Department of Digital Business
Journal of Artificial Intelligence and Digital Business (RIGGS)
Homepage: https://journal.ilmudata.co.id/index.php/RIGGS
Vol. 5 No. 1 (2026) pp: 4505-4515
P-ISSN: 2963-9298, e-ISSN: 2963-914X

Construction Process of the Original Road on Jl. Raya Waled Desa – Jl. Raya Jatimulya, Mekarjaya, Waled Subdistrict, Cirebon Regency

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Abstract

Road infrastructure design is an important aspect of regional development, especially in areas with high mobility such as Waled District, Cirebon Regency. This study aims to redesign the ±2.8 km section of Jl. Raya Waled Desa – Jl. Raya Jatimulya, Mekarjaya to meet the geometric standards for secondary collector roads as stipulated by the Directorate General of Highways. The research method was conducted through field surveys to obtain primary data on existing road conditions, topography, drainage, and traffic flow, which were then analyzed using civil engineering software such as Autodesk Civil 3D. The analysis results showed that the average width of the existing pavement was 5.5 meters with moderate to severe damage, so it needed to be widened to 6 meters to meet the standards. The maximum slope value of 3.2% is still within tolerance limits, but several points require elevation improvements to overcome flooding. Curve analysis shows that several segments have a radius of less than 90 meters, so superelevation improvements and curve widening are needed to ensure vehicle safety. Traffic load calculations (ESA5) show a total design load of 6,491,947 ESA (left direction) and 8,712,590 ESA (right direction), which are used as the basis for pavement thickness planning. In addition, a hydrological analysis using the Manning method resulted in a channel capacity of 1,643 m³/second with a flow velocity of 0.6 m/second, indicating that the drainage system needs improvement to accommodate rainwater runoff.

Keywords*: Road Design, Road Geometry, Road Drainage, Flexible Pavement, Mass Diagram*

1. Introduction

Road infrastructure is a key component in regional development, particularly in urban areas with high activity that require integrated and reliable access to support mobility and economic growth [1–4]. Urban development involves complex interactions across multiple sectors and stakeholders, where road infrastructure represents a crucial aspect of physical development [5–8].

Waled Subdistrict, Cirebon Regency, is a rapidly developing area, especially in the trade and agricultural sectors; however, the existing condition of the Jl. Raya Waled Desa – Jl. Raya Jatimulya road remains inadequate. Several segments experience pavement damage, potholes, and elevation irregularities caused by poor drainage and increasing traffic volume. Therefore, road infrastructure redesign in accordance with district geometric standards is necessary to improve safety, comfort, and mobility efficiency [9–12].

Road geometric planning focuses on designing the physical characteristics of the road to provide optimal traffic service, including pavement structure, construction type, and supporting road facilities based on field survey data and technical standards [13–19]. Proper geometric planning results in safe, comfortable, and economical roads; thus, in Indonesia, it must comply with the Road Geometric Design Guidelines No. 13/P/BM/2021 issued by the Directorate General of Highways [9, 20–22].

Road space is divided into Rumaja, Rumija, and Ruwasja, which respectively function as the road operational space, land-use control area, and clear sight and safety zone to ensure road functionality and traffic safety [23–27].

2. Research Method

2.1 Research Location

The research was conducted on the road section of Jl. Raya Waled Desa – Jl. Raya Jatimulya, Mekarjaya, Waled District, Cirebon Regency, with a total length of ±2.8 km. This road serves as a link between the economic center in Waled and the residential and agricultural areas in Jatimulya.

The location coordinates are at latitude 6°55'–6°57' S and longitude 108°40'–108°42' E. Road access is dominated by private vehicles and agricultural transport.

Figure 1. Research location

2.2 Data Analysis Techniques

Establishing design criteria

Determine road function & class, Vr = 70 km/h, flat-to-hilly terrain (≈2.5%), and cross-section type 2/2 TT. Determine superelevation (normal 2.5%, maximum 4%) and friction coefficient (≈0.147) as basic curve parameters.

Horizontal alignment

Determine curve type and spiral (SS) parameters for 5 curves with R = 250 m; calculate Ls, Ts, and related angles; prepare the superelevation diagram; then perform overlapping control between successive curves. According to TCPGJAK 1997 Table II.18, the minimum radius (R_min) for a Full Circle curve = 500 m > (R). The requirement for an S-C-S curve type is if $\theta_c > 0°$ and $L_c > 25$ meters. If one of these is not fulfilled, then the curve is of type S–S.

3. Results and Discussion

3.1. Data Analysis

1. Horizontal Alignment

Starting point coordinate	: -17815,41 + 48463,33
Turn 1 coordinates	: -17766,21 + 48510,1
Turn 2 coordinates	: -17658,55 + 48550,37
Coordinates of Turn 3	: -17592,52 + 48790,19
Coordinates of Turn 4	: -17502,55 + 49155,62
Coordinates of Turn 5	: -17663,49 + 49470,3
Coordinates of Turn 6	: -17578,87 + 49981,74
Coordinates of Turn 7	: -17419,45 + 50324,63
Coordinates of Final Turn	: -17244,42 + 50359,37

Traffic Data:
LHRT 2025: 5,284.83 vehicles/day (left), 3,719.30 vehicles/day (right)
LHRT Projection: 37,721.483 vehicles/day

Turns:

Turns 1 (Δ1)	= 22,97777778°
Turns 2 (Δ2)	= 54,09555556°
Turns 3 (Δ3)	= 1,563888889°
Turns 4 (Δ4)	= 40,91944444°
Turns 5 (Δ5)	= 36,48305556°

DOI: https://doi.org/10.31004/riggs.v5i1.6559

Turns 6 (Δ6) = 15,53972222°
Turns 7 (Δ7) = 53,84166667°
The type of curve used by SCS is 139,7233406

Visibility:
Stopping sight distance (Jh): 129,5906168 m
Preparatory sight distance: 497,1249197 m

2. Vertical Alignment
PVI Point
PV1 Point:
g1 : 0,009
g2 : -0,003
A : 0,012
Lv : 48
Ev : 0,72

PV2 Point:
g1 : -0,003
g2 : -0,006
A : 0,003
Lv : 48
Ev : 0,018

PV3 Point:
g1 : -0,006
g2 : 0
A : 0,006
Lv : 48
Ev : 0,036

This table presents the vertical alignment planning parameters, which include the initial grade (g_1), final grade (g_2), grade difference (A), vertical curve length (Lv), and curve elevation (Ev) at each PV point.

Tabel 1. Vertical Alignment

Vertical Curve Stationing					
Sta PLV	-24	-24	-24	49,4	m
	0+473,85	0+972,22	1+471,00	1+943,66	
Sta A	-12	-12	-12	24,7	
	0+485,85	0+984,22	1+483,00	1+968,36	
Sta PPV	0+497,85	0+996,22	1+495,00	1+993,06	
Sta B	12	12	12	-24,7	
	0+509,85	0+984,22	1+483,00	1+968,36	
Sta PTV	24	24	24	-49,4	
	0+473,85	1+020,22	1+519,00	2+042,46	
VERTICAL CURVE ELEVATION					
Elevation PLV	6,56	35,20	39,40	25,00	m
Elevation A	17,36	31,60	32,20	25,00	

Vertical Curve Stationing					
Elevation PPV		23,621	28,144	27,964	-5,505
Elevation B		28,15876	27,99856	24,99856	23,16973
Elevation PTV		28,16128	27,99856	25	23,77982
d	Stop sight distance safety requirements		71,00346457		

3.2. Vertical Alignment

Is the intersection point of two different gradients on the vertical alignment of a road connected by a vertical curve to produce a smooth elevation transition. The application of vertical curves aims to meet safety requirements, driving comfort, and stopping sight distance in accordance with road geometric design standards.

1. Vertical Alignment PV1

Shows the transition from an uphill to a downhill slope, which is smoothed by a vertical curve.

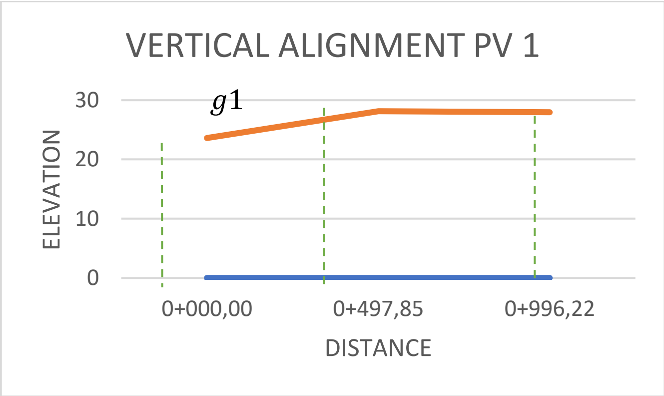

Figure 2.Vertical Alignment PV 1

2. Vertical Alignment PV2

Illustrates a relatively small change in slope, so that the vertical curve serves to refine the elevation transition.

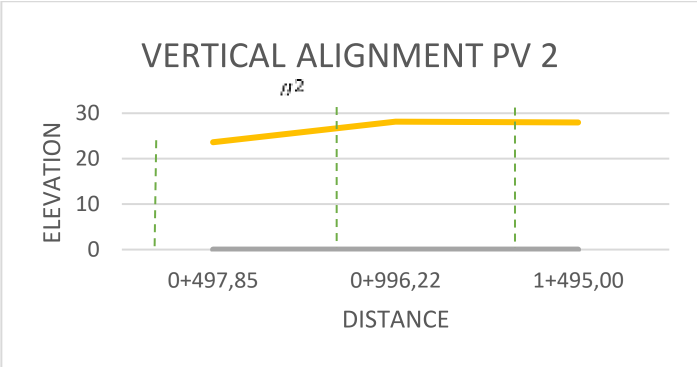

Figure 3.Vertical Alignment PV 2

3. Vertical Alignment PV3

Shows a change in slope towards a flat condition to improve comfort and visibility.

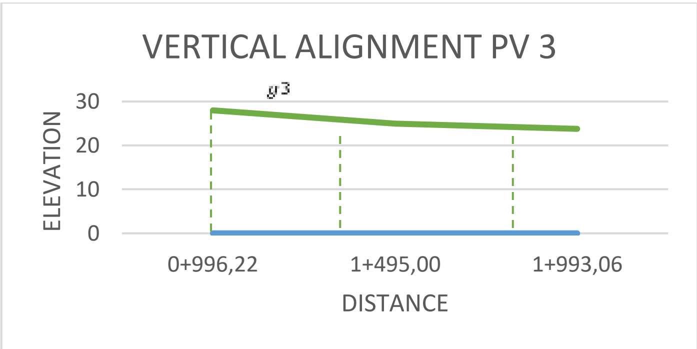

Figure 4.Vertical Alignment PV 3

4. Vertical Alignment PV4

Represents the slope adjustment at the end of the road section to maintain a safe and comfortable vertical profile.

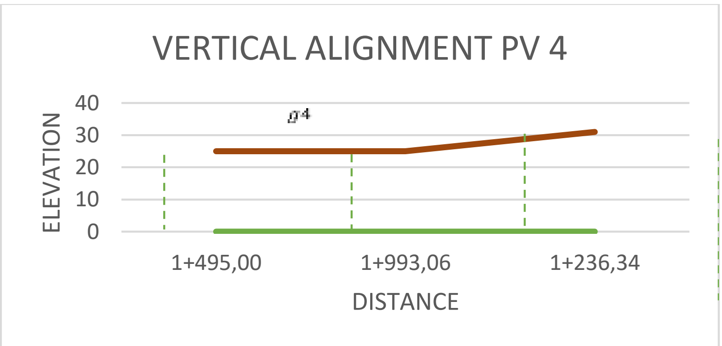

Figure 5.Vertical Alignment PV 4

3.3. Drainage planning

Debit calculation

$$\mathbf{Q = 0.278 \times C \times I \times A}$$

Q = 0.278 x 0,7 x 2500 x 4

DOI: https://doi.org/10.31004/riggs.v5i1.6559

Q = 1946 m^3/detik

Flow Velocity

$$\mathbf{V = Q/A}$$

= 0.5 / 0.875
≈ 0,6 m/detik (OK)

Calculate the free board height :

$$W = \sqrt{\mathbf{0,5}} \times \boldsymbol{h}$$

= 0.2 * 0.5
= 0.01m

3.4. Excavation and Fill Analysis

Excavation and embankment planning analysis is conducted to determine the volume of soil required for cut and fill work in road construction based on existing topographic conditions and geometric road design. By comparing the original ground elevation with the planned elevation, segments requiring excavation or embankment can be identified. The results of this analysis are essential for cost estimation, material planning, and improving construction efficiency in accordance with applicable technical standards

This image shows the distribution of excavation and fill depths at STA 0+500 This analysis is used to determine the excavation and embankment requirements for the initial segment of the road alignment.

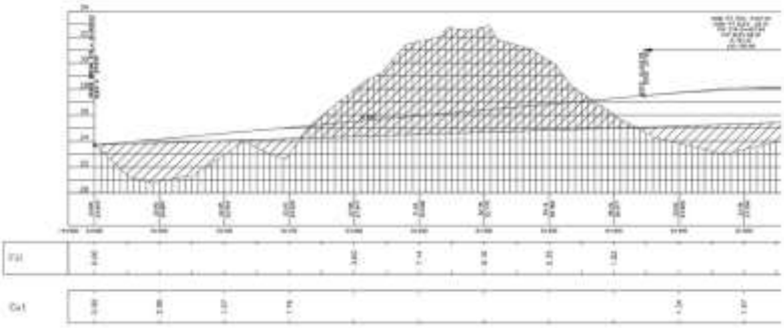

Figure 6. Cut&Fill Depth 0-500m

This image shows the distribution of excavation and fill depths at STA 0+500 to STA 1+000. Variations in the original ground elevation necessitate adjustments to the vertical profile in order to meet the geometric requirements of the road.

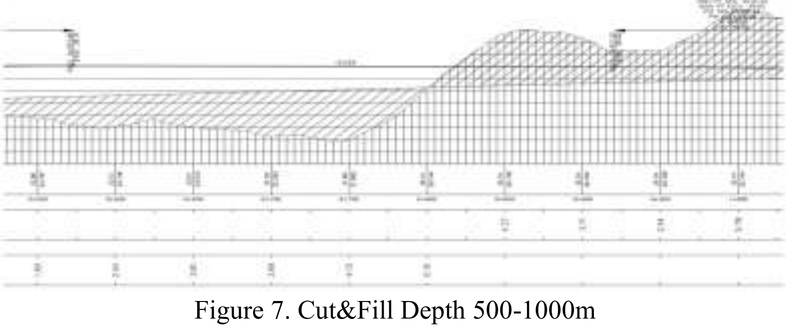

Figure 7. Cut&Fill Depth 500-1000m

DOI: https://doi.org/10.31004/riggs.v5i1.6559

This image shows the distribution of excavation and fill depths at STA 1+000 to STA 1+500. This image presents the cut and fill conditions in the middle segment of the road. This data is used as the basis for calculating the volume of earthworks in road construction planning.

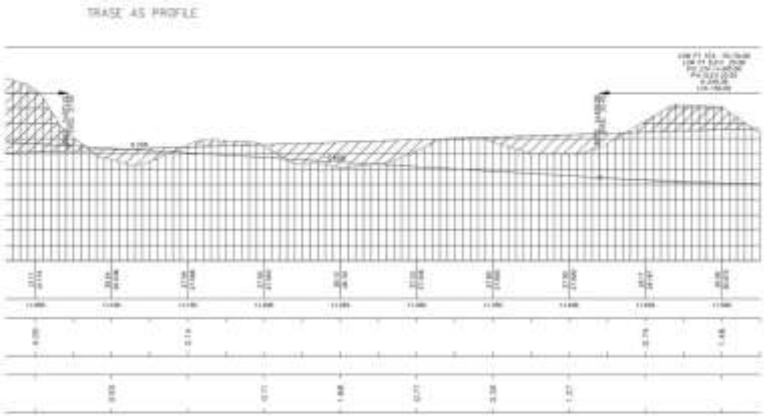

Figure 8. Cut&Fill Depth 1000-1500m

This image shows the distribution of excavation and fill depths at STA *1+500 to STA 2+200.* This figure illustrates the cut and fill requirements in the final segment of the road alignment, which are influenced by changes in ground elevation and adjustments to the geometric design of the road

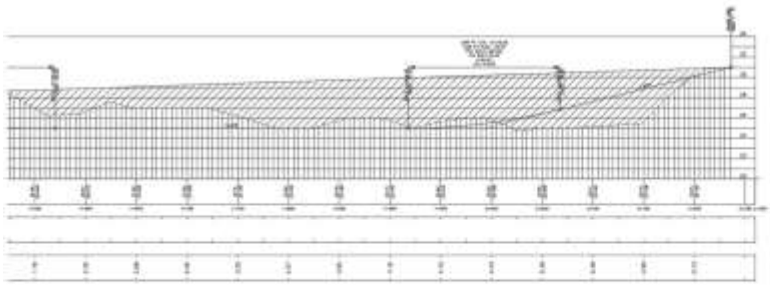

Figure 9. Cut&Fill Depth 1500-2200m

This diagram assists in planning the distribution of soil material to make construction work more efficient and economical.

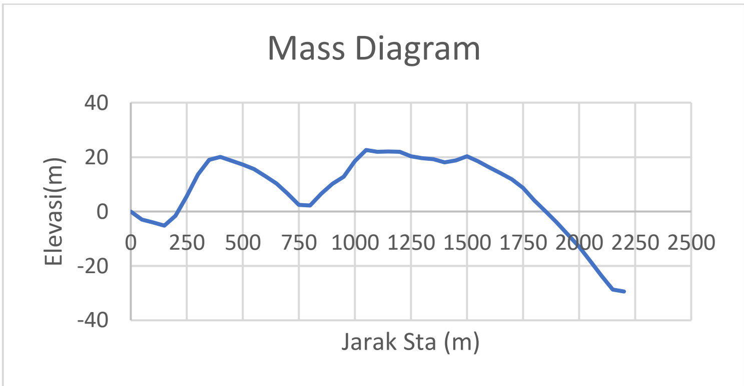

Figure 10. MassDiagram

3.5. Road Pavement Analysis
Road pavement thickness is the total vertical dimension of all structural layers that make up the road surthickness is determined through fundamental technical calculations, with the aim of effectively distributing vehicle traffic loads to the underlying layers down to the subgrade, without causing deformation or permanent damage to the road structure. Each pavement layer, which includes the surface layer (asphalt or concrete), upper foundation layer, and lower foundation layer, is designed with a specific thickness based on key parameters such as the bearing capacity of the subgrade as indicated by the CBR value, traffic load and volume characteristics, and the planned pavement life. face located above the subgrade. Pavement

1. Traffic Data
The data collected includes primary and secondary data. Primary data was obtained through field surveys that included topographic elevation measurements, average daily traffic (ADT) observations, and soil condition inspections.

Tabel 2. Traffic Data

Vehicle Class	Axle Configuration	Left Direction	Right Direction
(2) Light Vehicles	1.1	874	914
(5B) Large Buses	1.2	432	368
(6B) 2-Axle Trucks	1.2	111	135
(7A2) Heavy 3-Axle Trucks	1.22	87	76
(7A3) Heavy 3-Axle Trucks	11.22	99	82
(7B1) Heavy 4-Axle Trucks.	1.2 + 2.2	47	67
(7C2A) Heavy 5-Axle Trucks	1.22 – 22	16	9

Traffic growth before road opening (%/year)	5,50% 0,55%	8% 0,08
Design speed (km/h)	80	
Design life of pavement structure (years)	16	
CBR	4%	0,04
Rainfall (mm/year)	1900 – 2500	
Slope (%)	3%	0,03
Binding Material	AC – BC	
CTB	150mm	
LFA	Kelas B	
Lower Foundation Layer (LPB) Aggregate	Kelas B	

DOI: https://doi.org/10.31004/riggs.v5i1.6559

2. Cumulative Traffic Load Calculation Results CESA5

Tabel 3. Cumulative Traffic Load Calculation For CESA4 and CESA5 Left Side

Vehicle Class	**LHR 2041**		**LHR 2025**		**DD**	**DL**
	Left	Right	Left	Right		
(1)	(2)		(3)		(4)	(5)
(2) Light Vehicle	2058,5	3131,311576	874	914	0,5	0,8
(5B) Large Bus	1017,5	1260,746893	432	368	0,5	0,8
(6B) 2-Axle Truck	261,43	462,5022569	111	135	0,5	0,8
(7A2) Heavy 3-Axle Truck	204,91	260,3716409	87	76	0,5	0,8
(7A3) Heavy 3-Axle Truck	233,17	280,9272968	99	82	0,5	0,8
(7B1) Heavy 4-Axle Truck	110,7	229,5381571	47	67	0,5	0,8
(7C2A) Heavy 5-Axle Truck	37,684	30,83348379	16	9	0,5	0,8

VDF 5	VDF 5 FAKTUAL	R(i=0,055) 2025-2041	CES A5	CES A5
			Normal Load	Load Faktual
(6)	(7)	(8)	(9)	(10)
-	-	16,00066002	-	-
1,3	1,3	16,00066002	6251509,454	2654272,687
0,4	0,4	16,00066002	950766,444	403677,451
6,3	33,6	16,00066002	3847632,953	8712704,994
-	-	16,00066002	-	-
-	-	16,00066002	-	-
8,6	21,5	16,00066002	2223957,156	2360625,374
		TOTAL	13273866,007	14131280,51
		TOTAL	27405146,514	

Tabel 4. Cumulative Traffic Load Calculation For CESA4 and CESA5 Right Side

Vehicle Class	**LHR 2041**		**LHR 2025**		**DD**	**DL**
	Left	Right	Left	Right		
(1)	(2)		(3)		(4)	(5)
(2) Light Vehicle	2058,499599	3131,312	874	914	0,5	0,8
(5B) Large Bus	1017,473486	1260,747	432	368	0,5	0,8
(6B) 2-Axle Truck	261,4341596	462,5023	111	135	0,5	0,8
(7A2) Heavy 3-Axle Truck	204,9078548	260,3716	87	76	0,5	0,8

(7A3) Heavy 3-Axle Truck	233,1710072	280,9273	99	82	0,5	0,8
(7B1) Heavy 4-Axle Truck	110,6973469	229,5382	47	67	0,5	0,8
(7C2A) Heavy 5-Axle Truck	37,68420319	30,83348	16	9	0,5	0,8

VDF 5	**VDF 5 FAKTUAL**	**R(i=0,08) 2025-2041**	**CES A5**	**CES A5**
			Normal Load	Load Faktual
(6)	(7)	(8)	(9)	(10)
-	-	16,00096	-	-
1,3	1,3	16,00096	9509738	2775802
0,4	0,4	16,00096	1178113	343880
6,3	33,6	16,00096	6806962	10596732
-	-	16,00096	-	-
-	-	16,00096	-	-
8,6	21,5	16,00096	4611606	3365210
		TOTAL	22106418	17081623
		TOTAL	39188041	

4. Conclusion

From the results of the geometric analysis of the road, it is known that the average width of the existing pavement is only about 5.5 meters with moderate to severe damage, so it needs to be widened to 6 meters to comply with secondary collector road standards and accommodate the increasing traffic volume. The horizontal alignment analysis shows that there are several bends with fairly large deflection angles and radii below the minimum requirements, thus requiring the application of Spiral-Circle-Spiral (SCS) bends, superelevation adjustments, and widening of bends to improve the safety and comfort of passing vehicles. Overall, the redesign of the road infrastructure on the Waled Desa Highway – Jatimulya Highway section is expected to improve road service quality, road user safety, and community mobility, particularly in supporting economic, agricultural, and social activities in Waled District and its surroundings, while also serving as a practical application of students' understanding of comprehensive road infrastructure design concepts in accordance with applicable technical regulations.

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DOI: https://doi.org/10.31004/riggs.v5i1.6559