during the last 3 years (2018-2020), obtained from the Madiun City Police.

2). Primary Data.

The collection of primary data was carried out by conducting a Daily Traffic Volume Survey, International Roughness Index (IRI) Road Roughness Survey, and Road Component Testing in the field, with a focus on testing following the attachment form of the Minister of Public Works Regulation No. 11/PRT/M/2010 [1], which are as follows:

1. Technical geometric function test of the road. The road components tested, and the focus of the testing follows Form A.1.
2. Technical pavement structure function test of the road. The road components tested, and the focus of the testing follows Form A.2.
3. Technical function test of complementary road structure. The road components tested, and the focus of the testing follows Form A.3.
4. Technical function test of the use of road parts. The road components tested, and the focus of the testing follows Form A.4.
5. Technical function test of Traffic Management and Engineering Maintenance. The road components tested, and the focus of the testing follows Form A.5

Table 1 Weighting Total of Accidents on 13 National Roads in Madiun City using TRL and Bina Marga Weighting Methods.

| No | Road section National Year 2018-2020 | Accident Victim | | | TRL METHOD Total Weight of Accident Victims | Bina Marga Total Weight of Accident Victims |
|---|---|---|---|---|---|---|
| | | LR | LB | MD | | |
| **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** | **(7)** |
| 1 | Urip Sumoharjo | 41 | 0 | 2 | 47 | 61 |
| 2 | A. Yani | 21 | 0 | 1 | 24 | 31 |
| 3 | Pahlawan | 25 | 0 | 3 | 34 | 55 |
| 4 | Yos Sudarso | 47 | 0 | 1 | 50 | 57 |
| 5 | Majen Sungkono | 33 | 0 | 0 | 33 | 33 |
| 6 | Trunojoyo dan Agus Salim | 36 | 0 | 4 | 48 | 76 |
| 7 | Soekarno - Hatta (Jl.Ponorogo) | 24 | 0 | 1 | 27 | 34 |
| 8 | D.I. Panjaitan | 44 | 0 | 5 | 59 | 94 |
| 9 | Letjen Haryono | 34 | 0 | 1 | 37 | 44 |
| 10 | M. Thamrin | 40 | 0 | 1 | 43 | 50 |
| 11 | S. Parman | 28 | 0 | 0 | 28 | 28 |
| 12 | Basuki Rachmat | 25 | 0 | 2 | 31 | 45 |
| 13 | Raya Madiun - Ponorogo | 19 | 0 | 2 | 25 | 39 |

Table 2 The result of Traffic Survey on Jl Yos Sudarso Directions to Enter the City of Madiun at the Busiest/Crowded Hours

| **No** | **SURVEY TIME** | **VEHICLE TYPE** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| | **MORNING** | | | | | | | | |
| 1 | 06.00-06.15 | 65 | 9 | 1 | 4 | 0 | 2 | 0 | 5 |
| 2 | 06.15-06.30 | 117 | 14 | 0 | 1 | 0 | 8 | 0 | 2 |
| 3 | 06.30-06.45 | 142 | 26 | 0 | 1 | 0 | 1 | 0 | 7 |
| 4 | 06.45-07.00 | 272 | 20 | 0 | 1 | 0 | 4 | 0 | 5 |
| Number of (vehicle) | | 596 | 69 | 1 | 7 | 0 | 15 | 0 | 19 |
| EMP Index | | 0,3 | 1 | 1 | 1 | 2,5 | 2,5 | 3 | 7 |
| **Total Number = 396,5 (pcu/hour)** | | **149** | **69** | **1** | **7** | **0** | **38** | **0** | **133** |
| 5 | 07.00-07.15 | 251 | 30 | 1 | 3 | 0 | 7 | 0 | 3 |
| 6 | 07.15-07.30 | 219 | 32 | 2 | 1 | 0 | 5 | 1 | 4 |
| 7 | 07.30-07.45 | 221 | 44 | 1 | 1 | 0 | 12 | 2 | 2 |
| 8 | 07.45-08.00 | 257 | 60 | 3 | 3 | 0 | 9 | 0 | 3 |
| Number of (vehicle) | | 948 | 166 | 7 | 8 | 0 | 33 | 3 | 12 |
| EMP Index | | 0,3 | 1 | 1 | 1 | 2,5 | 2,5 | 3 | 7 |
| **Total Number = 593,5 (pcu/hour)** | | **237** | **166** | **7** | **8** | **0** | **83** | **9** | **84** |

Table 3 The result of Traffic Survey on D. I. Panjaitan Road.

| **No** | **SURVEY TIME** | **VEHICLE TYPE** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| | **AFTERNOON** | | | | | | | | |
| 1 | 12.00-12.15 | 204 | 72 | 2 | 14 | 1 | 18 | 5 | 1 |
| 2 | 12.15-12.30 | 156 | 68 | 8 | 12 | 2 | 7 | 1 | 4 |
| 3 | 12.30-12.45 | 154 | 74 | 6 | 10 | 0 | 9 | 3 | 1 |
| 4 | 12.45-13.00 | 165 | 63 | 3 | 10 | 3 | 11 | 6 | 1 |
| Number of (vehicle) | | 679 | 277 | 19 | 46 | 6 | 45 | 15 | 7 |
| EMP Index | | 0,3 | 1 | 1 | 1 | 2,5 | 2,5 | 3 | 7 |
| **Total Number = 733,25 (pcu/day)** | | **170** | **277** | **19** | **46** | **15** | **113** | **45** | **49** |
| 5 | 13.00-13.15 | 165 | 48 | 4 | 11 | 1 | 7 | 3 | 0 |
| 6 | 13.15-13.30 | 158 | 60 | 3 | 12 | 2 | 7 | 7 | 2 |
| 7 | 13.30-13.45 | 166 | 56 | 2 | 8 | 0 | 12 | 3 | 2 |
| 8 | 13.45-14.00 | 178 | 50 | 6 | 13 | 0 | 13 | 2 | 0 |
| Number of (vehicle) | | 667 | 214 | 15 | 44 | 3 | 39 | 15 | 4 |
| EMP Index | | 0,3 | 1 | 1 | 1 | 2,5 | 2,5 | 3 | 7 |
| **Total Number = 617,75 (pcu/day)** | | **167** | **214** | **15** | **44** | **7,5** | **98** | **45** | **28** |

6. Technical function test of road equipment related directly to road users. The road components tested, and the focus of the testing follows Form A.6a.
7. Technical function test of road equipment not directly related to road users. The road components tested. and the focus of the testing follows Form A.6b.

*C. Road Section Selection*

Based on information obtained from the Road Infrastructure Information System of the East Java Transportation Government (SiPANJA), there are 13 national highways in the city of Madiun. The study focused on national road section located in Madiun. The accident-prone locations or selection of road section were determined based on weighting of the number of accidents victims. Out of the 13 road sections, 2 sections were chosen with the highest total weight of accident victims, as the first and second sections.

*D. Test and Evaluation of Road Feasible Functionalist*

Figure 3 Cleaning up the trash is necessary to optimize the water flow into the side channels.

Testing of road components in the field follows the form attached to the Minister of Public Works Regulation No. 11/PRT/M/2010 [1]. The results of testing road components in the field are compared with technical requirements for roads (Ministerial Regulation No. 19/2011 regarding Technical Specifications for Roads) [2]. The results of the road feasible functionality test are: feasible, conditionally feasible, and unfeasible.

## RESULTS AND DISCUSSIONS

### *A. Road Section Selection*

This research focuses on 13 national road sections in Madiun city. From these 13 national road sections, two sections with the highest number of accident victims (the most accident-prone road sections) were selected, namely the section with the largest total weight of accident victims and the section with the second-largest total weight of accident victims. The traffic accident data for Madiun from 2018 to 2020 is presented in Table 1.
The weighting method used in this research is:

1. The TRL weighting method by Transport Research Laboratory, 1997 [3], Engineering Approach to Accident Prevention & Reduction, Institute of Road, Bandung, Indonesia, assigns an LR weight = 1, LB weight = 2 and MD weight = 3
2. The Weighting Method of Bina Marga was issued by the Directorate General of Bina Marga, assigns LR weight = 1, LB weight = 5 and MD weight =10

Total Weight of Accident Victims = Number of LR Victims x LR Weight + Number of LB Victims x LB Weight + Number of MD Victims x MD Weight.

Based on the TRL method, the largest weight of accident victims in column 6 of Table 2 is in the location with the highest accident-prone area 1, which is 59 on D.I. Panjaitan Road, and the second largest weight is 50 on Yos Sudarso Road. Meanwhile, using the Bina Marga method, the largest weight of accident victims in column 7 of Table 2 is in the location with the highest accident-prone area 1, which is 94 on D.I. Panjaitan Road, and the second largest weight is 76 on Trunojoyo - Agus Salim Road. In this study, the TRL method was used for weighting because it is widely used as a reference for assigning accident weight values. The calculation results of the TRL method showed that the largest weight of accident victims or the highest accident-prone area 1 was 59 on D.I. Panjaitan Road, and the second highest accident-prone area was 50 on Yos Sudarso Road. Two

Figure 2 Shoulder of D.I. Panjaitan Road, Madiun City KM 1 + 100.

roads, D.I. Panjaitan and Yos Sudarso, were chosen as research locations, and a Road Feasible Functionality Test will be conducted next.

### *B. Daily Traffic Volume*

The daily traffic volume survey, ADTV, was conducted from Wednesday, June 23, 2021 until Thursday, June 24, 2021, during peak/busy hours. In the morning from 06.00 to 08.00, in the afternoon from 12.00 to 14.00, and in the evening from 15.30 to 17.30. Vehicle grouping is divided into 8 (eight) categories.

1). Traffic Survey D.I. Panjaitan

The result of the traffic survey on D.I. Panjaitan Road showed in Table 2.

For urban areas with k = 6%, the ADTV 2021 of Jl. D.I. Panjaitan = Total Number (pcu/hour) x 1/k = 733.25 x 1/6% = 12,221 (pcu/day) with the busiest hour is from 12.00 to 13.00.

2). Traffic Survey Yos Sudarso

The result of the traffic survey on Yos Sudarso showed in Table 3.

For urban areas with k = 6%, the ADTV 2021 of Yos Sudarso = Total Number (pcu/hour) x 1/k = 593.5 x 1/6% = 9,892 (pcu/day) with the busiest hour is from 07.00 to 08.00. *International.*

### C. *Roughness Index (IRI)*

International Roughness Index or IRI is a roughness index commonly obtained from longitudinal road profiles, calculated from the cumulative number of ups and downs in the direction of the longitudinal profile surface divided by the measured distance/length of the surface.

In this survey, an Android mobile application called Roadroid Pro3 was used. The working process of this application is to measure vibrations on the road surface/road roughness using sensors that have been installed on the phone. The survey results obtained using this application can be an effective and efficient indicator of road roughness.

1). IRI D. I. Panjaitan Road

The IRI survey was conducted on the D.I. Panjaitan Road section 4 times, twice in each direction. The survey used vehicles, namely cars, and smartphones. The car was driven along the D.I. Panjaitan road section. The survey results showed that the average IRI value of the D.I. Panjaitan road section was 1.88 m/KM, while the

Table 4 The Component and Result of Feasible Functionality Test on D.I. Panjaitan Road

| Component | Feasible Test Result | Component | Feasible Test Result | Component | Feasible Test Result |
|---|---|---|---|---|---|
| **A.1. Technical Road Geometric Design** | | **A.3. Technical Design of Supporting Structures for Roads** | | A.5.7. Crosswalk | Conditionally Feasible |
| A.1.1.1. Traffic Lane | Feasible | A.3.1. Bridge, Overpass, Underpass | Not Found | **A.6a. Technical Equipment of the Road Directly Related to Road Users** | |
| A.1.1.2. Road Shoulder | Conditionally Feasible | | | A.6a.1. Markings | Conditionally Feasible |
| A.1.1.3. Median (on the Road) | Feasible | A.3.2. Pontoon | Not Found | A.6a.2. Signs | Conditionally Feasible |
| A.1.1.4. Side Drainage Channel/Ditch | Conditionally Feasible | A.3.3. Culvert | Not Found | A.6a.3. Separators | Not Found |
| A.1.1.5. Speed Hump | Feasible | A.3.4. Parking Area | Conditionally Feasible | A.6a.4. Road Islands | Feasible |
| A.1.1.6. Traffic Safety Equipment | Conditionally Feasible | A.3.5. Retaining Wall Construction | Not Found | A.6a.5. Sidewalks | Conditionally Feasible |
| | | | | A.6a.6. Traffic Signals Devices (APILL) | Feasible |
| A.1.2.1. Straight Section | Conditionally Feasible | A.3.6. Roadside Drain Construction | Conditionally Feasible | A.6a.7. Supporting Facilities for Traffic and Road Transportation | |
| A.1.2.2. Curved Section | Not Found | **A.4. Technical Utilization of Road Parts** | | **A.6b. Technical Equipment of Road not Directly Related to Road Users** | |
| A.1.2.3. At-Grade Intersection | Conditionally Feasible | A.4.1 Roadway Functional Space | Not Found | A.6b.1. Directional Pole | Not Found |
| A.1.2.4. Access of Land Parcel to Road Sections | Conditionally Feasible | A.4.2. Roadway Ownership Space | Conditionally Feasible | A.6b.2. Kilometre Pole | Not Found |
| A.1.3.1. Straight Section | Feasible | A.4.3. Roadway Surveillance Space | Conditionally Feasible | A.6b.3. Hectometre Pole | Not Found |
| A.1.3.2. Climbing Lane | Not Found | **A.5. Technical Implementation of Traffic Management and Engineering** | | A.6b.4. Road Ownership Pole | Feasible |
| A.1.3.3. Vertical Curve | Not Found | A.5.1. Markings | Conditionally Feasible | (Roadway Ownership Space markers) | |
| A.1.4.1. The position of vertical curves on straight or curved sections | Not Found | A.5.2. Signs | Conditionally Feasible | A.6b.5. Sectional Border Pole | Not Found |
| **A.2 Road Pavement Structure Technique** | | A.5.3. Separators | Not Found | A.6b.6. Road Fence | Not Found |
| A.2.1. Types of Road Pavement | Feasible | A.5.4. Road Islands | Feasible | A.6b.7. Rest Area | Not Found |
| A.2.2. Road Pavement Condition | Feasible | A.5.5. Sidewalks | Conditionally Feasible | A.6b.8. Facilities and/or Equipment for Road User Safety | Conditionally Feasible |
| A.2.3. Road Construction Strength | Conditionally Feasible | A.5.6. Traffic Signals Devices (APILL) | Feasible | | |

technical requirements stated that the IRI of the road section should be <4.00 m/KM.

2). IRI Yos Sudarso Road

The IRI survey was conducted on the Yos Sudarso road section 4 times, twice in each direction. The survey used vehicles, namely cars, and smartphones. The car was driven along the Yos Sudarso road section. The survey results showed that the average IRI value of the Yos Sudarso road section was 1.56 m/KM, while the technical requirements stated that the IRI of the road section should be <4.00 m/KM.

*D. Road Feasible Functionality Test*

The national road sections of D.I. Panjaitan and Yos Sudarso are the objects of this study. The next step is to conduct a road feasible functionality test survey. The Road Feasible Functionality Test Survey is carried out based on the annex form of Regulation of the Minister of Public Works No.11/PRT/M/2010 [1], which includes 7 components to be tested, namely:

a. A.1. Geometric Technical Feasible Functionality Test
b. A.2. Technical Feasible Functionality Test of Road Pavement Structure
c. A.3. Technical Feasible Functionality Test of Supplementary Building Structures for the Road.
d. A.4. Technical Feasible Functionality Test for the Utilization of Road Components
e. A.5. Technical Feasible Functionality Test for Traffic Management and Engineering Maintenance

Figure 4 Road Construction Strength on Yos Sudarso Road KM 1 + 900.

Figure 5 Shoulder Road in Yos Sudarso Road KM 1 + 100

Figure 6 The type of road pavement on Yos Sudarso Road

f. A.6A. Technical Feasible Functionality Test for Road Equipment Directly Related to Road User
g. A.6B. Technical Feasible Functionality Test for Road Equipment Indirectly Related to Road Users1).

1). Road Feasible Functionality Test D.I. Panjaitan

The results of the survey and evaluation of the seven components of road feasible functionality testing on the national road section of D.I Panjaitan Road in Madiun City (0-1,670m) are summarized and presented in Table 5 below.

A.1 Geometric Technical Road

A.1.1. Cross-Sectional Road

A.1.1.1. Traffic Lane

The traffic lane is the width of the lane consisting of one or more lanes, viewed transversely, and used by vehicle traffic bounded by the edge line markings (the width of the traffic lane does not include the edge line markings) as well as the continuous and/or broken line

Table 5 Accident Number in National Road of Madiun City 2018-2020

| No. | Accident Number in National Road of Madiun City 2018-2020 | Number of Accident Victims (people) | | |
|---|---|---|---|---|
| | | LR | LB | MD |
| 1. | Urip Sumoharjo | 41 | 0 | 2 |
| 2. | Ahmad Yani | 21 | 0 | 1 |
| 3. | Pahlawan | 25 | 0 | 3 |
| 4. | Yos Sudarso | 47 | 0 | 1 |
| 5. | Mayjen. Sungkono | 33 | 0 | 0 |
| 6. | Trunojoyo dan Agus Salim | 36 | 0 | 4 |
| 7. | Soekarno-Hatta (Jl. Ponorogo) | 24 | 0 | 1 |
| 8. | D. I. Panjaitan | 44 | 0 | 5 |
| 9. | Letjen Haryono | 34 | 0 | 1 |
| 10. | M. Thamrin | 40 | 0 | 1 |
| 11. | S. Parman | 28 | 0 | 0 |
| 12. | Basuki Rachmat | 25 | 0 | 2 |
| 13. | Raya Madiun – Ponorogo | 19 | 0 | 2 |

markings that serve as dividers for lanes in the same direction or opposite directions. If there are no edge line markings, then the measurement of the lane or traffic lane is measured from the edge of the road surface.

a. The measurement of the traffic lane is 7.65 m (4.15 m northbound and 3.50 m southbound) from the outer edge of the left edge line marking to the outer edge of the right edge line marking.
b. The road technical requirements (Ministry of Public Works Regulation No. 19/2011 on Technical Guidelines for Roads/TGR) [2] stipulate that the width of each lane must be ≥ 3.50 m, measured from the outer boundary of the lane's edge markings to the centre line.
c. Based on the markings and width, this road section is a type of 1 lane 2 lane/direction road with a width of 2x3.50 m per lane/direction for traffic flow, with a DTV of 12,221 vehicles per day for the placement of continuous line markings. That means the width of the traffic lane meets the technical requirements and the cross slope in the field complies with the Technical Guidelines for Roads (TGR).
d. Feasible Functionality Test: Feasible (

A.1.1.2. Road Shoulder

The road shoulder is an emergency lane that can be used to temporarily stop to avoid other vehicle maneuvers that may endanger the driver who stops temporarily. The shoulder is not intended for pedestrians.

a. Based on field observations, there are 2 (two) types of road shoulders, namely asphalt pavement with a width between 0.20 m - 0.50 m and the inner shoulder with asphalt pavement and some parts still with gravel/aggregate/soil with a width of approximately 0.50 m.
b. The position of the shoulder surface compared to the road surface is in line with the road surface with a transverse slope of 3-5%.
c. Based on the TGR which stipulates that the width of the road shoulder should be ≥ 2m, the position of the shoulder on the road surface is in line with the road surface with a transverse slope of 3% for the shoulder. Certain parts have trees planted in them.
d. Functionality test result: Conditionally functional (CF)

Table 6 The Component and Result of Feasible Functionality Test on Yos Sudarso Road

| Component | Feasible Test Result |
|---|---|
| **A.1. Technical Road Geometric Design** | |
| A.1.1.1. Traffic Lane | Feasible (F) |
| A.1.1.2. Road Shoulder | Conditionally Feasible |
| A.1.1.3. Median (on the Road) | Feasible (F) |
| A.1.1.4. Side Drainage Channel/Ditch | Conditionally Feasible |
| A.1.1.5. Speed Hump | Feasible (F) |
| A.1.1.6. Traffic Safety Equipment | Conditionally Feasible |
| A.1.2.1. Straight Section | Conditionally Feasible |
| A.1.2.2. Curved Section | Not Found |
| A.1.2.3. At-Grade Intersection | Feasible (F) |
| A.1.2.4. Access of Land Parcel to Road Sections | Conditionally Feasible |
| A.1.3.1. Straight Section | Feasible (F) |
| A.1.3.2. Climbing Lane | Not Found |
| A.1.3.3. Vertical Curve | Not Found |
| A.1.4.1. The position of vertical curves on straight or curved sections | Not Found |
| **A.2 Road Pavement Structure Technique** | |
| A.2.1. Types of Road Pavement | Feasible (F) |
| A.2.2. Road Pavement Condition | Conditionally Feasible |
| A.2.3. Road Construction Strength | Conditionally Feasible |
| **A.3. Technical Design of Supporting Structures for Roads** | |
| A.3.1. Bridge, Overpass, Underpass | Not Found |
| A.3.2. Pontoon | Not Found |
| A.3.3. Culvert | Not Found |
| A.3.4. Parking Area | Conditionally Feasible |
| A.3.5. Retaining Wall Construction | Not Found |
| A.3.6. Roadside Drain Construction | Feasible (F) |
| **A.4. Technical Utilization of Road Parts** | |
| A.4.1 Roadway Functional Space | Conditionally Feasible |
| A.4.2. Roadway Ownership Space | Feasible (F) |
| A.4.3. Roadway Surveillance Space | Conditionally Feasible |
| **A.5. Technical Implementation of Traffic Management and Engineering** | |
| A.5.1. Markings | Conditionally Feasible |
| A.5.2. Signs | Conditionally Feasible |
| A.5.3. Separators | Not Found |
| A.5.4. Road Islands | Feasible (F) |
| A.5.5. Sidewalks | Conditionally Feasible |
| A.5.6. Traffic Signals Devices (APILL) | Feasible (F) |
| A.5.7. Crosswalk | Conditionally Feasible |
| **A.6a. Technical Equipment of the Road Directly Related to Road Users** | |
| A.6a.1. Markings | Not Found |
| A.6a.2. Signs | Conditionally Feasible |
| A.6a.3. Separators | Conditionally Feasible |
| A.6a.4. Road Islands | Not Found |
| A.6a.5. Sidewalks | Feasible (F) |
| A.6a.6. Traffic Signals Devices (APILL) | Conditionally Feasible |
| A.6a.7. Supporting Facilities for Traffic and Road Transportation | Feasible (F) |
| **A.6b. Technical Equipment of Road not Directly Related to Road Users** | |
| A.6b.1. Directional Pole | Not Found |
| A.6b.2. Kilometer Pole | Not Found |
| A.6b.3. Hectometer pole | Not Found |
| A.6b.4. Road Ownsership Pola | Not Found |
| A.6b.5. Sectional Border Pole | Not Found |
| A.6b.6. Road Fence | Feasible (F) |
| A.6b.7. Rest Area | Not Found |
| A.6b.8. Facilities and/or Equipment for Road User Safety | Not Found |

e. Functionality test result: Conditionally functional (CF)
f. Recommendation: For road user safety, several areas prone to accidents need to be considered for tree removal or increased distance between trees along
g. asphalt pavement with some parts still using gravel/aggregate/soil. This can be seen in Figure 2.

A.2. Road Pavement Technical Structure

A.2.1. Road Pavement Type

According to Regulation of the Minister of Public Works No. 19/PRT/M/2011, medium-sized roads must have road pavement in the form of asphalt or concrete. For areas with high rainfall, poor drainage, and high traffic of heavy vehicles, it is recommended to use concrete road pavement.

this road section, at KM 1 + 100. Coordination is needed between the Directorate General of Highways, the City Government, the Ministry of Environment and Forestry, and the installation of "No Stopping/Parking" signs. The type of road shoulder is

a. The conformity of the road pavement structure with the traffic that passes through, road functional class, and road usage class is appropriate.
b. The road pavement structure is in the form of asphalt pavement (in good condition). There are still some uneven road surfaces caused by cracks and small potholes. Therefore, the road condition is declared fit.
c. Feasible Functionality Test: Feasible (F)

A.2.3. Road Construction Strength

Road construction must be able to control water on the road surface both from rainfall runoff, and the pavement

material must be able to support the traffic according to the volume of traffic and the composition of vehicles served.

a. Visually, the road surface on the section is flat with some cracks at certain points at KM 0+750.
b. Feasible Functionality test: Conditionally Feasible (CF)
c. Recommendation: It is necessary to maintain consistency in road maintenance, especially optimizing water flow towards the side drains and clearing trash, such as at KM 1+200.

2). Functionality Test Yos Sudarso Road

The survey and evaluation of the road feasible functinality test on the national road section of Jl. Yos Sudarso in Madiun City resulted in the following:

A.1 Geometric Technical of the Road

A.1.1. Cross-Section of the Road

A.1.1.1. Traffic Lanes

If there are no edge line markings on the road, the measurement of the traffic lane or lane is measured from the edge of the road pavement.

a. The measurement of the traffic lane is 9.7m (5.8m northbound, 3.9m southbound) from the outer edge of the left edge line marking to the outer edge of the median line marking. Technical requirements for roads (Minister of Public Works Regulation No. 19/2011 regarding Technical Guidelines for Roads/TGR) [2] stipulate that the minimum lane width is 3.5 m measured from the outer edge of the edge line marking to the center line marking. Considering the markings and widths present, this road section is a type of 2 lanes 1 direction road with a traffic lane width per lane/direction of 3.8 m with an ADT of 9,892 vehicles/day for the placement of continuous line markings. Thus, the traffic lane width is met and the cross slope in the field is in accordance with the TGR.
b. Feasible Functionality Test: Feasible (F)

A.1.1.2. Road Shoulder

The shoulder is an emergency lane that can be used to temporarily stop in order to avoid other vehicles that may endanger the stopping driver. The shoulder is not intended for pedestrians.

a. Based on observations in the field, there is only one type of road shoulder, with the inner part using asphalt pavement, while the other part is still using gravel/aggregate/soil with a width of approximately 1m. This does not comply with the TGR which requires a width of 2m, with the shoulder position on the continuous pavement surface with a cross slope of 3%. Certain parts are already planted with trees.
b. Feasible Functionality Test: Conditionally Feasible (CF)
c. Recommendation: For the safety of road users, it is necessary to consider several places that are prone to accidents for tree removal and installation of no parking signs across from PT. INKA. Coordination is needed between the Directorate General of Highways, Local Government, and the Ministry of Environment, and the installation of no stopping/parking signs.

A.2. Road Pavement Technical Structure

A.2.1. Road Pavement Type

The types of road pavement according to Regulation of the Minister of Public Works No. 19/PRT/M/2011 [2] are that a medium road must have a road pavement in the form of asphalt or concrete. For areas with high rainfall, poor drainage, and high traffic volume of heavy vehicles, it is recommended to use concrete road pavement.

- The road pavement structure is in the form of asphalt (in good condition).
- Feasible Functionality Test: Feasible (F)

A.2.3. Road Construction Strength

The road construction should be able to control the water on the road surface, both from rainwater runoff, and the pavement materials should be able to support traffic according to the volume and composition of vehicles served.

- Visually, the road surface is flat with cracks at certain points.
- Feasible Functionality Test: Conditionally Feasible (CF)
- Recommendation: Repair work is needed at KM 1 + 900 and the railroad intersection in front of PT. INKA, and consistent road maintenance is required, especially in optimizing the flow of water toward the side drainage channels, including cleaning up any debris.

## CONCLUSIONS AND SUGGESTIONS

### *A. Conclusions*

Based on the results of the research on the Analysis of Vehicle Accident Potential and Safety Road Planning in Madiun City, the following conclusions are drawn:

1. Accident Rate. Based on the accident data from the Madiun City Police in 2018, 2019, and 2020 on 13 national roads in Madiun City, the victims of traffic accidents were categorized as Slightly Injured, Seriously Injured, and Fatalities. The rate of traffic accidents that occurred on national roads in Madiun City is shown in Table 6.
2. Roads with the Highest Number of Accidents. By assigning a weight of Slightly Injured = 1, Seriously Injured = 2, and Fatalities = 3, the largest total weight of accident victims was found on Route 1 = 59 on D.I. Panjaitan National Road and the second-largest total weight of accident victims was found on Route 2 = 50 on Yos Sudarso National Road. The national road section with the highest number of traffic accidents are D.I. Panjaitan National Road and Yos Sudarso National Road. These roads were selected for Road Feasible Functionality Testing.
3. Daily Traffic Volume. A traffic survey was conducted on D.I. Panjaitan National Road at the entrance and exit of Madiun City during busy hours: 6:00-8:00 a.m., 12:00-2:00 p.m., and 3:30-5:30 p.m. Based on the survey conducted on June 24th, 2021, the Daily Traffic Volume in the direction of entering the city on D.I. Panjaitan National Road was 11,975 vehicles per day at 6:00-7:00 a.m. and 12,221 vehicles per day in the direction of leaving the city at 12:00-1:00 p.m. The Daily Traffic Volume in the direction of entering the city on Yos Sudarso National Road was 9,892 vehicles per day at 7:00-8:00 a.m.,

and 9,792 vehicles per day in the direction of leaving the city at 3:30-4:30 p.m.

4. IRI. The road surface condition was evaluated based on the International Roughness Index (IRI). The average survey results for the IRI on D.I. Panjaitan National Road was 1.88, while the IRI on Yos Sudarso National Road was 1.56. The IRI of Flatness Conditionally Feasible <4 for both section roads.
5. Feasible Functionality Test.

a) Feasible Functionality Test of D.I. Panjaitan Road

The feasible functionality test of D.I. Panjaitan Road resulted in road elements that meet technical requirements for road feasible functionality, but still pose safety issues, including:

a. Unpaved road shoulders that should be hardened.
b. Trees on the road shoulders.
c. Open roadside drains that need to be covered.
d. Vegetation and the height of the road island at the intersection of Sukarno Hatta Street slightly obstruct the view from Sukarno Hatta to Madiun Ponorogo Road.

Meanwhile, the road elements that do not meet technical requirements but do not pose safety issues are as follows:

a. Width/dimensions of the side ditch
b. Width of the road safety barrier
c. Width of the traffic lane parking
d. Width of Roadway Ownership Space and Roadway Surveillance Space
e. Zebra cross markings
f. Completeness of hectometre markers per hm
g. Completeness of Roadway Ownership Space markers
h. Completeness of section boundary markers

b) Feasible Functionality Test for Yos Sudarso Road Section

a. The feasible functionality test for Yos Sudarso road section resulted in road elements that meet the technical requirements for roads but still pose safety issues, including:
b. Shouldered road that needs to be hardened.
c. Open side drainage that needs to be regulated in the road's functional suitability (such as Pertamina trains entering or leaving the Pertamina Depot).

Meanwhile, the road elements that do not meet technical requirements but do not pose safety issues are as follows:

a. Width/dimension of the side ditch
b. Width of the road safety barrier
c. Width of Roadway Ownership Space and Roadway Surveillance Space
d. Zebra crossing markings
e. Completeness of hectometre markers per hm
f. Completeness of Roadway Ownership Space markers
g. Completeness of sectional boundary markers

6. Recommendation: Road safety improvements are recommended for roads with a Conditional Pass rating to minimize the number of traffic accidents. Complete recommendations are provided in the paper.

### *B. Suggestions*

The suggestions that can be given based on the results of this research analysis are as follows:

1. It is necessary to examine road safety issues at night, during rain/wet conditions, and when tank trucks are entering/leaving the Pertamina depot to identify road safety problems that arise in these conditions and provide recommendations for handling problems when experiencing these conditions.
2. Future research is recommended to use the Accident Equivalent Number Weighting Method (AENW) for the selection of road sections. The AENW weighting method combines accidents resulting in fatalities, serious injuries, minor injuries, and the level of traffic accident fatalities as well as the number of accident occurrences that cause material damage/loss.

## REFERENCES

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[3] Transport Research Laboratory, "Engineering Approach to Accident Prevention and Reduction," 1997.