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Geometric Evaluation of Highways and Railroads on Safety at Crossings (Case Study of JPL 136 and JPL 138 Madiun City)

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ABSTRACT

Railway and road transportation are land transportation that service users widely use because these modes play an important role in community activities, especially people on the island of Java. The train is a mass transportation with many advantages over other transportation, especially as a solution to the congestion problem in the country. Level crossing is a meeting between the railroad and the highway. Level crossings must meet the standard requirements set by the relevant agencies including geometric conditions, free space and wake space, and visibility so that level crossings are comfortable and safe for vehicles to pass through. The purpose of this study is to evaluate the geometric conditions, free space and shape as well as the visibility of level crossings. This study uses field observations and data from DAOP 7 Madiun to compare field conditions with requirements. The research was conducted at level crossings, namely JPL 136 and JPL 138 Kota Madiun.

Keywords: highways; railroads; level crossings; safety; trains, railways.

INTRODUCTION

Along with the development of technology and the number of population in Indonesia, it will greatly affect the existing traffic conditions, so adequate transportation facilities and infrastructure are needed to support community activities that continue to increase. Railway and road transportation are land transportation that service users widely use because these modes play an important role in community activities, especially people on the island of Java. To run safely, comfortably and orderly, it must be supported by good infrastructure. Train is a mass transportation with many advantages over other transportation, especially as a solution to congestion problems in the country. Convenience in traffic-free travel makes many people use this mode of transportation as their means of transportation. The high public interest in trains is responded positively by the government because it is in accordance with the government's spirit to hold mass transportation modes that can reduce congestion, save energy and be more environmentally friendly so that the construction and improvement of railway infrastructure and facilities are also being improved. The existence of a plot crossing can cause various problems, including congestion and accidents. Congestion at a plot crossing is influenced by the closing of the crossing door to prioritize train travel and by the condition of the intersection of the rail with the highway. Accidents at crossings can also be influenced by drivers who lack discipline in driving and many unauthorized crossings.

The research was conducted on JPL 136 Jalan Basuki Rahmat, and JPL 138 Jalan Yos Sudarso Kota Madiun. Geometric observations of plot crossings include vehicle stop visibility, train free visibility, and road and crossing dimensions. For calculation of analysis on the geometric aspects of plot crossings, refer to the Regulation of the Directorate General of Land Transportation SK no.770 of 2005 concerning Technical Guidelines for Crossing Plots Between Roads and Railway Lines.

A plot crossing is a meeting involving the flow of motor vehicles on one side while there is a train flow on the other. A road intersection is a general area where two or more road sections (links) meet each other/intersect, including roadway and roadside facilities, where traffic can move (Warpani, 1985). Based on the Regulation of the Minister of Transportation Number 36 of 2011 concerning Intersections and Intersects between Railway Lines and Other Buildings, it is stated that the requirements for a plot crossing are the intersection between a railway line and other buildings, it can be in the form of a plot intersection or intersection not on a plot and the intersection between a railway line and a road is called a crossing.

The rail road must always be free of obstacles and can be passed by the train at all times safely. To meet these demands, it is necessary to have space above the gauge that is always free from all objects that can be touched by the train. In terms of space above the gauge that must always be free, it is known as Free Space and Building Space.

Free space is the space above the rail road that must always be free from all obstacles and obstructions; this space is reserved for rail traffic.

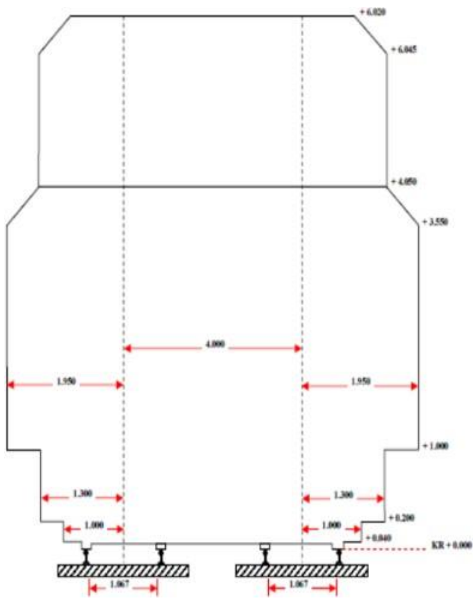

Figure 1. Free Space on Straight Lines for Double Lines

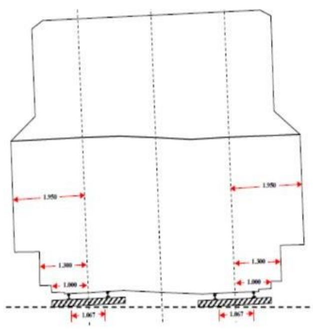

Figure 2. Curved Lane Free Space for Double Track

According to PM 24 of 2015, the building room is a space on the side of the rail road that must always be free from all fixed buildings. The building space boundary is measured from the axis of the rail road at a height of 1 meter to 3.55meters. The space distance is applied as in Table 1.

Table 1. Distance to Build a Space

Line Segments	Rail Road Width 1067 mm and 1435 mm	
	Straight Path	**Arch R<800**
Free	Minimum 2.3, on left right axle rail road	R< 300, minimum 2.55 m R>300, minimum 2.45 m on left right as rail road

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Traffic		
Emplacement	Minimum 1.95 m on left right axle of rail road	Minimum 2.35 m on left right axle of rail road

Traffic procedures at plot crossings have been regulated in Law No. 22 of 2009 stating that at the intersection of railway lines with roads used for general traffic or special traffic, road users must prioritize train travel, therefore users of plot crossings must prioritize trains first and then continue their journey.

Good rail service requires a combination of high quality rail and adequate facilities. Investments in maintaining and improving rail infrastructure, along with providing comfortable and safe facilities for passengers, are essential to achieving efficient and satisfactory train operations. Providing accurate and timely information regarding schedules, delays and route changes is essential. Automatic information screens and announcements at stations and inside trains can help passengers (Kurniawan W, Rulhendri R, 2015; Sanjaya A, 2021; Putri EM, Herwangi Y, 2023; Santoso GP, Dwiatmoko H, 2023).

Comfortable stations with facilities such as adequate waiting areas, clear information, clean toilets and accessibility for people with disabilities improve the passenger experience. Timely schedules greatly influence passenger perceptions and satisfaction with train services. An efficient rail traffic management system can help achieve this. The use of advanced technology for train traffic management, such as automatic signals and computer-based train control, can increase efficiency and safety (Sihombing SB et.al, 2021; Syaiful S, Rulhendri R, 2014).

RESEARCH METHODS

Research Phase

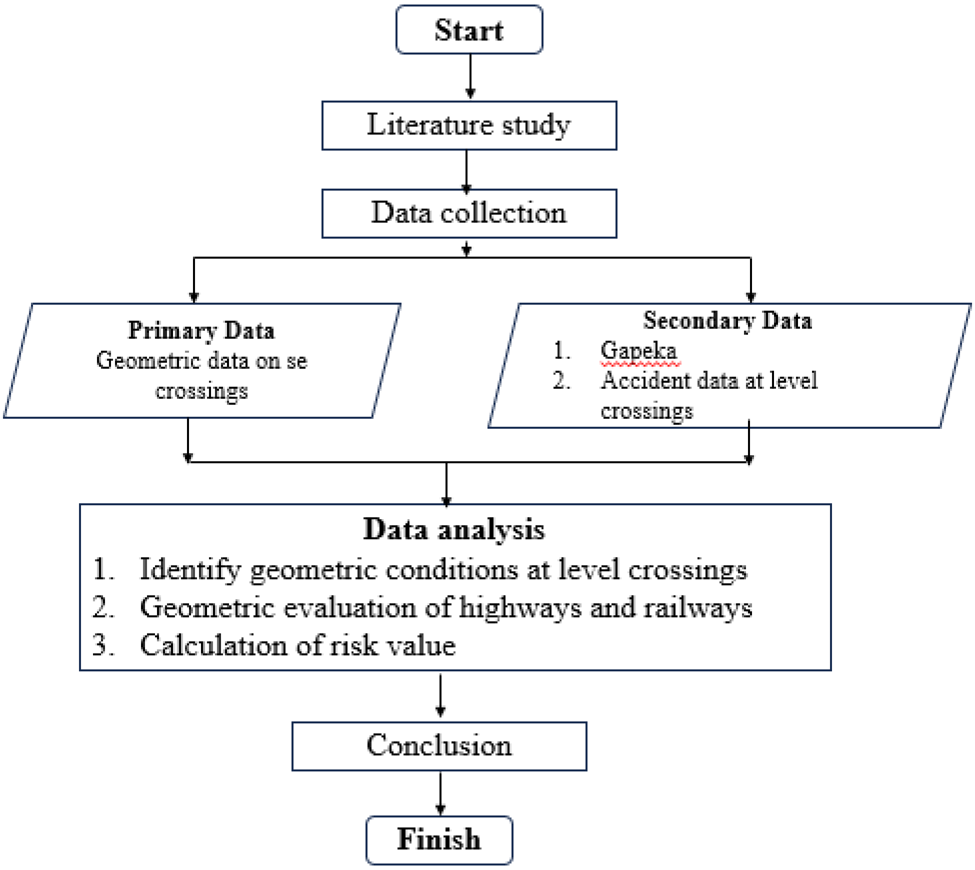

Figure 3. Research Flow Diagram

Data Collection Techniques

Data collection is carried out to obtain sources of information that are used as the basis for research conclusions. Here are the steps taken to collect the required data.

Primary Data

Highway geometric and rail road geometric data are obtained based on field observations and measurements.

Secondary Data

Secondary data was obtained from the DAOP 7 Madiun document in the form of accident data at the crossing and Gapeka data. In addition, geometric data is needed to get the value of D (Distance from the stop line or the front of the vehicle to the nearest rail) with the help of Googlemaps and Google streetview applications.

Data Analysis

Conformity Analysis of Fulfillment of Technical Requirements for Field Crossings includes:

a. Calculation of vehicle LHR and railway LHR
b. Calculation of Free Visibility of Machinists and Road Users
c. The calculation refers to the formula for free visibility regulations at crossings through the Guidelines for Planning for Road Crossings with Railway Lines No. 008/PW/2004 (Director General of Regional Infrastructure, 2004).

Evaluation of the conformity of geometric data in the field with the Regulation of the Director General of Land Transportation Number SK.770/KA.401/DRJD/2005 concerning Technical Guidelines for Crossing Plots between Roads and Railways.

Calculates the risk value of geometric aspects of crossing a plot.

RESULTS AND DISCUSSION

Travel Traffic Volume

The calculation used to determine the traffic volume in passenger cars (junior high school) is equivalent to passenger cars (emp) for different types of vehicles. The data taken for calculation is the largest during rush hour. To calculate the vehicle volume for each type of vehicle multiplied by the emp factor. For example, for motorcycles on Tuesday. Rush days and hours on Tuesdays at 07:00-08:00 WIB. So that the volume of the motorcycle at :

Table 2. Vehicle Volume at Specific Hours

16.00 – 17.00	171	213	105
17.00 – 18.00	193	232	119

Yos Sudarso Street based on its function is included in the local class with a capacity of 1313 junior high school/hour. With an average daily LHR of 251 junior high school/hour for the morning rush hour, 146 junior high school/hour for the afternoon rush hour, and 173 junior high school/hour for the afternoon rush hour, Yos Sudarso street has low traffic. Average total daily traffic at crossing 112A Jalan Wiradesa – 07:00-08:00 = motorcycle volume at 07:00- 08:00 × 0.25 = 837 × 0.25 = 209 junior high school/hour

Light vehicle volume 07.00-08.00 WIB = (light vehicle volume 07.00 – 08.00) × 1.00 = 9 × 1.00 = 9 junior high school/hour.

Furthermore, the results of calculating the volume of junior high school vehicles/hour on Jalan Yos Sudarso for Tuesday, Friday and Saturday can be seen in Table 3 below.

Table 3. Vehicle Volume on Yos Sudarso Street (smp/hr)

Vehicle volume (SMP/hour)

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Hit	Tuesday	Friday	Saturday
07.00 - 08.00	218	262	131
08.00 - 09.00	326	372	196
12.00 – 13.00	144	183	87
13.00 –14.00	163	196	98

Dadirejo can be seen that there are 7,410 vehicles or 3,746 junior high schools. SMPK at the crossing is 247,236 SMPK, so according to Guideline SK 770 of 2005 it is mandatory to be upgraded to a non-level crossing.

Figure 4. Undivided Two-Way Road (Without Median)

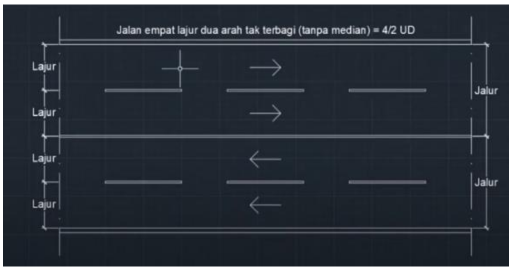

Figure 5. Four-lane Two-Way Undivided Road (No Median)

Table 4. Emp for Undivided Urban Roads

Road Type	**Past flow Cross**	**Emp**		
	Bidirectional Total (Vehicle/Hour)		**MC Wc Traffic lane width(m)**	
Undivided Road		**HP**	**≤6**	**>6**
Two undivided lanes (2/2 OUT)	0	1.3	0.5	0.40
	≥1800	1.2	0.35	0.25
Four lanes undivided (4/2 UD)	0	1.3	0.4	
	≥3700	1.2	0.25	

The classification of light vehicles, heavy vehicles and motorcycles is based on the classification system of Highways as follows:

JPL 138 crossing shows that the vehicle that passes the most is motorcycles as many as 27,153 vehicles per day, private cars 6,082 vehicles per day. Likewise, JPL 136 is dominated by motorcycles and private vehicles. Still, the types of vehicles that pass JPL 136 are more diverse considering that JPL is included in the provincial road category where various types of heavy vehicles such as intercity/interprovincial buses, 3-axis trucks, articulated trucks pass through this crossing.

LHR Railways

Based on Gapeka (Train Travel Chart) 2021, the trains passing at the JPL 138 Railway crossing are 59 trains with details of 20 Freight Trains and 46 passenger trains, with a maximum train speed of 105 km/h. Based on LHR and Total data.

1. Light vehicles (LV), namely four-wheeled motorized vehicles with two axles spaced 2.0 – 3.0 m (including oplet passenger vehicles, micro buses, pickups and small trucks).
2. Heavy vehicles (HV), i.e. motor vehicles with two axles, with distance

3.5 – 5.0 (includes small buses, two-axle trucks with six wheels. Large trucks, namely three-axle trucks and combination trucks with axle clearance (first to two axles) < 3.5 m. Large buses are buses with two or three axles with a distance of 5.0 – 6.0 m.

3. Motorcycle (MC) is a two- or three-wheeled motor vehicle (including motorcycles and 3-wheeled vehicles).

Based on the traffic volume survey, it can be seen that the composition of the types of vehicles passing through the passing train, can be calculated by SMPK as follows:

SMPK = SMP LHR per day x (number of trains + number of curtains) = 13,638 junior high school x (59 trains + 55 curtains) = 1,554,732 SMPK

While the LHR Train at JPL 136 based on Gapeka (Train Travel Chart) 2023 Trains passing at the JPL 136 Railway crossing are 60 trains with details of 20 Freight Trains and 46 passenger trains, with a maximum train speed of 105 km/hour. Based on LHR data and the number of trains passing through, SMPK can be calculated as follows:

SMPK = SMP LHR per day x (number of trains)

= 10,310 Junior High School x (60 Trains)

= 618,600 SMPK

Regulation of the Director General of Land Transportation Number SK.770/KA.401/DRJD/2005 concerning Technical Guidelines for Crossing Plots between Roads and Railways Crossing between roads and railway lines, consisting of 3 parts, namely as follows: a. Crossing a plot equipped with automatic doors if it exceeds the provisions regarding:

1. The number of trains passing through the location is at least 25 trains/day and a maximum of 50 trains/day.
2. The average daily traffic volume (LHR) is 1,000 to 1,500 vehicles on inner city roads and 300 to 500 on out-of-town roads or railways between 12,500 and 35,000 smpk.

Based on the calculation results of SMPK JPL 138 and JPL 136, it needs to be considered to be upgraded to a non-plot crossing.

Environmental Conditions of Yos Sudarso Road Railway Crossing

The neighborhood around the railway crossing on Jalan Yos Sudarso has many people's houses and businesses. Part of the houses and businesses are in the Railway-Owned Area, which is supposed to be occupied by the railway line. The business activities carried out by residents along this railway disrupt railway operations and endanger their safety. The density of buildings around the railway is due to the rapid growth of settlements and the business interests of the people in the area. Unfortunately, many people do not understand the rules and regulations related to using and regulating space around the railway tracks. This caused the growth of buildings to continue to

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increase around the railway tracks.

CONCLUSION

Based on the results of the analysis and discussion, it was concluded that the Yos Sudarso lane section that passes JPL 138 is included in the category of Undivided Two-Way Four Lane Road (Without Median), with the number of vehicles passing JPL 138 more than 3,700 vehicles per day so that the EMP coefficient chosen for motorcycles is 0.25, while heavy vehicles are 1.2. While the lane section that passes JPL 136 is included in the category of Undivided Two-Way Two-Lane (Without Median) roads with a lane width of more than 6m and the number of vehicles passing more than 1,800 vehicles per day, so the EMP coefficient chosen for motorcycles is 0.25, while heavy vehicles is 1.2. Based on the survey of VLHR traffic volume at JPL 138, VLHR in 2023 = 6,885 junior high school/day in the direction of PT INKA to the Madiun City Police and VLHR in 2023 = 6,753 junior high school/day in the direction of the Madiun City Police to PT INKA or in total for both directions of 13,638 junior high school/day. Meanwhile, in JPL 136, VLHR in 2023 = 5,351 junior high schools/day in the direction of Jalan Basuki Rahmat to Jalan S. Parman, and 4,958 junior high schools/day in the direction of Jalan S. Parman to Jalan Basuki Rahmat or in total for both directions of 10,310 junior high school/day. Based on Gapeka (Train Travel Chart) 2021, trains passing at the JPL 138 Railway crossing are 59 trains with details of 20 Freight Trains and 46 passenger trains, with a maximum train speed of 105 km/h with the result of SMPK JPL 138 is 1,554,732 SMPK. While the LHR Train at JPL 136 based on Gapeka (Train Travel Chart) 2023 Trains passing at the JPL 136 Railway crossing are 60 trains with details of 20 Freight Trains and 46 passenger trains, with a maximum train speed of 105 km/h with the results of SMKP JPL 136 is 618,600 SMPK. The results of geometric observations of JPL 138 plot crossing show that road visibility from the rail axle dH = 45.54 meters (46 meters), the visibility of train drivers to road users dT = 113.9 meters (114 meters). While the results of geometric observations of JPL 136 plot crossings show that road visibility from the rail axle dH = 69.95 meters (70 meters), the visibility of train drivers to road users dT = 95.53 meters (94 meters). The JPL 138 risk category analysis results can be concluded that the road visibility from the dH rail axle results of the risk value is 300 (Risk category B), and the visibility of train drivers to dT road users results in the risk value 750 (SB risk category). While the results of the JPL 136 risk category analysis show that the road visibility from the dH rail axle as a result of the risk value is 630. (SB risk category), the visibility of train drivers to dT road users results in a risk value 1000 (SB risk category).

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