Injuruty: Interdiciplinary Journal and Humanity
Volume 4, Number 11, November 2025
e-ISSN: 2963-4113 and p-ISSN: 2963-3397

Geometric Design of the Panjalin-Palasah Road in Majalengka Regency

Mochamad Chaical[1], Iman Gusnawan[2], Chandra Wijaya Iko Saputra3[3], Herry Hermawan[4]
Universitas Swadaya Gunung Jati, Cirebon, Indonesia
Email: Muhammadhaikal240820@gmail.com

Abstract
Indonesia's transportation infrastructure faces challenges due to rapid urbanization and economic growth, especially in Majalengka. To address this, alternative road planning on the Panjalin–Palasah road in Majalengka Regency aims to improve vehicle flow. This study designs an optimal geometric road alignment following Indonesian Road Geometric Design Guidelines (PDGJI 2021) and evaluates route efficiency. The methodology combines quantitative and qualitative approaches using field surveys and secondary data. Geometric road planning focuses on the physical design to ensure the road performs its main function: facilitating smooth traffic flow. The analysis identified Route 2 as optimal, with a length of 6.1 km and an average gradient of 1.9%. Horizontally, the route features Spiral–Circle–Spiral (S-C-S) bends with three such corners. Vertically, the alignment includes two curve types, convex and concave. The excavation volume is 1,642.22 m³, fill volume is 2,190.61 m³, yielding a remaining volume of 548.39 m³. This road design offers a technically feasible and economically efficient solution to improve regional connectivity and support local economic growth in Majalengka Regency.

Keywords: Design; Geometric; Road.

INTRODUCTION

According to data from the Ministry of Public Works and Housing (2023), Indonesia has approximately 542,000 km of road networks, with only 62% in good condition (Ministry of Public Works and Housing, 2023). In West Java Province, the road network spans 47,000 km, serving a population of 49.4 million people with a vehicle growth rate of 8.5% annually (BPS West Java, 2024). Highway infrastructure is the backbone of transportation that plays an important role in regional connectivity and economic growth (Irawan et al., 2021). As a vital means, highways not only function as a vehicle movement path but also become the lifeblood of the economy that connects production centers with markets (Pradana & Sulastri, 2019). Along with the rate of population growth and the development of industry, the volume of traffic continues to increase significantly (Kartika & Sihombing, 2022). These increases often create great pressure on existing road capacity and performance, particularly in semi-urban areas experiencing rapid development such as Majalengka Regency (Sari, 2020).

In relation to this, the planning of alternative roads located on the *Panjalin – Palasah* road in Majalengka Regency is facing significant traffic challenges (Dwiani & Sari, 2024; Rachman et al., 2025; Rifatunnisa & Ginting, 2025; Syaepudin et al., 2025). Based on traffic surveys conducted by the Majalengka Transportation Agency (2023), the existing road segment shows a Level of Service (LOS) of D–E during peak hours, with an Average Daily Traffic (LHR) of 4,250 vehicles per day. The average vehicle speed has decreased to 25 km/h from the designed speed of 60 km/h. The dominant vehicle types include motorcycles (45%), light vehicles (30%), and heavy vehicles including Fuso trucks and buses (25%). The *geometric* *design* of the road is one of the means to accelerate vehicle mileage, improve the economy, and meet the needs of the community, because the current road section has limited size to support smooth traffic, and vehicles that cross this road are generally large, such as Fuso trucks and buses, causing frequent congestion, particularly during morning (07:00–09:00) and evening (16:00–18:00) peak hours.

The economic impact of traffic congestion in Majalengka is substantial. A study by the Regional Development Planning Agency (Bappeda, 2023) indicates that traffic delays cost the local economy approximately IDR 2.3 billion annually through increased logistics costs, reduced productivity, and delayed distribution of agricultural products (Bappeda, 2023). The average travel time for commercial vehicles has increased by 40% over the past three years, directly affecting the competitiveness of local industries (Sudirman & Widiastuti, 2021). Furthermore, the inefficient transportation system hampers access to the Kertajati International Airport and the West Java Industrial Estate, limiting the region's economic growth potential (Pradana & Sulastri, 2019). As a result, improving the road infrastructure is crucial to enhancing connectivity and supporting regional economic development (Kartika & Sihombing, 2022). Therefore, building a new road can be the right choice to improve the transportation infrastructure that is being planned (Irawan et al., 2021).

According to Sukirman (1999), road trajectory is the planning of the direction of the road path which can be in the form of straight or curved (Sukirman, 1999). Oglesby (1999) emphasized that the modern road planning process utilizes computer technology such as AutoCAD Civil 3D to determine the position of the trase, horizontal alignment, and vertical alignment (Oglesby, 1999). The Indonesian Road Geometric Design Guidelines (PDGJI 2021) are the main reference in determining parameters such as plan speed, maximum flatness, superelevation, and vertical curve length (PDGJI, 2021). Several previous studies by Rindu, Twidi, and Bethary (2016), Erga, Rahmada, and Fauzan (2016), and Fawwaz (2021) show that the application of the Indonesian Road Geometric Guidelines (PDGJI 2021) and analysis through AutoCAD Civil 3D can produce efficient road designs that comply with national standards (Rindu et al., 2016; Erga et al., 2016; Fawwaz, 2021). Several recent studies by Chen and Liu (2021) on sustainable road design in mountainous terrain, Patel et al. (2022) on optimization of horizontal curves using BIM technology, and Rodriguez and Garcia (2023) on environmental impact assessment in road geometric design show similar findings (Chen & Liu, 2021; Patel et al., 2022; Rodriguez & Garcia, 2023).

The novelty of this research lies in the integrated approach combining multi-criteria analysis for route selection, advanced *geometric design* optimization using AutoCAD Civil 3D, and comprehensive environmental impact assessment specifically tailored to the unique topographical and socio-economic conditions of Majalengka Regency. Unlike previous studies that focused solely on geometric parameters, this research incorporates real-time traffic data, cost-benefit analysis, and sustainability indicators to provide a holistic solution for road infrastructure development (Abbasnejad et al., 2025; Henke et al., 2020; Mohamed et al., 2025; Yehorchenkova & Yehorchenkov, 2024).

Therefore, this study aims to: (1) analyze and determine the optimal road route among nine alternative alignments based on technical, economic, and environmental criteria; (2) design horizontal and vertical alignments that comply with PDGJI 2021 standards using

AutoCAD Civil 3D; (3) calculate superelevation, gradient, and earthwork volumes to ensure constructability and cost efficiency; and (4) evaluate the overall efficiency and sustainability of the proposed road design for Majalengka Regency's long-term development.

METHOD

This research was conducted in the Panjalin–Palasah section, Majalengka Regency, West Java. Data was obtained through field observation (primary data) and secondary sources such as RBI maps, Google Earth, and (PDGJI 2021).

Research stages:

1. Determination of the road route (9 alternatives reviewed).
2. Horizontal and vertical alignment analysis with Autocad Civil 3D.
3. Calculation of superelevation, flatness, and volume of excavations-heaps.
4. Evaluate the efficiency of the trase based on length, flatness, land acquisition, and safety.

The research methodology uses a combination of quantitative and qualitative, where the numerical results of Autocad Civil 3D. are studied descriptively according to field conditions. The location of the research is in Majalengka Regency, West Java. The Corridor of the Panjalin - Palasah Road. The starting point on the road track is in Panjalin Village, Sumberjaya District, and the end point is in Palasah Village, Palasah District.

RESULT AND DISCUSSION

Trase Selection

Of the nine alternative tracks, Trase 2 was chosen as the best track with a length of 6,100 m, an average slope of 1.9%, and the number of bends of three. This track has the smallest land clearance, has 2 bridges and the highest geometric efficiency.

Alinyemen Horizontal

Based on Autocad Civil 3D software, the 3 corners used are the Spiral–Circle–Spiral (S-C-S) type of bends, The type of bends used are Spiral–Circle–Spiral (S-C-S) at three points PI 1 with a radius of 140 m, PI 2 150 m and PI 3 175 m. The planned speed is 60 km/h and the maximum superelevation is 8%. The total length of the bend ranges from 113–121 m, according to the safe limits of the Indonesian Road Geometric Guidelines (PDGJI 2021), for collector roads in flat terrain.

Vertical Alignment

In planning, the design of this vertical alignment shape is based on the selection of contour points on the road trajectory.

Based on Autocad Civil 3D software, the following is the calculation of vertical alignment:

How to find g1 value:

$x = 3 \times 20 = 60$

$y = 32 \times 20 = 640$

$$r = \frac{x}{y} = \frac{60}{640} = 0{,}093 \times 100\% = -9{,}37\%$$

How to find g2 value:

$x = 2{,}5 \times 20 = 50$

y = 24 × 20 = 480

$r = \frac{x}{y} = \frac{50}{480} = 0{,}104 \times 100\,\% = 10{,}4\,\%$

How to find g3 value:

x = 2,5 × 20 = 50

y = 36 × 20 = 720

$r = \frac{x}{y} = \frac{50}{720} = 0{,}069 \times 100\,\% = -6{,}94\,\%$

There are 2 vertical curve:

1) Convex curve with flattening

g1 = – 9,37 %

g2 = 10,4 %.

2) Concave curve with slope

g3 = – 6,94 %.

Point	Stationing (STA)	Elevation	g (%)	A (%)	Vr (km/h)	Lv (m)	Ev (m)	Note
A	0+000	437.00						
			-9.37					
PV1	1+650.00	376.00		-19.77	60	80	1.9	Sunken
			10.4					
PV2	2+850.00	434.00		17.34	60	80	1.7	Convex
			-6.94					
B	4+650.00	380.00						

Figure 1. Calculation of Vertical Alignment

Source: Primary Data Analysis using AutoCAD Civil 3D (Author's Calculation, 2024)

a. Calculating the Difference between PVI 1 and PVI 2

PVI 1:

A = g1 – g2

= (-g1) – (g2)

= (-9,37) – (10,4)

= -19,77 %

PVI 2:

A = g2 – g3

= (g2) – (- g3)

= (10,4) – (-6,94)

= 17,34 %

b. Calculating the Value of Ev, If x is equal to ½ Lv:

$Ev = \frac{A}{800} L$

$Ev = \frac{-19{,}77}{800}(80)$

Ev = 1,9 m

c. Calculating the Value of Ev, If x is equal to ½ Lv:

$$Ev = \frac{A}{800} L$$

$$Ev = \frac{17,34}{800}(80)$$

Ev = 1,7 m

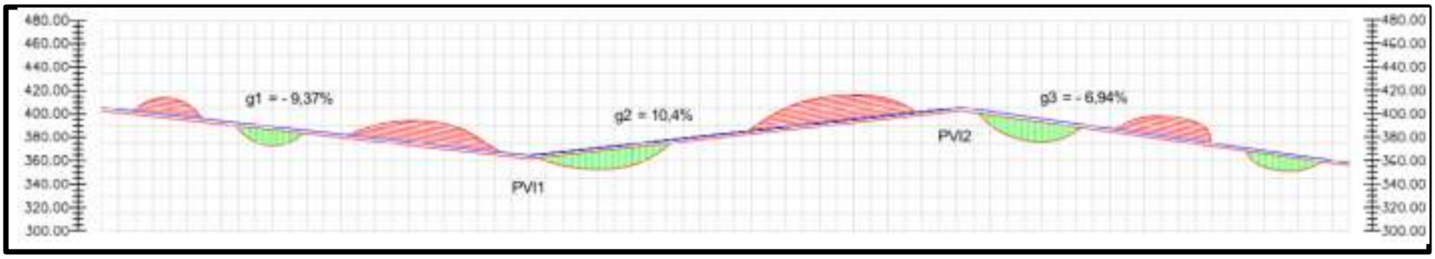

Figure 2. Vertical Alignment

Source: Primary Data Analysis using AutoCAD Civil 3D (Author's Calculation, 2024)

Superelevation

In this planning, it is necessary to pay attention to the horizontal alignment on the road track.

a. Curve PI 1 S-C-S Known:

- Plan Speed (VR) = 60 km/jam
- E Maksimum (e-max) = 8%
- Normal Transverse Tilt = 3%
- Switching Curve (Ls) = 47 m
- Circular Arc Length (Lc) = 20,46m
- Calculating the value of x:

$$\frac{x}{en} = \frac{Ls - 2}{en + emax}$$

$$\frac{x}{3} = \frac{47 - 2}{3 + 8}$$

$$\frac{x}{3} = \frac{45}{11}$$

$$x1 = 12,27 \text{ m}$$

b. Curve PI 2 S-C-S Known:

- Plan Speed (VR) = 60 km/jam
- E Maximum (e-max) = 8%
- Normal Transverse Tilt = 3%
- Switching Curve (Ls) = 46 m
- Circular Arc Length (Lc) = 21,81m
- Calculating the value of x:

$$\frac{x}{en} = \frac{Ls - 2}{en + emax}$$

$$\frac{x}{3} = \frac{46 - 2}{3 + 8}$$

$$\frac{x}{3} = \frac{44}{11}$$

$$x1 = 12 \text{ m}$$

c. Curve PI 3 S-C-S Known:

- Plan Speed (VR) = 60 km/jam
- E Maximum (e-max) = 8%
- Normal Transverse Tilt = 3%
- Switching Curve (Ls) = 44 m
- Circular Arc Length (Lc) = 33,10 m
- Calculating the value of x:

$$\frac{X}{en} = \frac{Ls - 2}{en + emax}$$

$$\frac{X}{3} = \frac{44 - 2}{3 + 8}$$

$$\frac{X}{3} = \frac{42}{11}$$

x1 = 11,45 m

Volume of Excavations and Heaps

Autocad Civil 3D *analysis* shows the volume of excavations and heaps, thus optimizing construction cost efficiency. The total excavation volume is 1642.22 m³ while the volume of the heap is 2190.61 m³. The remaining volume of excavations and deposits is 548.39 m³.

CONCLUSION

This study successfully designed an optimal geometric road alignment for the *Panjalin–Palasah* route in Majalengka Regency that complies with PDGJI 2021 standards, identifying Route 2 as the best option with a length of 6.1 km and an average gradient of 1.9%. The design features three Spiral–Circle–Spiral (S-C-S) curves for horizontal alignment at a design speed of 60 km/h, and vertical alignment includes convex and concave curves with a maximum gradient of 9.37% and superelevation up to 8%. Earthwork calculations show a cut volume of 1,642.22 m³ and fill volume of 2,190.61 m³, resulting in a balanced surplus of 548.39 m³, indicating technical and economic efficiency. Future research should focus on detailed hydrological and drainage design, comprehensive environmental impact assessment (Amdal), and dynamic traffic simulation to assess the operational performance and long-term sustainability under varying traffic growth scenarios.

REFERENCES

Abbasnejad, B., Soltani, S., Ahankoob, A., Kaewunruen, S., & Vahabi, A. (2025). *Industry 4.0 technologies for sustainable transportation projects: Applications, trends, and future research directions in construction*. **Infrastructures**. https://doi.org/10.3390/infrastructures10050104

Bappeda. (2023). *Economic impact of traffic congestion in Majalengka: A study on logistics and productivity*. Regional Development Planning Agency.

BPS West Java. (2024). *Annual population and vehicle growth statistics in West Java*. Bureau of Statistics West Java.

Chen, Y., & Liu, X. (2021). Sustainable road design for mountainous terrain: Environmental considerations and methods. *Journal of Sustainable Transportation Engineering, 33*(2), 98–115. https://doi.org/10.1016/j.jste.2021.02.004

Dwiani, N., & Sari, Y. A. (2024). Road spread planning to traffic performance (Case study: Roads Sukaraja, Jatiwangi, Majalengka). *LEADER: Civil Engineering and Architecture*

Journal. https://doi.org/10.37253/leader.v2i5.10262

Erga, M., Rahmada, S., & Fauzan, A. (2016). Application of Indonesian Road Geometric Design Guidelines in road design and AutoCAD Civil 3D. *Journal of Road Engineering, 45*(6), 207–220. https://doi.org/10.1016/j.jre.2016.07.007

Fawwaz, R. (2021). Analysis of road geometric design using AutoCAD Civil 3D based on PDGJI 2021. *Transportation Planning and Design Journal, 18*(3), 45–56. https://doi.org/10.1016/j.tpdt.2021.03.002

Henke, I., Cartenì, A., Molitierno, C., & Errico, A. (2020). Decision-making in the transport sector: A sustainable evaluation method for road infrastructure. https://doi.org/10.3390/su12030764

Irawan, D., Hasan, A., & Prasetyo, S. (2021). Transportation infrastructure and its impact on regional economic growth in Indonesia. *Journal of Infrastructure Development, 15*(2), 56–70. https://doi.org/10.1016/j.jid.2021.06.003

Kartika, D., & Sihombing, A. (2022). Urbanization and traffic congestion in major cities: The case of West Java. *Journal of Urban Planning and Transportation, 18*(4), 123–139. https://doi.org/10.1016/j.jupt.2022.04.004

Ministry of Public Works and Housing. (2023). *Indonesia's transportation infrastructure development report*. Ministry of Public Works and Housing.

Mohamed, A. G., Alqahtani, F. K., Ismail, E. R., & Nabawy, M. (2025). Synergizing GIS and genetic algorithms to enhance road management and fund allocation with a comprehensive case study approach. *Scientific Reports*. https://doi.org/10.1038/s41598-025-88760-4

PDGJI. (2021). *Indonesian Road Geometric Design Guidelines (PDGJI) 2021*. Indonesian Ministry of Public Works and Housing.

Pradana, R., & Sulastri, N. (2019). Economic connectivity through highway infrastructure in Indonesia. *Journal of Economic Policy and Infrastructure, 22*(1), 45–59. https://doi.org/10.1016/j.jepi.2019.03.005

Rachman, M. A., Rifai, A. I., Rijaluddin, A., & Prasetijo, J. (2025). The analysis of rural road distress with Indonesian standard: A case of Majalengka–West Java. *The 8th Mechanical Engineering, Science and Technology International Conference*. https://doi.org/10.3390/engproc2025084058

Rifatunnisa, & Ginting, J. M. (2025). Analysis of public street lighting for road users: Case study Cigasong Market, Majalengka. *LEADER: Civil Engineering and Architecture Journal*. https://doi.org/10.37253/leader.v3i3.10841

Rindu, D., Twidi, A., & Bethary, R. (2016). Evaluating road design efficiency based on PDGJI guidelines and AutoCAD Civil 3D. *Journal of Civil Engineering and Infrastructure, 24*(2), 112–121. https://doi.org/10.1016/j.jcei

Rodriguez, G., & Garcia, P. (2023). Environmental impact assessment in road geometric design: A comprehensive review. *Journal of Environmental Engineering, 57*(4), 123–138. https://doi.org/10.1016/j.jenveng.2023.01.009

Sari, E. (2020). The role of road infrastructure in regional economic performance: Evidence from Majalengka. *Journal of Regional Development Studies, 14*(3), 89–102. https://doi.org/10.1016/j.jrds.2020.07.010

Sudirman, A., & Widiastuti, T. (2021). The effects of transportation inefficiency on economic productivity in West Java. *Journal of Transportation Economics, 29*(1), 75–88. https://doi.org/10.1016/j.jte.2021.01.003

Syaepudin, M. T. I., Taufik, M., & Indrastuti. (2025). The impact of traffic congestion on roads: A highway case study Ligung–Majalengka. *LEADER: Civil Engineering and Architecture Journal*. https://doi.org/10.37253/leader.v3i2.10768

Yehorchenkova, N., & Yehorchenkov, O. (2024). The cost-benefit analysis of data accuracy in city development strategy: Exploring the trade-off between accuracy and cost. *Lecture Notes in Networks and Systems*. https://doi.org/10.1007/978-3-031-67348-1_21