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Geometric, Pavement, and Drainage Design of the Cibogo KM 9 Road Segment, Subang (± 2 km)

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Abstrak

Road infrastructure development is crucial for mobility and the economy; design must satisfy geometric, structural, and drainage aspects. The research method used was a direct survey in the field to obtain primary data in the form of horizontal curve data, vertical slope, and other existing road geometric conditions. In addition, secondary data was obtained through literature studies and relevant supporting technical documents. This study analyzes the geometry of the Cibogo KM 9 road segment, ± 2 km, in Padaasih Village, Subang. Referring to PDGJ 2021 and PKJI 2023; using 2025 LHR data, traffic growth of 8% (left direction) / 7.5% (right direction), a subgrade CBR of 5.5%, a design speed (V_r) of 70 km/h, and rainfall of 1,400–1,800 mm/year. The alignment produces 5 Spiral–Spiral curves with $R = 250$ m, the overlapping control is OK, and the cross-section type is 2/2 TT (two-lane, two-way, undivided). Drainage channel capacity from STA 0+000 – 2+024.63 using a $100 \times 100 \times 120$ cm channel type (precast concrete), at 100-meter intervals, results in $Q < Q_{sal}$. The design meets geometric criteria and base/drainage channel capacity requirements. These findings are expected to form the basis for recommendations for road improvements in the future.

Keywords: Road Geometric, Road Drainage, PDGJ 2021, Horizontal Curves.

1. Introduction

Road infrastructure development is the foundation of mobility and economic growth; a good design must integrate geometry, pavement structure, and drainage while also considering safety, operational efficiency, and environmental impacts [1, 2]. The design framework in this study follows national standards and guidelines so that performance and safety are fulfilled throughout the service life [3, 4].

The study focuses on the Cibogo KM 9 road segment in Padaasih Village, Cibogo Subdistrict, Subang Regency (West Java) with a length of ± 2 km, from “Cuci Steam Mobil & Motor Dua Putra” to “Kontrakan Pak Musli.” This segment connects residential areas, public facilities (Pertamina gas station 34.412.20, Alfamart), and industrial areas around PT LEN Technopark and PT Patna Lestari, making it strategically important for local movement. The location map and existing conditions refer to Google Earth imagery observations (2025) in the project document.



Figure 1. Location Map of the Cibogo KM 9 Road Segment, Padaasih Village, Cibogo, Subang

(source: Google Earth, 2025)

Traffic survey data in 2025 show that light vehicles dominate (>60%), while heavy vehicle composition remains significant for pavement loading. The projected traffic growth is 8.0% per year (left direction) and 7.5% per year (right direction) as the basis for determining the planned LHR and ESA [5–7]. The design speed (V_r) is set at 70 km/h in flat-to-hilly terrain with an average grade of 2.5%. The subgrade CBR of 5.5% is classified as moderate bearing capacity; annual rainfall in Subang is 1,400–1,800 mm/year, making surface drainage a critical element.

Referring to the geometric analysis in the document, the planned road segment is of type 2/2 TT, with five Spiral–Spiral (SS) curves and a design radius $R = 250$ m; design parameters include normal superelevation of 2.5%, maximum superelevation (e_{max}) of 4%, and a friction coefficient $f \approx 0.147$. Overlapping control between curves is stated as OK for all tested segments. Average daily traffic must be converted from smp/hour to vehicles/day referring to PKJI 2023 [8–11].

The objectives of this study are: to analyze road geometry (horizontal–vertical) and evaluate the existing road geometry. The practical contribution of this study is to present an integrated design for a 2/2 TT segment in flat-to-hilly terrain in Subang, with validation of geometric controls (including stopping sight distance ≈ 96.787 m) and example calculations of drainage discharge (Q) and channel capacity, which can be replicated for similar corridors in comparable regions [12–16].

2. Research Method

2.1 Framework and References

The analysis follows the 2021 Road Geometric Design Guide (PDGJ 2021) for geometric design and SNI 03-3424-1994 for drainage channel planning (Manning method, flow velocity limits). All technical parameters and data used were taken from the project document [2, 17].

2.2 Approach, Location, and Time of Study

The study location is in Padaasih Village – Cibogo (Subang) along ± 2 km. The road type is 2/2 TT with $V_r = 70$ km/h in flat-to-hilly terrain ($\approx 2.5\%$). Data collection was conducted from morning to afternoon so that observation of existing road conditions was carried out for 1 day.

2.3 Types and Sources of Data

Data were collected from two main sources: primary data and secondary data. Primary data were obtained from field surveys, while secondary data were gathered from various sources such as relevant institutions and literature, including location maps, PDGJ 2021, and relevant scientific journals.

2.4 Data Collection Techniques

In this study, the data collection techniques were field surveys to obtain primary data and secondary data. Primary data were obtained through field observation, including information on the availability and condition of road geometry, vehicle speed, and road edges. Secondary data were collected from various sources such as related institutions and literature, including location maps, PDGJ 2021, and relevant scientific journals [18–20].

2.5 Data Analysis Techniques

Establishing design criteria

Determine road function & class, $V_r = 70$ km/h, flat-to-hilly terrain ($\approx 2.5\%$), 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 L_s , T_s , and related angles; prepare the superelevation diagram; then perform overlapping control between successive curves. According to TCGJAK 1997 Table II.18, the minimum radius (R_{min}) for a Full Circle curve = $500 \text{ m} > (R)$. The requirement for an S–C–S curve type is if $\theta_c > 0^\circ$ and $L_c > 25$ meters. If one of these is not fulfilled, then the curve is of type S–S.

1. Spiral curve angle, calculated using the formula:

$$\theta_s = \frac{1}{2} \Delta \quad (2.6)$$

2. Central angle, calculated using the formula:

$$\theta_c = \Delta - 2 \times \theta_s \quad (2.7)$$

3. Circular arc length, calculated using the formula:

$$L_c = \frac{\theta_c \times \pi \times R}{180} \quad (2.8)$$

4. Transition curve length, calculated using the formula:

a. Based on 3-second travel time:

$$L_s = \frac{V_R}{3,6} T \quad (2.9)$$

b. Based on anticipation of centrifugal force:

$$L_s = 0,022 \frac{V^3}{Rc \cdot C} - 2,727 \cdot \frac{V \cdot c}{C} \quad (2.10)$$

c. Based on the rate of grade attainment:

$$L_s = \frac{e_m - e_n}{3,6 \cdot 0,025} V_R \quad (2.11)$$

5. Tangent shift to the spiral:

$$p = \frac{L_s^2}{6R} - R(1 - \cos \theta_s) \quad (2.12)$$

6. Abscissa p on the spiral tangent line:

$$k = L_s \times \left(1 - \frac{L_s^2}{40 R^2}\right) - R \cdot \sin \theta_s \quad (2.13)$$

7. Tangent length from PI to TS or ST:

$$T_s = (R + p) \cdot \tan \frac{\Delta}{2} + k \quad (2.14)$$

8. Distance from PI to the apex of the circular arc

$$E_s = (R + p) \cdot \sec \frac{\Delta}{2} - R \quad (2.15)$$

9. SS curve length:

$$L = 2 \cdot L_s \tag{2.16}$$

Keterangan :

- L_s : Transition curve length
- V/V_R : Design speed
- T : Travel time
- R_c : Design radius
- C : Side friction coefficient
- e_m/e_{max} : Maximum superelevation
- e_n/e : Design superelevation
- L_c : Circular arc length
- θ_c : Central angle at the curve
- π : Circle constant
- R : Design radius
- R_{min} : Minimum radius
- Δ : Bearing angle
- θ_s : Spiral curve angle
- D_{max} : Maximum degree of curve
- e_{max} : Maximum superelevation
- D : Degree of curve
- f_{max} : Friction coefficient
- p : Tangent shift to the spiral
- k : abscissa p on the spiral tangent line
- T_s : Tangent length from PI to TS or ST
- E_s : Distance from PI to the apex of the circular arc
- L : SS curve length

Lateral clearance & sight distance

Stopping sight distance is the minimum distance required for a driver to see an obstacle ahead, and lateral clearance is the minimum clear distance on the inside of a curve so that the driver has sufficient stopping sight distance. The formulas used:

10. Stopping sight distance:

$$J_h = \left(\frac{V}{3,6} \times T \right) \left(\frac{\left(\frac{V}{3,6} \right)^2}{2 \times g \times f} \right) \tag{2.17}$$

11. Lateral clearance:

$$E = R \left(1 - \cos \frac{28,65 \cdot j_h}{R} \right) \tag{2.18}$$

Vertical alignment

Vertical alignment consists of tangents and curves. Vertical curves consist of two main types: crest curves and sag curves. From the starting point of design, tangents may be positive grades (uphill), negative grades (downhill), or zero grade (flat). The formulas used: (2.19) – (2.22).

$$g = \frac{\text{End elevation} - \text{Start elevation}}{\text{End STA} - \text{Start STA}} \times 100\% \quad (2.19)$$

$$A = g_2 + g_1 \quad (2.20)$$

$$L_v = \frac{A \times S^2}{100 \times \sqrt{2 \times Jh^2}} \quad (2.21)$$

$$y_1' = \frac{(A)}{200 \cdot L_v} \times x^2 \quad (2.22)$$

Surface drainage design

Road drainage is a system of road appurtenant structures that functions to convey, control, and dispose of water (rainwater and surface runoff) to prevent ponding that can damage the pavement. The formulas used:

Design discharge calculation:

$$Q = \frac{1}{3,6} \times I \times A \quad (2.23)$$

Discharge capacity calculation:

$$Q_{sal} = V_{ren} \times F \quad (2.24)$$

3. Results and Discussion

3.1. Horizontal Alignment

The planned segment is of type 2/2 TT in flat-to-hilly terrain ($\approx 2.5\%$) with $V_r = 70$ km/h. The alignment produces 5 Spiral–Spiral (SS) curves with $R = 250$ m; $e_n = 2.5\%$, $e_{max} = 4\%$, $f \approx 0.147$. The minimum spiral length from the comfort/3-second control is around $L_s \approx 62.25$ m. Overlapping control between curves meets the requirements: for example, A–PI1: $97.127 \text{ m} \leq 340.07 \text{ m}$ (OK); PI4–PI5: $163.824 \text{ m} \leq 384.02 \text{ m}$ (OK); PI5–B: $92.799 \text{ m} \leq 508.92 \text{ m}$ (OK). Stopping sight distance ($V_r = 70$ km/h) is computed as $J_h \approx 96.787$ m and is used as a reference for clear sight on representative curves.

Table 1. Recapitulation of Horizontal Alignment Calculations

Description	T1	T2	T3	T4	T5
Bearing Angle	125,09	15,93	124,47	150,38	61,79
θ_s	62,547	7,963	62,23	75,19	30,90
θ_c	0	0	0	0	0
Lc	0	0	0	0	0
Rc	250	250	250	250	250
e	0,039	0,039	0,039	0,039	0,039
C	0,4	0,4	0,4	0,4	0,4
Ls	62,251	62,251	62,251	62,251	62,251
P	-132,161	0,17	-130,95	-183,52	-32,89
k	-159,693	26,62	-159,96	-180,44	-67,12
L	116,666	124,50	124,50	124,50	124,50
Ts	67,127	61,61	66,16	71,03	62,80
Es	5,60	2,61	5,55	10,11	3,01
Jh	96,787	96,787	96,787	96,787	96,787
Jd	416,95	416,95	416,95	416,95	416,95

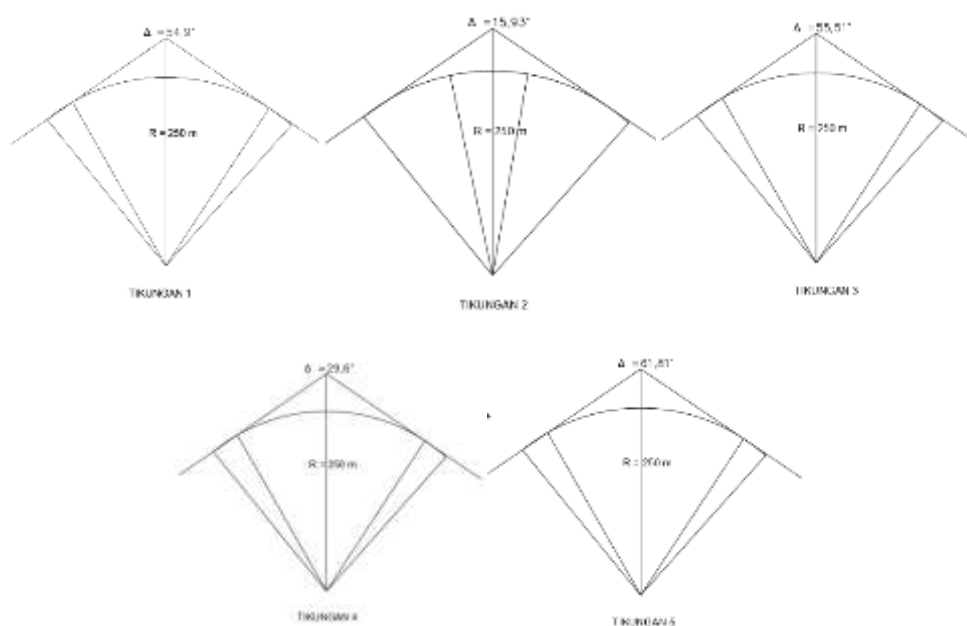


Figure 2. Horizontal Alignment

3.2. Vertical Alignment

Example of a crest vertical curve at PPV1 (STA 0+200) with $g_1 = 1.639\%$ and $g_2 = -3.819\%$ yields $L_v \approx 97.246$ m; PLV/PTV elevations are traced consistently from the gradient values. Another crest vertical curve example at PPV3 (STA 0+400) with $g_1 = -3.819\%$ and $g_2 = 1.873\%$ yields $L_v \approx 86.799$ m.

Table 2. Recapitulation of Vertical Alignment

CURVE POINT	Lv	PLV		A	
		STA	Elv.	STA	Elv.
PV1	97,246	0+151,377	61,416	0+175,688	61,811
PV2	86,799	0+356,60	56,232	0+378,30	55,614
PV3	80,216	0+609,892	58,507	0+629,946	58,880
PV4	85,450	1+557,3	47,977	1+578,6	47,396
PV5	157,311	1+621,3	47,600	1+660,7	49,790

Table 3. Continuation of Vertical Alignment Recapitulation

CURVE POINT	PPV		B		PTV	
	STA	Elv.	STA	Elv.	STA	Elv.
PV1	0+200	61,948	0+224,311	60,356	0+248,623	60,356
PV2	0+400,00	54,786	0+421,70	55,388	0+443,40	55,388
PV3	0+650	59,078	0+670,054	57,785	0+690,108	57,785
PV4	1+600,00	46,613	1+621,4	48,795	1+642,7	48,795
PV5	1+700,00	51,302	1+739,3	50,374	1+778,7	50,374

3.3. Drainage Channel

Rainfall intensity $I = 1800$ mm/hour is used as the intensity in the sample calculation. Channel slope is calculated based on a 100-meter interval distance. The channel type used is $100 \times 100 \times 120$ cm using precast concrete material with Manning coefficient $n = 0.014$. The resulting channel type at each STA is as follows:

Table 4. Recapitulation of Drainage Channel Calculations

STA	Q (m ³ /s)	n	Qsal (m ³ /det)	Q10<Qsal	Tipe Saluran
0+100	0,9	0,014	2,39	OK!	100X100X120
0+200	0,9	0,014	3,53	OK!	100X100X120
0+300	0,9	0,014	2,92	OK!	100X100X120
0+400	0,9	0,014	3,16	OK!	100X100X120
0+500	0,9	0,014	1,55	OK!	100X100X120
0+600	0,9	0,014	3,03	OK!	100X100X120
0+700	0,9	0,014	3,03	OK!	100X100X120
0+800	0,9	0,014	3,03	OK!	100X100X120
0+900	0,9	0,014	3,03	OK!	100X100X120
1+000	0,9	0,014	2,12	OK!	100X100X120
1+100	0,9	0,014	3,51	OK!	100X100X120
1+200	0,9	0,014	1,97	OK!	100X100X120
1+300	0,9	0,014	1,74	OK!	100X100X120
1+400	0,9	0,014	2,62	OK!	100X100X120
1+500	0,9	0,014	2,95	OK!	100X100X120

1+600	0,9	0,014	2,92	OK!	100X100X120
1+700	0,9	0,014	2,80	OK!	100X100X120
1+800	0,9	0,014	3,54	OK!	100X100X120
1+900	0,9	0,014	2,48	OK!	100X100X120
2+024,63	1,12	0,014	1,29	OK!	100X100X120

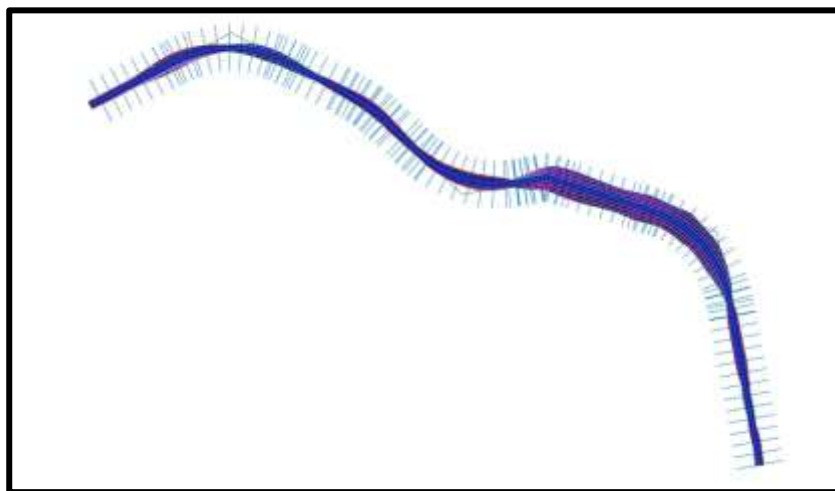


Figure 3. Research Location Design Plan

3. Conclusion

Road geometry meets the main safety controls. The ± 2 km 2/2 TT segment with $V_r = 70$ km/h results in 5 Spiral-Spiral curves ($R = 250$ m, $e_n = 2.5\%$, $e_{max} = 4\%$, $f \approx 0.147$). All overlapping controls for the tested curve pairs are OK, and the stopping sight distance ≈ 96.787 m is satisfied under the design condition. These findings indicate design consistency with PDGJ 2021 criteria for flat-to-hilly terrain. Drainage: capacity is adequate, flow velocity needs to be controlled. In the example STA 0+000–0+100, $Q \approx 0.9$ m³/s and channel capacity $Q_{sal} \approx 2.57$ m³/s (OK). In general, the integrated design has met the study objectives. Geometric and drainage elements support safe and reliable operation; however, further consideration is needed regarding flow velocity in the drainage channels.

Reference

1. Candra, B.Y.Y., Heryadiana, A.D., Prasetijo, J.: A Systematic Review of Geometric Road Design Evaluation Methods with AutoCAD Civil 3D Applications: Tinjauan Sistematis Metode Evaluasi Desain Geometris Jalan dengan Aplikasi AutoCAD Civil 3D. *RIGGS: Journal of Artificial Intelligence and Digital Business*. 4, 5237–5246 (2025)
2. Bina Marga: *Pedoman Desain Geometrik Jalan*. Kementerian Pekerjaan Umum dan Perumahan Rakyat, Jakarta (2021)
3. Isradi, M., Prasetijo, J., Prasetyo, Y.D., Hartatik, N., Rifai, A.I.: Prediction of Service Life Base on Relationship between PSI and IRI for Flexible Pavement. *Proceedings on Engineering*. 5, 267–274 (2023)
4. Isradi, M., Prasetijo, J., Irfan, A., Andraiko, H., Zhang, G.: The Prediction of Road Condition Value during Maintenance Based on Markov Process. *International Journal on Advanced Science, Engineering and Information Technology (IJASEIT)*. 14, 1083–1090 (2024). <https://doi.org/https://doi.org/10.18517/ijaseit.14.3.19475>
5. Isradi, M., Arifin, Z., Setiawan, M.I., Nasihien, R.D., Prasetijo, J.: Traffic Performance Analysis of Unsignalized Intersection Using the Traffic Conflict Parameter Technique. *Sinergi*. 26, 397 (2022). <https://doi.org/10.22441/sinergi.2022.3.015>
6. Azhari, A.N.Z., Isradi, M.: *Analysis of High-Risk Traffic Accident Areas on Tegar Beriman Road, Bogor Regency*. (2025)
7. Isradi, M., Nareswari, N.D., Rifai, A.I., Mufhidin, A., Prasetijo, J.: Performance Analysis of Road Section and Unsignalized Intersections in Order to Prevent Traffic Jams on Jl. H. Jole-Jl. Pasar Lama. *ADRI International Journal of Civil Engineering*. 6, 56–67 (2021)

8. Scalco, L., Bordin, F., de Souza, E.M., Brum, D., Racolte, G., Marques Jr, A., da Silveira Jr, L.G., Veronez, M.R.: Improving Geometric Road Design Through a Virtual Reality Visualization Technique. *Transportes*. 31, e2838–e2838 (2023)
9. Wang, L.: Safety Evaluation for Highway Geometric Design Based on Spatial Path Properties. *J. Adv. Transp.* 2023, 6685010 (2023)
10. Afolayan, A., Abiola Samson, O., Easa, S., Modupe Alayaki, F., Folorunso, O.: Reliability-based Analysis of Highway Geometric Elements: A Systematic Review. *Cogent Eng.* 9, 2004672 (2022)
11. Anugraha, P.T., Rifai, A.I.: Road Geometric Redesign used AutoCAD 2D A Case Jalan Majalengka-Rajagaluh. In: SEMINAR TEKNOLOGI MAJALENGKA (STIMA). pp. 329–337 (2024)
12. Wijaya, R.R., Isradi, M.: Geometric Road Evaluation on Sukanagara Road–Bukanagara Road, Lembang District, West Bandung Regency.
13. Muhammad Luthvan, S.F.: Perencanaan Geometrik Jalan Menggunakan AutoCAD Civil 3d Studi Kasus Jalan Duku–Sicincin Sta 0+ 000–Sta 2+ 700 Provinsi Sumatera Barat, (2021)
14. Setiawan, A.A., Tamsih, I.J.T.R.: Analisis Geometrik Jalan Raya dengan Pendekatan Bina Marga (Studi Kasus: Jl. Poros Tikungan SP 4, Kelurahan Makbalim, Kilometer 37, Kabupaten Sorong). *Jurnal Ilmiah Rekayasa Sipil*. 22, 114–123 (2025)
15. Anugraha, P.T., Rifai, A.I., Taufik, M., Isradi, M.: The redesign of provincial road geometric used AutoCAD® 2D: A case Jalan Majalengka-Rajagaluh, Indonesia. *Indonesian Journal of Multidisciplinary Science*. 3, (2024)
16. DGH: Departemen Pekerjaan Umum Direktorat Jenderal Bina Marga. (2009)
17. Sukirman: Dasar-dasar Perencanaan Geometrik Jalane. Nova, Bandung (1994)
18. Taqwadin, A.S., Anggraini, R., Taufiq, L.C.: Evaluasi Geometrik Tikungan di Jalan Medan–Banda Aceh pada STA 81+ 000-STA 82+ 000 dengan Menggunakan Pedoman Desain Geometrik Jalan Tahun 2021. *Journal of The Civil Engineering Student*. 5, 246–252 (2023)
19. Wirdianto, A., Fadillah, A., Rijaluddin, A., Isradi, M.: Geometric Evaluation of Bends Implications for Traffic Performance: A Systematic Literature Review. *RIGGS: Journal of Artificial Intelligence and Digital Business*. 4, 5555–5565 (2025)
20. Sembada, A., Candra, B.Y.Y., Ginting, R.R., Heryadiana, A.D., Isradi, M.: The Relationship Between Road Capacity and Road Level of Service: A Systematic Review of Recent Studies. *RIGGS: Journal of Artificial Intelligence and Digital Business*. 4, 5193–5206 (2025)