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Geometric Analysis of the Road on the Pramuka Road Section in Harjamukti District, Cirebon City, West Java Province STA 0+000 – STA 2+000

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Abstract

Road infrastructure design is an important component in the land transportation system that serves to improve mobility, safety, and comfort for road users. This study discusses the infrastructure planning of Jalan Pramuka, located in Harjamukti District, Cirebon City, with a route length of ±2.3 km. The main objective is to produce design recommendations that not only improve safety and efficiency but are also environmentally and economically sustainab. The research methodology includes the collection of primary and secondary data, including topography, road geometry, traffic, subgrade conditions, and hydrology data. The analysis covers horizontal and vertical alignment planning, road pavement structure analysis, drainage system design, and construction cost analysis. All collected data were subsequently used as the basis for geometric analysis, pavement planning, drainage design, and construction cost analysis. Road geometric planning was carried out with a design speed of 70 km/h and considered safety aspects through the use of spiral-circle-spiral (SCS) curves. Pavement analysis was based on the average daily traffic (ADT) in the design year 2025 and a subgrade CBR value of 5.5%, with a pavement design life of 15 years. The drainage system was designed using trapezoidal channels capable of accommodating rainfall discharge in accordance with the rainfall in the study area. The planning results show that the proposed road design meets applicable technical standards and is expected to support smooth traffic flow and sustainable regional development.

Keywords: Road Design, Road Geometry, Road Pavement, Road Drainage, Transportation Infrastructure.

1. Introduction

1.1. Background

Road infrastructure is the backbone of national development, which not only facilitates the transportation of goods and people but also drives regional economic growth. In Indonesia, with an area of more than 1.9 million km² and a population of around 270 million, the road network plays a crucial role in connecting rural and urban areas and supporting strategic sectors such as agriculture, industry, and tourism [1–3]. However, road infrastructure challenges in this country are becoming increasingly complex due to rapid urbanization, increased motor vehicle ownership, and the impact of climate change, such as floods and landslides, which worsen road conditions [4–8].

Data from the Ministry of Public Works and Public Housing (PUPR) shows that around 40% of national and provincial roads in Indonesia are in poor condition or in need of repair, which has an economic impact on the country amounting to trillions of rupiah per year due to congestion and accidents [9–11]. Specifically, the city of Cirebon in West Java Province, as one of the economic centers in the Pantura (North Coast of Java) region, faces similar road infrastructure problems. The city has an area of approximately 37.36 km² with a population of more than 300,000, and economic growth driven by the trade, textile, and religious tourism sectors. Pramuka

Road in Harjamukti District, which is one of the main arteries, often becomes a bottleneck due to high daily traffic volume, especially during rush hour (PRI) [12–15].

This study is based on an analytical approach that integrates field data, traffic surveys, and software simulations such as AutoCAD or Civil 3D for design modeling. The main objective is to produce design recommendations that not only improve safety and efficiency but are also environmentally and economically sustainable [16–20].

2. Research Method

2.1. Approach, Location, adn Research Period

This study uses a descriptive quantitative approach that aims to analyze and plan road infrastructure based on existing conditions and measurable technical data. This approach is used to describe the geometric characteristics of the road, traffic conditions, pavement structure, and drainage system on the road section under study. This research was conducted on Jalan Pramuka, located in Harjamukti District, Cirebon City, West Java Province. The road section that was the object of the study stretched from Sate Klasik Cirebon (Kalijaga Village) to Toko Tiga Putri Madura (Argasunya Village) with a length of approximately 2.3 km and a north-south orientation. This area is dominated by residential areas, shops, and public facilities, so it has a fairly high traffic volume [21, 22]. The topography is relatively flat to slightly sloping, with drainage channels on the sides of the road that require attention in technical planning. Research data was collected in 2025 to reflect representative traffic conditions. Traffic surveys were conducted during rush hour to obtain Average Daily Traffic (ADT) data and the composition of vehicles passing through the Pramuka Road section. Topographic data, road geometry, and environmental conditions were obtained through field observations and map image analysis. All collected data were subsequently used as the basis for geometric analysis, pavement planning, drainage design, and construction cost analysis [23–25].

2.2. Types and Sources of Data

Data collection was conducted through two main sources, namely primary data and secondary data. Primary data was obtained from field surveys, while secondary data was collected from various sources such as relevant agencies and literature, including location maps, the 2023 PKJI Book, and scientific journals relevant to the PRI method.

2.3. Data Collection Techniques

In this study, the data collection technique used was a field survey to obtain primary and secondary data. Primary data was obtained from field observations, which included information on the availability and condition of crossing facilities, road geometry, vehicle speed, traffic volume, vehicle travel time to the crossing area, and the distance of vehicles from the crossing point and road edge. Meanwhile, secondary data was collected from various sources such as relevant agencies and literature, including location maps, the 2023 PKJI Book, and scientific journals relevant to the PRI method.

2.4. Data Analysis Techniques

The collected data was then analyzed to evaluate road performance using the PKJI 2023 guidebook, identify potential conflicts between vehicles and pedestrians, analyze traffic conflicts, and calculate the PRI value using the formula proposed by to determine the level of crossing risk at the study site as an effort to improve pedestrian safety, especially for elementary school students.

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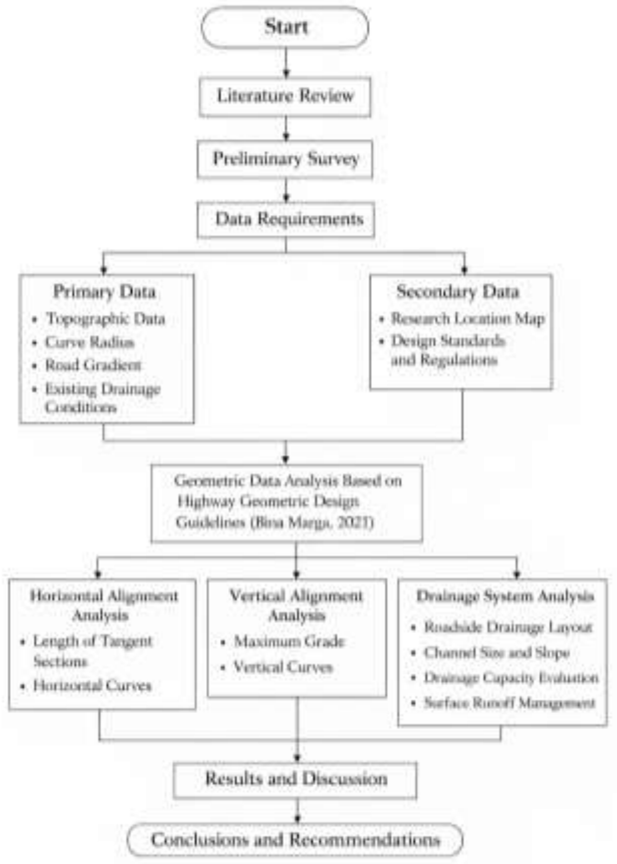

Fig. 1 Research Flow Chart

Fig. 2 Research Location

3. Research Method

A. Research Location

The research location is on the Pramuka Kalijaga road section – Pramuka road, Kedung Mendulang village, with a length of 2.3 km. Kedung Mendeng, spanning 2.3 km with coordinates of the starting point of the research location (N 9251707.68 E 228791.755) and the end point of the research location (N 9253771.94 E 228957.015).

Data collection was conducted using images from Google Earth to obtain information

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topography and existing conditions in the research area. In addition, Average Daily Traffic (ADT) data was also collected to determine the volume of vehicles passing through the road section. All data was then processed and illustrated using AutoCAD Civil 3D 2019 software. The following is the layout of the research location in its existing condition (Figure 3.1).

Tabel 1 Traffic Data ADT Plan 2025

(2) LIGHT VEHICLES	1.1	874		914
(5B) LARGE BUS	1.2	432		368
(6B) 2-AXLE TRUCK	1.2	111		135
(7A2) HEAVY 3-AXLE TRUCK	1.22	87		76
(7A3) HEAVY 3-AXLE TRUCK	11.22	99		82
(7B1) TRUM 4 HEAVY AXES	1.2+2.2	47		67
(7C2A) 5-AXLE HEAVY TRUCK	1.22+22	16		9
TRAFFIC GROWTH (% PER YEAR)		8		4
PLANNED SPEED (KM/H)			70	
Pavement Age			15	
CBR			5.5	
RAINFALL			1900 - 2500	
SLOPE			3	
BINDING MATERIAL			HRS - WC	

Fig 3. Contour Map of Research Location

B. Field Data Analysis

1. Horizontal Alignment Existing Conditions

Based on the data for the 4 curves in the table, the existing horizontal alignment shows angle variations between 20°01'26" and 53°53'11", with some fairly sharp curves. Changes in coordinates between points indicate a significant bend in the route. This condition indicates that some curves may have a radius smaller than the minimum standard of 130 m according to PDGJ 2021 and MDP 2024, so an evaluation of their geometric feasibility is needed.

2. Existing Vertical Alignment

The existing vertical alignment shows a gentle elevation change with a slope value between 0.00%–0.75%. The elevation ranges from 14,000 m to 17,461 m, indicating that the road has a smooth contour without steep inclines or declines. In general, these conditions describe a relatively flat and stable road, which supports driving comfort and minimizes the potential for water pooling.

C. Horizontal Alignment Planning

The horizontal alignment planning for this road route consists of four curves, each located at the following STA and angles: Curve 1 at STA 0+283.66 with an angle of 47°02'20", Curve 2 at STA 0+759.89 with an angle of 20°01'26", Curve 3 at STA 1+714.25 with an angle of 53°53'11", and Curve 4 at STA 2+051.25 with an angle of 36°17'27". Each curve has a radius of approximately 156 m with a design speed of 70 km/h and a maximum superelevation of 8% to ensure vehicle safety when turning. The average spiral curve length is 66.53 m, and the curve widening is 1.81 m, designed to allow vehicles to maneuver smoothly. Overall, the calculations show that this horizontal alignment meets road geometric standards and provides comfort and safety for road users.

D. Road Length Numbering *(*Stationing*)*

Stationing is the numbering of road lengths at the planning stage of new curves/alignments with numbers at specific intervals at the start of the work. The stationing numbering method starts from STA (0+000) from the start of the work.

Tabel 2 Summary of Curves 1–4 Horizontal Alignment

No	CALCULATION	T1	T2	T3	T4
1	ANGLE	47.03888889	20.02388889	53.88638889	36.29083333
2	T	3	3	3	3
3	e max	0.08	0.08	0.08	0.08
4	e n	0.02	0.02	0.02	0.02
5	re	0.035	0.035	0.035	0.035
6	V	63	63	63	63
7	V plan	70	70	70	70
8	R	156.2598425	156.2598425	156.2598425	156.2598425
9	R max	290	290	290	290
10	C	0.4	0.4	0.4	0.4
11	m	15	15	15	15
12	Full circle (1) :	Cannot be used	Cannot be used	Cannot be used	Cannot be used
13	Full circle (2) :				
	dd	9.166782565	9.166782565	9.166782565	9.166782565
	ed	0.05	0.05	0.05	0.05
14	Full circle (3) :				
	Ls (time)	52.5	52.5	52.5	52.5
	Ls (centrifugal)	66.535875	66.535875	66.535875	66.535875
	Ls (slope)	30	30	30	30
	Max value	66.535875	66.535875	66.535875	66.535875
15	P check:	1.180465017	1.180465017	1.180465017	1.180465017
16	SCS or SS :				
	θs	12.19835104	12.19835104	12.19835104	12.19835104
	θc	22.64218682	-4.372813183	29.48968682	11.89413126
	Lc	61.75087548	-11.92574925	80.42571123	32.4382545
17	Check SCS or SS	SCS	SCS	SCS	SCS
	Xs	66.23428783	66.23428783	66.23428783	66.23428783
	Ys	4.721860066	4.721860066	4.721860066	4.721860066
	P	-148.0099439	-148.0099439	-148.0099439	-148.0099439

	K	33.217104	33.217104	33.217104	33.217104
	Tt	278.4672293	275.5410457	279.6916346	277.0667995
	Et	-1283.075118	-1284.737506	-1282.129156	-1284.010195
	L total	194.8226255	121.1460008	213.4974612	165.5100045
18	Tik Expansion	1.818396443	1.818396443	1.818396443	1.818396443
19	Jh :	184.2316514	184.2316514	184.2316514	184.2316514
20	Jd	308.20295	308.20295	308.20295	308.20295

Based on the geometric calculations of the road section on Jalan Pramuka STA 0+000 – STA 2+523.51, it was found that the existing conditions generally still require adjustments to meet urban road geometric standards. The analysis results show that four curves with a radius of ±156 m and a design speed of 70 km/h are in accordance with the 2021 PDGJ standards. The vertical alignment has a gentle slope between 0.00–0.75%, indicating stable topography and safe conditions for traffic. The resulting design elevation also provides good contour adjustments to field conditions. Overall, the horizontal and vertical alignment planning ( ) has met technical requirements, ensuring the comfort and safety of road users, and can serve as a basis for infrastructure improvement planning on the Pramuka Road section.

E. Horizontal Alignment Planning

The vertical alignment needs to be re-planned in accordance with planning standards to meet the standards used. Therefore, it is necessary to re-plan the vertical alignment. Based on the results of the analysis of the original ground elevation of the road cross-section, the planned elevation for the vertical curve is taken as described in the following table:

Tabel 3. Vertical Alignment Planning

Planning					
Point	**STA**	**Elevation CL (m)**	**g (%)**	**A (%)**	**Requirements G≤ 8%**
A	0 + 000	733,936	0.830	-4.925	OK
PPV1	0 + 495	736.01	5,755	-1,276	OK
PPV2	0 + 985	764,786	4,479	7,112	OK
PPV3	1 + 330	720.00	-2,633	-	OK
PPV4	1 + 760	710,000	3,500	-	OK
PPV5	2 + 209.96	700,000	2,900	-	OK
B	2 + 520	699.89	-	-	OK

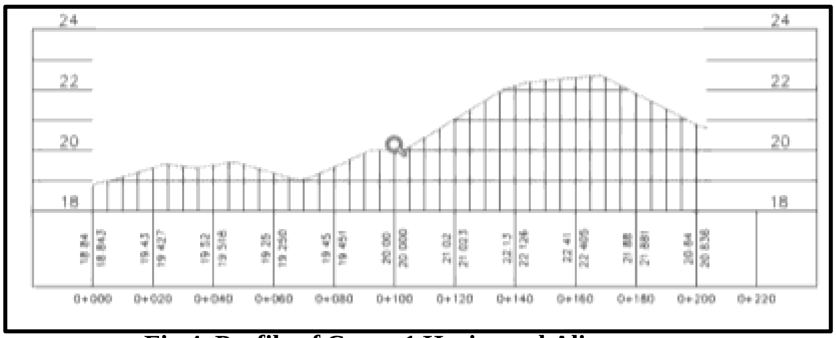

Fig 4. Profile of Curve 1 Horizontal Alignment

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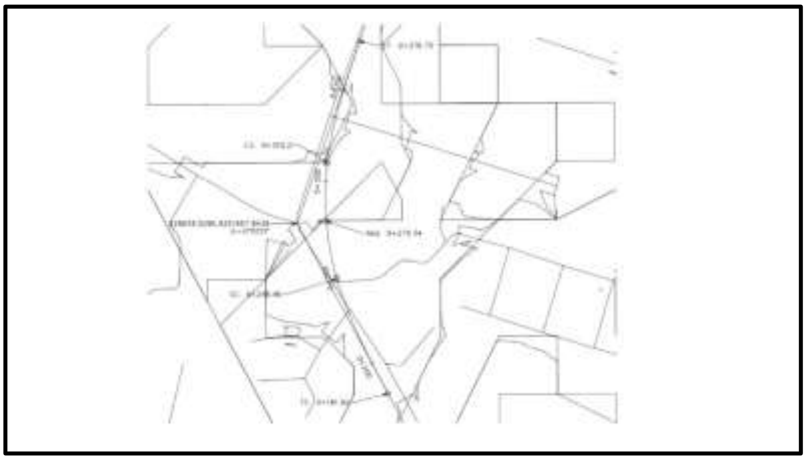

Fig 5. Curve 1 Horizontal Alignment

F. Drainage Analysis

Primary local road project (ikk – ikk) with a length of 2.3 km. The horizontal alignment and vertical alignment plans have been finalized. Data:

a. Average longitudinal slope: 3.0%
b. Pavement width:
c. Local drainage area coefficient (c_weight): 0.7 (Mountainous area)

Kondisi Permukaan Tanah	C
* Lereng - tanah berbutir halus	0,40-0,65
- tanah berbutir kasar	0,10-0,30
- tanah batuan keras (hardrock)	0,70-0,85
- tanah batuan lunak (softrock)	0,50-0,75
* 'Turf' Diselimuti tanah berpasir	
- Kemiringan 0-2 %	0,05-0,10
- Kemiringan 2-7 %	0,10-0,15
- Kemiringan >7 %	0,15-0,20
Diselimuti tanah 'cohesive'	
- Kemiringan 0-2 %	0,13-0,17
- Kemiringan 2-7 %	0,18-0,22
- Kemiringan >7 %	0,25-0,35
* Daerah perbukitan	0,30-0,50
* Daerah pegunungan	0,50-0,70
* Sawah dan genangan air	0,70-0,80
* Padang ilalang	0,10-0,30

d. IDF data: T = 15 years, I = 1900–2500 mm/year
e. Channel material: Earth channel (n = 0.03)

G. Drainage Design

a. Rainfall data conversion (i)

I = 1900 – 2500 mm/year → s converted to mm/hour. (the largest value is taken, i.e., 2500 mm/year)

$$I = \frac{2500}{24 \times 365}$$

$$I = 0,29 \text{ mm/jam}$$

b. Calculate the cross-sectional area of the drainage trapezoid (a):

For the initial drainage cross-section design, use the following design assumptions:

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- B (channel width) = 1 m
- H (channel height) = 0,5 m
- Z (channel slope) = 1,5

Calculate the channel area (a) :

$$A = (B + ZH).H$$
$$A = (1 + (1{,}5 \times 0{,}5) \times 0{,}5$$
$$A = 1{,}37\ m^2$$

c. Calculate flow rate q :

$$Q = \frac{1}{3{,}6} \times C \times I \times A$$

$$= \frac{1}{3{,}6} \times 0{,}7 \times 0{,}29 \times 4$$

= 0,22 m^3/s

d. Calculate the velocity (v) :

$$V = \frac{Q}{A}$$

$$= \frac{0{,}22}{4}$$

$$= 0{,}055\ m/s$$

(because the velocity is less than 0.6 > 0.14, it is sedimentation soil). Therefore, it is necessary to redesign the cross-section.

e. Redesign drainage:

For the next drainage cross-section design, use the following design assumptions as follows:

- B (channel width) = 0,5 m
- H (channel height) = 0,5 m
- Z (channel slope) = 1,5

Calculate the channel area (a) :

$$A = (B + ZH).H$$
$$A = (0{,}5 + (1{,}5 \times 0{,}5) \times 0{,}5$$
$$A = 0{,}875\ m^2$$

f. Calculate the velocity (v):

$$V = \frac{Q}{A}$$

$$= \frac{0{,}5}{0{,}875}$$

$$= 0{,}6\ m/s$$

(because the velocity meets the requirement of 0.6 < 0.76, the soil is sedimented). Therefore, the trapezoidal drainage design is met

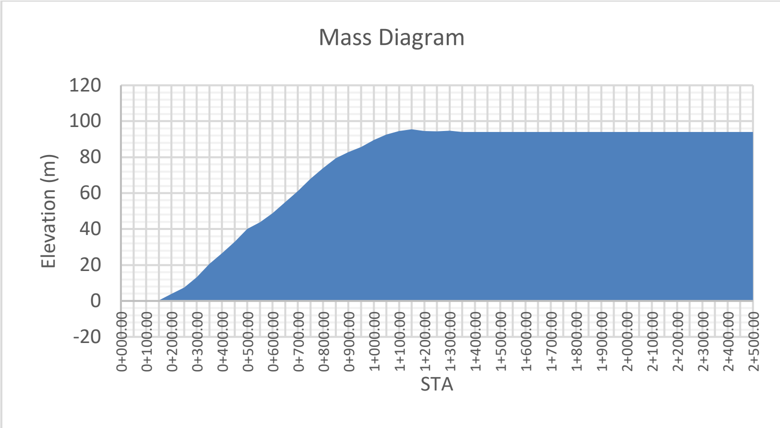

Fig 6. Mass Diagram Analysis

4. Conclusion

1). Based on the results of the geometric analysis of the Pramuka Road section in Harjamukti District, Cirebon City, from STA 0+000 to STA 2+520, it was found that the horizontal and vertical alignments meet the geometric standards for urban roads in accordance with PDGJ 2021. 2). The planning results show that there are four main curves with a radius of approximately 156 meters and a planned speed of 70 km/h, which have been equipped with a maximum superelevation of 8% to ensure vehicle comfort and safety when maneuvering. 3). In terms of vertical alignment, the slope (g) ranges from 0.00% to 7.11%, which is still below the maximum permissible limit (8%), meaning that the terrain is classified as hilly and safe for traffic. 4). The planned elevation (CL elevation) shows good contour adjustment to field conditions, resulting in a road with a smooth slope and free from extreme inclines or declines. 5). Overall, the planning results indicate that the existing conditions require minor adjustments to the vertical design, but in general, they already meet the technical, comfort, and safety aspects for road users.

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