E-ISSN : 2963-4946
Vol. 2 No. August 11, 2024

Asian Journal of Social and Humanities
https://ajosh.org/

The Evaluation of Horizontal Alignment Design: A Case Study of Jalan Tarikolot Majalengka

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KEYWORDS
street geometric design; road geometric design guidelines; horizontal alignment

ABSTRACT
Road geometric design is a way of planning a road geometrically or involves calculating angles through the process. Regarding the geometric design of roads, it is important to assess the conformity of the design criteria with the applicable guidelines, namely the Road Geometric Design Guidelines. In this paper, an evaluation of the geometric design of existing roads, namely Jalan Raya Tarikolot, Majalengka, and adjustments to the Road Geometric Design Guidelines is carried out. The research method used is an evaluation research method for the research object, namely Jalan Raya Tarikolot, Majalengka. The results obtained show that Jalan Raya Tarikolot, Majalengka is a road with a flat terrain type. Alignment P2 is the FC alignment type, while the other seven alignments are S-C-S alignment types. Through the evaluation carried out, the results showed that the horizontal adjustment of the Tarikolot Highway, Majalengka met the criteria, so it did not require design improvements.

Introduction

Road geometric design is a design process that involves calculating angles in the construction of roads. The geometric design of the road aims to improve the comfort and safety of road users while maintaining the efficiency of traffic operations and minimizing construction and maintenance costs. Road geometric planning includes road section planning, horizontal and vertical bends, as well as road planning that meets predetermined criteria. However, road geometry not only involves shaping the arrangement of roads based on the location where the road is built, but also predicting things that will affect drivers while driving. Therefore, globally the geometric design of roads is very important because the geometric design of roads is not only a form of support for the function of the road but can also support the safety of road users if it is designed in such a way (Andito et al., 2022).

In road geometric design, examples of things that can affect the safety of road users are the user's visibility, corner angle, sign planning, and several other factors. In Indonesia, these have been regulated in the Road Geometric Design Guidelines along with other standards in the form of criteria and procedures for creating road geometric designs. In addition, the higher accident rate is proven to be a function of the difference between the free-flow velocity and the velocity depending on the radius of curvature. Thus, in addition to maintaining the safety of road users and routinely checking the condition of vehicles, road planning according to guidelines can also reduce the number of accidents caused by road geometry factors. Therefore, the geometric shape of roads in Indonesia needs to consider whether the condition is in accordance with existing guidelines or not (Mitrović Simić et al., 2020).

In West Java, Indonesia, the geometric condition of the existing roads does not require further attention, but sometimes some horizontal bends have sharp angles for motorists. Horizontal bends are one of the most important aspects that affect road efficiency and safety. Where the purpose of horizontal bend planning is to improve the level of road safety, attention should be paid to the type of bend, the condition of the ground contour to avoid ramps and rivers, as well as the average speed of road users, which can later affect the minimum value of the circle radius. The minimum value of the circle radius is a factor that can later affect the sharpness of the horizontal bend of the road, where if the minimum radius is used, the bend will be very sharp. So, it needs to be taken into account and adjusted to the standards regarding the required bend value so that the horizontal bend of the road is not too sharp for the user (V. F. Salsabila et al., 2022).

In addition to horizontal bends, the geometric design of vertical alignment also needs to be considered in road planning. Geometry deals with horizontal and vertical bends, visibility, gradients, and intersections; also indicates the main factor. This means that aspects such as attention to vehicles passing through vertical corners, lighting distance, visibility, and others also need to be considered. Due to the topographical conditions in Majalengka Regency, some vertical alignments are steep slopes or descents that pose a high risk to road users. In this way, factors in the planning of vertical corners involving road safety and the safety of passing vehicles need to be taken seriously according to existing regulations (Mandal et al., 2019).

Regarding the geometric design of roads, it is necessary to evaluate their conformity with applicable guidelines. Guidelines in road geometry are intended as a technical reference in road geometric design to obtain minimum and maximum limit values in design parameters through consideration of ideal design conditions, field survey results, and terrain conditions. In order to plan a good and correct geometric design of roads, it is necessary to adhere to existing guidelines because they have established factors that can maintain the standard of road geometry both in the topography and passing vehicles. In this way, in this paper, an evaluation of the geometric design of the Tarikolot Highway, Majalengka will be carried out regarding its conformity with the Road Geometric Design Guidelines. With this study, if the results of the geometric design evaluation are found to be inconsistent with the geometric design guidelines of the road, the road can be immediately renovated to prevent a decrease in the effectiveness and efficiency of the road (Farid et al., 2022).

Literature Review

Road Geometric Design

Road geometric design is the planning of the shape of the road design to maximize the use of the road by users. Geometric planning as part of road planning focuses on the physical shape of the road so that the main function of the road to provide optimal services in traffic flow and as a connecting road access can be fulfilled. In planning the geometric design of the road, several criteria need to be considered. References regarding design criteria that need to be considered have been stated in the Road Geometric Design Guidelines. The basis for selecting and determining design criteria is to optimize effectiveness and efficiency for the needs of vehicle movement both in terms of quantity and quality which also refers to the applicable law. The basis of road geometric design planning includes vehicle characteristics, vehicle movement, vehicle size, driver characteristics in controlling the vehicle, and traffic flow characteristics (Adiputra et al., 2022; Arifin & Rifai, 2022; Nugroho et al., 2022).

Road planning must pay attention to rainwater flow. The pavement layer is easily damaged due to waterlogging caused by the basic properties of the asphalt mixture itself. This condition occurs because asphalt has properties that are not very strong against water immersion. In addition to the effectiveness and efficiency of vehicle movement, the geometric design of the road will also certainly affect the safety of road users by the geometric conditions of the road. To produce safe and comfortable road conditions is the goal of road geometric design through consideration of visibility, movement space, surface friction coefficient, economy, efficiency, ease of implementation, and having infrastructure that pays attention to road terrain. With optimal road geometric design planning, safety and comfort for road users will be maximized so that it will increase the effectiveness and efficiency of road functions. Because after all, in road construction, it is very important to have the right geometric plan so that the road can provide comfort and safety for its users (Agniya et al., 2022; Rizqi et al., 2022; V. F. Salsabila et al., 2022).

The development of an adequate road transportation system is a major need for developing countries. The road transportation system involves its infrastructure, namely the road itself. Good road geometric design planning will result in adequate road transportation system infrastructure in road development. Therefore, road geometric design planning is an indirect necessity for developing countries. Thus, developing countries can achieve more equitable development and increase their competitiveness in the global arena (Pangesti et al., 2022).

Horizontal Road Alignment

Road adjustment consisting of vertical and horizontal adjustment is part of curve design planning in road geometric design. In designing horizontal and vertical adjustments, the existing bends need to go through pre-defined standards. In addition, factors such as the driver's point of view and speed also affect the planning of road adjustment design. The lack of significant visibility is another reason for the reduction in road safety as it can affect the driver's ability to properly assess road conditions. Therefore, for the safety and security of road users, road adjustments need to be carefully calculated (S. Salsabila et al., 2022).

Horizontal adjustment is the geometric bend of the road in the form of a bend to connect the sections of the road. In planning, horizontal adjustments can be made according to the topography of the road or for other reasons through various considerations. The main consideration for horizontal adjustment is the possible value of the largest radius and not less than the minimum value according to the speed of the design. So in the early stages of horizontal adjustment design planning, it is necessary to start with careful calculation regarding the speed of design. In addition, it is also important to consider the cost of building a horizontal adjustment of the road (Stefanus et al., 2022; Ulchurriyyah et al., 2022).

A horizontal bend on a road refers to the adjustment or straightness of the road segment. Topographically, there are three types of terrain: flat, hilly, and mountainous. These three terrain conditions will affect the road planning design criteria. In particular, horizontal geometry, more specifically, continuous trend of bends is indispensable for the ex-post application of some standard design rules and assessing the coherence, consistency and homogeneity of road infrastructure (Cantisani & Del Serrone, 2020; Latif et al., 2020).

Road Geometric Design Guidelines

Road geometric design guidelines serve as a reference or benchmark in road planning to improve the effectiveness and efficiency of road functions in the future. Each country has different guidelines depending on the conditions in the country to produce accuracy in design, adjust to technical and regulatory needs, and can be implemented in the field. The applicable guideline in Indonesia for road planning is the Road Geometric Design Guidelines (PDGJ). So, in the planning of road geometric design in Indonesia, the design results must be in accordance with these guidelines (Joice et al., 2022).

In addition to the effectiveness and efficiency of road functions, good road geometric design planning can also improve safety and security on the road. Geometric design of the road adapted to the function of the road. To build a well-planned road geometric design, several things require more attention in its implementation. Road geometric planning and design involves planning horizontal and vertical adjustments, calculating visibility, and determining the radius of horizontal and vertical curves that must be carefully performed. By referring to the Road Geometric Design Guidelines, the things involved in road design planning can become more precise so that a well-planned road geometric design can also be achieved (Nurjannah et al., 2022; Rizki et al., 2022).

The main goal of road planning is the safety of road users (Gunawan et al., 2022). The geometric design of the road is not always the only major cause that affects the occurrence of traffic accidents. However, elements of the geometric design of a road such as short visibility and a small radius can significantly increase the severity of traffic accidents. Therefore, guidance is needed to take into account road geometric design planning to reduce the risk of traffic accidents caused by road geometric design (Islam et al., 2019).

Research Methods

In this study, the research method used to identify the problem is the evaluation research method. This research is located on Jalan Raya Tarikolot, Majalengka Regency, West Java, Indonesia. The design criteria for Jalan Raya Tarikolot, Majalengka are as a Primary Local Road, Class III with a class of road use as a medium road, and have a flat road terrain. In this study, the evaluation method was used to evaluate the suitability of the geometric design of Jalan Raya Tarikolot, Majalengka with applicable standards. This research aims to ensure that the road design meets the technical and safety requirements that have been set.

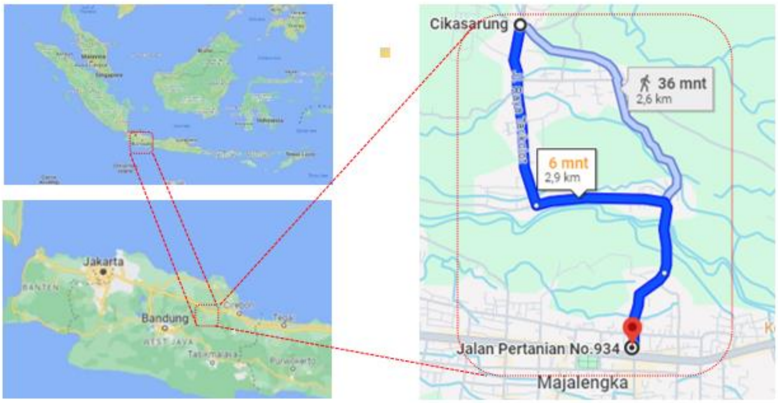

Figure 1 Research Location

Data is one of the main forces in compiling scientific research and modeling. In this study, primary data collection will be obtained through the contour map of Jalan Raya Tarikolot, Majalengka through Google Earth and Global Mapper. Meanwhile, secondary data to support primary data will be obtained through the Road Geometric Design Guidelines. Primary data will then be processed through its feasibility with PDGJ. The results of the research obtained are in the form of conclusions regarding whether the geometric design of the road follows the design criteria or does not follow the design criteria.

The data collected and processed in this study is a strong foundation for evaluating the suitability of the geometric design of the road with the applicable standards. Using primary data from contour maps as well as secondary data from the Road Geometric Design Guidelines, this study aims to assess the extent to which the geometric design of the Tarikolot Highway, Majalengka is in accordance with the set criteria. Careful analysis of the data is expected to provide an in-depth understanding of the suitability of the design with existing standards, as well as provide recommendations for improvement or enhancement if needed. Thus, this research will not only provide an overview of the actual condition of the road, but will also make a positive contribution to improving the effectiveness and safety of road users.

Results and Discussions

Design Criteria

Adjustment begins with setting design criteria that must be adhered to, followed by the preparation of a road adjustment plan. Jalan Raya Tarikolot, Majalengka is classified as a Class III Primary Local Road and is included in the category of Medium Roads in accordance with the design criteria that have been set. The evaluation of the slope of the Tarikolot Highway, Majalengka resulted in an average value of 5.82%, in accordance with the flat terrain classification listed in the road geometric design guide. The design criteria that must be met for the Tarikolot Highway, Majalengka include the design speed VD = 60 km/h, the width of the road benefit space is 13 m, the width of the road is 15 m, the road control room is 7 m, the lane width is 3.5 m, the maximum elevation is 8%, and the maximum slope is 6%. The results of this study form the basis for designing road adjustments that are in accordance with the conditions of the Tarikolot Highway, Majalengka.

Then for the results of the calculation of the design criteria on Jalan Raya Tarikolot, Majalengka are in the table below.

Table 1 Angle Calculation

POINT	COORDINATE		DISTANCE			AZIMUTH	ANGLE
	X	**Y**	**ΔX (m)**	**ΔY (m)**	**d (m)**	**α**	**Δ**
A	189852,47	9245977,72					
			388,27	318,69	502,3116	50,62103	
PI 1	190240,74	9246296,41					**59,553**
			205,19	-75,39	218,6014	110,1741	
PI 2	190445,93	9246221,02					**12,892**
			375,39	-244,4	447,9386	123,0664	
PI 3	190821,32	9245976,62					**14,625**
			359,68	-119,94	379,1508	108,4416	
PI 4	191181	9245856,68					**22,434**
			168,02	-145,42	222,2109	130,8759	
PI 5	191349,02	9245711,26					**41,524**
			525,04	5,94	525,0736	89,35182	
PI 6	191874,06	9245717,2					**16,774**
			314,59	98,72	329,7158	72,57787	
PI 7	192188,65	9245815,92					**26,057**
			790,08	-119,98	799,138	98,63485	
PI 8	192978,73	9245695,94					**19,825**
			176,46	-95,65	200,7164	118,4599	
B	193155,19	9245600,29					

By calculating the distance to the coordinates of each point, the angles of the eight horizontal alignment points are obtained. After obtaining the angles of the horizontal alignment points, the next step is to evaluate the compatibility of these planning results with the design criteria that have been set. This evaluation is important to ensure that the horizontal alignment is in accordance with the expected standards for the Tarikolot Highway, Majalengka.

Horizontal Alignment Calculation

After determining the road design and alignment criteria, in calculating the horizontal alignment, the Straight Section Length (LL), Bend Radius (RC), Bend Length (Lc), and Transition Curve Length (LS) are then calculated.

Based on the design criteria, the design speed used is 60 km/h, so the following calculations are obtained:

Table 2 Calculation Result of Horizontal Alignment Criteria

LL	LC	LS
$L_L \leq 2{,}5\ minute\ x\ V_D$ $L_L \leq 2{,}5\ minute\ x\ 60\ km/hour$ $L_L \leq 2{,}5\ km$ $L_L \leq 2500\ m$	$L_C \leq 6\ second\ \ x\ V_D$ $L_C \leq 6\ second\ \ x\ 60\ km/hour$ $L_C \leq 0{,}1\ km$ $L_C \leq 100\ m$	$L_S \leq 1/2\ x\ 6\ second\ \ x\ V_D$ $L_S \leq \frac{1}{2} x\ 0{,}1\ km$ $L_S \leq 0{,}05\ km$ $L_S \leq 50\ m$

a. Alignment P1

LL = 210 m ≤ 2500 m ... OK

- Arch Design

  VD = 60 km/hour | Rmin = 110 m
  emax = 0.08 | R = 130 m
  e = 0.08 | Ls max = 50 m

  $L_{s1} = \frac{60}{3{,}6} 2 = 33{,}33\ m$

  $L_{s2} = table = 47\ m$

  $L_{s3} = 0{,}0214 \frac{60^3}{130\ x\ 1{,}2} = 29{,}63\ m$

  $L_{s4} = \sqrt{24\ x\ 0{,}2\ x\ 130} = 24{,}98\ m$

  Taken Ls table = 47 m ≤ 50 ... OK
- Alignment type

  $p = \frac{L_S^2}{24R_c} = \frac{47^2}{24\ x\ 130} = 0{,}71\ m\ \geq 0{,}25\ m$ … Alignment type S-C-S
- Calculation of Lc

  $L_C = (\Delta c/360) * 2 * \pi * R$

  $L_C = (38{,}845/360) * 2 * \pi * 130$

  $L_C = 87{,}132\ m \leq 100\ m \ldots OK$

b. Alignment P2

LL = 450 m ≤ 2500 m... OK

- Arch Design

  VD = 60 km/hour | Rmin = 110 m
  emax = 0.08 | R = 250 m
  e = 0.062 | Ls max = 50 m

  $L_{s1} = \frac{60}{3{,}6} 2 = 33{,}33\ m$

  $L_{s2} = table = 37\ m$

  $L_{s3} = 0{,}0214 \frac{60^3}{250\ x\ 1{,}2} = 15{,}41\ m$

  $L_{s4} = \sqrt{24\ x\ 0{,}2\ x\ 250} = 34{,}64\ m$

  Taken Ls table = 37 m ≤ 50 ... OK
- Alignment type

  $p = \frac{L_S^2}{24R_c} = \frac{37^2}{24\ x\ 250} = 0{,}23\ m\ \leq 0{,}25\ m$ … Alignment type FC
- Calculation of Lc

$L_C = (\Delta/360) * 2 * \pi * R$
$L_C = (13/360) * 2 * \pi * 250$
$L_C = 56{,}723\ m \leq 100\ m \ldots OK$

c. Alignment P3
LL = 400 m ≤ 2500 m... OK

- Arch Design

VD	= 60 km/hour	Rmin	= 110 m
emax	= 0.08	R	= 200 m
e	= 0.07	Ls max	= 50 m

$L_{s1} = \frac{60}{3{,}6} 2 = 33{,}33\ m$
$L_{s2} = table = 41\ m$
$L_{s3} = 0{,}0214 \frac{60^3}{200\ x\ 1{,}2} = 19{,}26\ m$
$L_{s4} = \sqrt{24\ x\ 0{,}2\ x\ 200} = 30{,}98\ m$
Taken Ls table = 41 m ≤ 50 ... OK

- Alignment type
$p = \frac{L_S^2}{24R_c} = \frac{41^2}{24\ x\ 200} = 0{,}35\ m\ \geq 0{,}25\ m$ … Alignment type S-C-S
- Calculation of Lc
$L_C = (\Delta c/360) * 2 * \pi * R$
$L_C = (1{,}249/360) * 2 * \pi * 200$
$L_C = 4{,}360\ m \leq 100\ m \ldots OK$

d. Alignment P4
LL = 220 m ≤ 2500 m ... OK

- Arch Design

VD	= 60 km/hour	Rmin	= 110 m
emax	= 0.08	R	= 175 m
e	= 0.074	Ls max	= 50 m

$L_{s1} = \frac{60}{3{,}6} 2 = 33{,}33\ m$
$L_{s2} = table = 44\ m$
$L_{s3} = 0{,}0214 \frac{60^3}{175\ x\ 1{,}2} = 22{,}01\ m$
$L_{s4} = \sqrt{24\ x\ 0{,}2\ x\ 175} = 28{,}98\ m$
Taken Ls table = 44 m ≤ 50 ... OK

- Alignment type
$p = \frac{L_S^2}{24R_c} = \frac{44^2}{24\ x\ 175} = 0{,}46\ m\ \geq 0{,}25\ m$ … Alignment type S-C-S
- Calculation of Lc
$L_C = (\Delta c/360) * 2 * \pi * R$
$L_C = (6{,}285/360) * 2 * \pi * 175$
$L_C = 19{,}196\ m \leq 100\ m \ldots OK$

e. Alignment P5
LL = 550 m ≤ 2500 m ... OK

- Arch Design

VD	= 60 km/hour	Rmin	= 110 m
emax	= 0.08	R	= 130 m
e	= 0.08	Ls max	= 50 m

$L_{s1} = \frac{60}{3,6} 2 = 33,33\, m$

$L_{s2} = table = 47\, m$

$L_{s3} = 0,0214 \frac{60^3}{130\ x\ 1,2} = 29,63\, m$

$L_{s4} = \sqrt{24\ x\ 0,2\ x\ 130} = 24,98\, m$

Taken Ls table = 47 m ≤ 50 ... OK

- Alignment type

  $p = \frac{L_S^2}{24R_c} = \frac{47^2}{24\ x\ 130} = 0,71\, m\ \geq 0,25\, m \ldots$ Alignment type S-C-S

- Calculation of Lc

  $L_C = (\Delta c/360) * 2 * \pi * R$

  $L_C = (20,845/360) * 2 * \pi * 135$

  $L_C = 47,296\, m \leq 100\, m \ldots OK$

f. Alignment P6

LL = 350 m ≤ 2500 m ... OK

- Arch Design

VD	= 60 km/hour	Rmin	= 110 m
emax	= 0.08	R	= 175 m
e	= 0.074	Ls max	= 50 m

$L_{s1} = \frac{60}{3,6} 2 = 33,33\, m$

$L_{s2} = table = 44\, m$

$L_{s3} = 0,0214 \frac{60^3}{175\ x\ 1,2} = 22,01\, m$

$L_{s4} = \sqrt{24\ x\ 0,2\ x\ 175} = 28,98\, m$

Taken Ls table = 44 m ≤ 50 ... OK

- Alignment type

  $p = \frac{L_S^2}{24R_c} = \frac{44^2}{24\ x\ 175} = 0,46\, m\ \geq 0,25\, m \ldots$ Alignment type S-C-S

- Calculation of Lc

  $L_C = (\Delta c/360) * 2 * \pi * R$

  $L_C = (1,286/360) * 2 * \pi * 175$

  $L_C = 3,928\, m\ \leq 100\, m \ldots OK$

g. Alignment P7

LL = 800 m ≤ 2500 m ... OK

- Arch Design
  - VD = 60 km/hour
  - emax = 0.08
  - e = 0.078
  - Rmin = 110 m
  - R = 150 m
  - Ls max =50 m

Conclusion

The researcher concluded that the analysis of information technology governance in the academic system at SMPN 102 Jakarta in measuring the level of performance ability with the aim of improving student achievement, obtained the following results:

Table of Research Conclusions

Governance Objectives		Capability Level (%)				Yield	Hope	GAP
		N	P	L	F	(As-Is)	(To-Be)	
APO 09	Managed Service Agreement	0-14	15-49	50-84	85-100	72,50	100	27,5
DSS 01	Managed Operations	0-14	15-49	50-84	85-100	72,22	100	27,8

Explaining that the researcher obtained the results of the capability level of information technology governance in academic services at SMPN 102 Jakarta as follows:

Obtained an objective level capability score of APO 09 with an achievement score of 72.50% (Largery Achieved). Obtained an objective level capability value of DSS 01 with an achievement value of 72.22% (Largery Achieved). There is a GAP in the APO 09 domain of 27.5%. There is a GAP in the APO 09 domain of 27.8%. The level of ability obtained by APO 09 and DSS 01 is the level of objective ability of the process which states that the activity has been carried out but has not been carried out well so that improvements are needed based on GAP to achieve the expected level of ability, namely level 4 where the expectation states that the activity is carried out as well as possible, consistently and structured.

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