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The Geometric Design of Horizontal Alignment Using Indonesian Road Design Standard: A Case of Jalan Samarang – Jalan Simirih STA 0+000 – STA 0+715, Garut, West Java

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ABSTRACT

Indonesia is a country that has many beautiful places that made Indonesia famous for the tourism industry. Connecting road between Jalan Samarang and Jalan Simirih is made to support residents' economic activities as more tourists come. This research is purposed to design geometric roads, especially horizontal alignment according to "Guidelines For Road Geometric Design 2021". The road that will be made from STA 0+000 to STA 0+715 with objective data in 2022 using AutoCAD® 2D. This road planning uses quantitative data divided into primary and secondary data. The calculation can be concluded that on a 0,715 km road that uses Spiral-Spiral (SS) `

1. Introduction

In the modern age, the construction world is exceedingly improved, one of which is on the horizon of transportation. Road infrastructure plays an important role in boosting the socio-economic development of countries and regions [1]. Great road planning is necessarily needed. The geometric must be designed in such a way that the road can provide optimal service. The goal of geometric planning is to make safe infrastructure, efficient traffic flow services, economical to construct, and provides security and comfort to road users [2].

Road planning in Indonesia must comply with the principles that are guided by the "Guidelines for Road Geometric Design 2021" [3]. In road planning, several aspects must be considered, such as traffic analysis, determination of the design speed, pavement planning, and geometric (horizontal & vertical) planning of the road. Inconsistency in road planning and non-fulfillment of road geometry requirements is one of the causes of driving discomfort, resulting in frequent accidents. Therefore, it is necessary to plan a road geometry that meets the rules of road planning.

Accidents are one of the causes of death worldwide and every year as many as 1.25 million people die and nearly 50 million people are injured due to accidents [4]. The World Health Organization (WHO) reports that every year as many as 1.25 million people die and nearly 50 million people are injured due to traffic accidents worldwide. In Indonesia, the number of traffic accidents that occur is quite large. One example is West Java, one of the provinces with the highest number of traffic accidents in Indonesia, according to the Indonesian Central Bureau of Statistics [5]. Garut is one of the areas in West Java with many traffic accidents.

Garut's topographic characteristics consist of plateaus and mountains. Besides that, most of Garut's surface also has a steep and unstable level of steepness. According to [6] Garut is an area that has the

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potential to create a creative economy in the West Java area due to the many destinations that can be visited in the Garut area. So access roads are needed that can facilitate and support the mobility of people in the area. Based on this background, this research will discuss a road plan that is fast, safe, comfortable, and fulfills the rules of road planning, especially in terms of horizontal geometric.

2. Literature Review

2.1 Road Geometric Planning

The road is a land of transportation infrastructure that includes complementary buildings and equipment intended for traffic, which is at ground level, above ground level, below ground and water level, and above water level [7]. Roads are a crucial component of a region's infrastructure, enabling local growth and facilitating the efficient mobilization of people and goods [8]. Roads not only enhance accessibility and connectivity but also contribute to local economic development. Based on their status, public roads are categorized into national, provincial, district, city, and village roads [9] [10] [11].

One of the essential things of road design is geometric planning which focuses on placing roads on topographic maps [12]. Geometric planning is part of road planning that focuses on the physical shape so that the primary function of the planned road can be fulfilled. Road user safety is the main priority in the geometric planning of a road. Geometric features can define the shape of a driveway, such as deflection angle, curve radius, tangent length, spiral length, and ramp width. These elements are in the geometric path used in planning [13] [14] [15]

. The geometric layout of the road has three fundamental parts: horizontal alignment, vertical alignment, and cross-section. The three essential parts, when combined, will provide a three-dimensional format for a road [16]; [17].

2.2 Horizontal Alignment

Horizontal alignment is the projection of the road axis on the horizontal area, consisting of straight lines connected by curved lines. The operation of the road is directly affected by horizontal alignment, road classification, design speed, traffic volume, and environmental conditions are some of the horizontal alignment factors [18]; [19] [20]. The alignment design is primarily contingent upon the designated speed for the road. The bend in the road is a crucial aspect of horizontal alignment as the car is subject to the centrifugal force that pushes it outward from the corner. Accidents occur more frequently in areas with multiple curves, often because the turning radius does not align with Bina Marga guidelines. To ensure the safety of road users, it is essential to consider maximum transverse slope, alternating curves, visibility, side-free area, and lane expansion in curve sections during the planning process. [21]; [22]; [23]; [24].

To design horizontal alignment, the first requirement is to determine the function and class of the road, which is based on the characteristics and volume of traffic traveling on the road and the terrain conditions [25]. Horizontal alignment planning should still prioritize the safety of drivers and other road users. In horizontal alignment planning, it is necessary to consider the calculation of straight sections, superelevation, curves, degrees of curvature, transitional curves, and stationing. Horizontal alignment consists of straight lines connected by curved lines, divided into three elements that have a relationship between the steering wheel of the vehicle and the longitudinal axis of the body, such as 0° (straight line), constant (circular curve), or changeable (transition curve) [26]. The horizontal alignment consists of 3 curves namely Full Circle (FC), Spiral-Circle-Spiral (SCS), and Spiral-Spiral (SS). Full Circle (FC). Spiral-Circle Spiral (SCS). Spiral - Circle - Spiral (SCS) is a bend consisting of one circular curve and two spiral

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curves or transition curves. Spiral-Spiral (SS) is a type of bend where a transition curve is installed at the beginning at the end and at the turning point of the curve to ensure that there are no abrupt changes in the bend radius, superelevation, and road widening. FC (Full Circle) is a type of bend that only consists of part of a circle.

3. Method

Data is one of the leading forces in compiling scientific research and modeling. After the preparation period before the study is carried out, data collection is then carried out. The data are obtained according to the research plan for the appropriate data. In obtaining and managing data, this study uses a literature method which is a method for identifying and processing written materials used in library data collection activities. **[27]**; **[28]**; **[29]**.

The location of the road design is in the Jalan Samarang – Jalan Simirih STA 0+000 – STA 0+715 Samarang Regency area. This road aims to improve the road that connects the Samarang road to the Simirih road. the planning will be discussed from STA 0+000 to STA 0+715. the data is taken from Google Earth and Global Mapper, the data used for road design in this region.

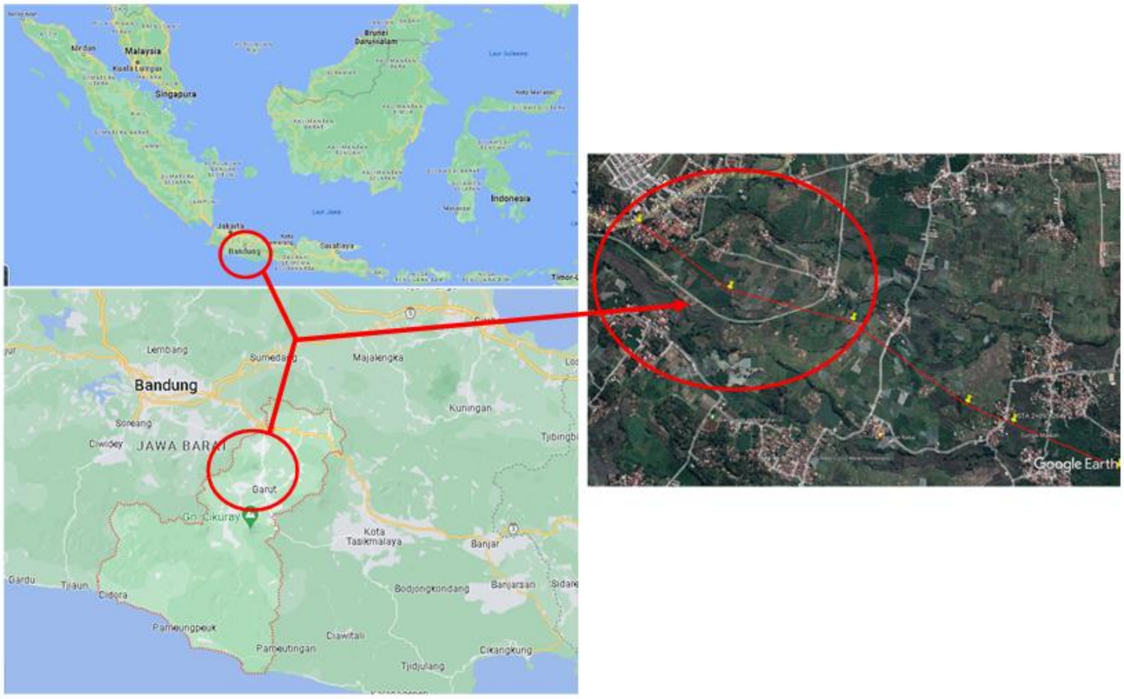

Figure 1. Research Location

This study uses road regulations based on road functions and classifications referring to the Highway Design Standard of Indonesia 2021, page 30, Table 4-1, page 42, Table 5-1, and page 49, Table 5-3. The results of the calculation of geometric elements will subsequently be presented in the form of data tables and superelevation drawings.

4. Result and Discussion

According to the Guidelines For Road Geometric Design 2021, the connecting road between Jalan Samarang and Jalan Simirih is included in primary local roads. Clarification of design planning for the connecting road between Jalan Samarang and Jalan Simirih is on flat terrain with a 4/2 UD road type, width 3.5/lane, and the design speed is taken as 80 km/hour. The maximum superelevation value is 10% and the superelevation of the slope is 7,155%.

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4.1 Horizontal Alignment

Before calculating the horizontal alignment, obtaining a land surface contour to calculate the coordinate points of the connecting road to be constructed is necessary. As shown in Table 1, the coordinate points on the horizontal alignment are obtained with the help of Global Mapper and implemented in AutoCAD® 2D.

Table 1. Horizontal Alignment Coordinates

Point	Coordinates	
	X	Y
Start	815489,9486	9201773,0441
1	815927,4186	9201449,2164
End	816505,4982	9201299,1489

The coordinates were obtained from the results of data visualization from google earth to AutoCAD® 2D with the assistance of the Global Mapper application. The coordinates points obtained one horizontal alignment curve made with the provisions of the arch (Spiral-Spiral).

1) Coordinate Difference (Δx and Δy)

a. Coordinate Difference (Δx)

$\Delta x_{start-1}$ = 815927,4186 – 815489,9486
= 437,470 m

Δx_{1-end} = 816505,4982 – 815927,4186
= 578,080 m

b. Coordinate Difference (Δy)

$\Delta y_{start-1}$ = 9201449,216 − 9201773,0441
= 323,828 m

Δy_{1-end} = 9201299,1489 − 9201449,2164
= 150,067 m

2) The length before the curve (D)

$$D = \sqrt{\Delta x^2 + \Delta y^2} \quad (1)$$

$D_{start-1} = \sqrt{437,470^2 + 323,828^2} = 544,283$ m

$D_{1-end} = \sqrt{578,080^2 + 150,067^2} = 597,241$ m

3) Azmiuth Angle (Z)

$$Z = \text{arc tan}\frac{\Delta x}{\Delta y} \quad (2)$$

$Z_{start-1} = \text{arc tan}\frac{437,470}{323,828} = 53,490\ °$

$Z_{1-end} = \text{arc tan}\frac{578,080}{150,067} = 75,447\ °$

4) Delta Angle (Δ)

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$\Delta \quad = 75{,}447 - 53{,}490 \quad = 21{,}957\,°$

Shown in Table 2 are the results of the resume from the calculation of coordinate points to get the azimuth angle, delta angle, and determination of the type of arc.

Table 2. Calculating Horizontal Arch Planning

Point	Coordinates		Different Coordinates		Distance	Azimuth	Δ	Type
	X	Y	ΔX	ΔY				
Start	815489,	9201773,						
			437,470	323,828	544,283	53,490		
1	815927,	9201449,					21,957	SS
			578,080	150,067	597,241	75,447		
End	816505,	9201299,						

After obtaining the coordinate data and the length of the arch, proceed with the data by calculating the horizontal curve according to PDGJ 2021. Minimum radius = 112,26 m, the radius used on Spiral-Circle-Spiral (SCS) type is 400 m, Spiral-Spiral (SS) type is 200 m, and Full Circle (FC) type is 800 m. The following are calculations to determine the design of Spiral-Spiral (SS) arches.

5) Determine Ls

A transitional arch (Ls) is an arch where the cross-section transitions from a straight road to a road with superelevation. This transition curve is strongly influenced by the nature of the driver, vehicle speed, curve radius, and road superelevation. The determination of the transition arch can be found in the following three ways:

a. According to relative slopes

$$B = \frac{1}{2} \times pavement\ width \quad (3)$$

$$m = \frac{1}{relative\ slope} \quad (4)$$

Based on the design of the road, the design speed is 80 km/hour and the relative slope used is 1:160.

$$Ls\ min = B \times m \times (e + en) \quad (5)$$

b. According to centrifugal force

$$Ls\ min = 0{,}022 \times \frac{V^3}{R.C} - 2{,}727\frac{V.e}{C} \quad (6)$$

c. According to travel time

$$Ls\ min = \frac{V}{3{,}6}T \quad (7)$$

The minimum transition arc (Ls) used in planning is the calculation that produces the largest Ls value.

6) Determine θs and Δc

$$\theta s = \frac{28{,}648 \times Ls}{R\ plan} \quad (8)$$

On Spiral-Spiral (SS) arch type, $\Delta c = 0$

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7) Determine bend arc length requirements (Lc)

In Spiral-Spiral (SS) calculation:

$$\text{Lcs} = \frac{2 \text{ x } 3{,}14 \text{x R}}{360} \times 2\theta\text{s} \quad \ldots\ldots (9)$$

8) Determine the arc length (L)

In Spiral-Spiral (SS) calculation:

$$L = 2Ls \quad \ldots\ldots (10)$$

Shown in Table 3 is a resume of the calculation results on the Spiral-Circle-Spiral (SCS) and Spiral-Spiral (SS) arches.

Table 3. Spiral-Spiral (SS) arch calculation results

Point	Type	Δ	Ls minimum	Δc	Lc	L	
			Relative Slopes				
Start							
1	SS	21,957	114	23.57	0	0	329.031

Full circle arch planning calculations have a different way compared to the other two arches. Full circles have only one section of the circle and are only used for curves with a large radius to avoid fractures, because with a small R, a large superelevation is required.

9) Determine fictitious Ls

$$\text{Ls min} = B \times m \times (e + en) \quad \ldots\ldots (11)$$

10) Determine the bend start (TS)

$$\text{TS} = R\,plan \times \left(tan\frac{\Delta}{2}\right) \quad \ldots\ldots (12)$$

11) Determine the PI to arch distance (ES)

$$\text{ES} = \frac{R}{Cos\frac{\Delta}{2}} - R \quad \ldots\ldots (13)$$

12) Determine the arc length (Lc)

$$\text{Lc} = \frac{\Delta}{360} - 2\pi R \quad \ldots\ldots (14)$$

Shown in Table 4 is a resume of the calculation results on the Spiral-Spiral (SS) arch type.

Table 4. Spiral-Spiral (SS) arch calculation results

Point	Type	Δ	TS	ES	Lc
3	SS	21,957	173,956	11,22	344,905
End					

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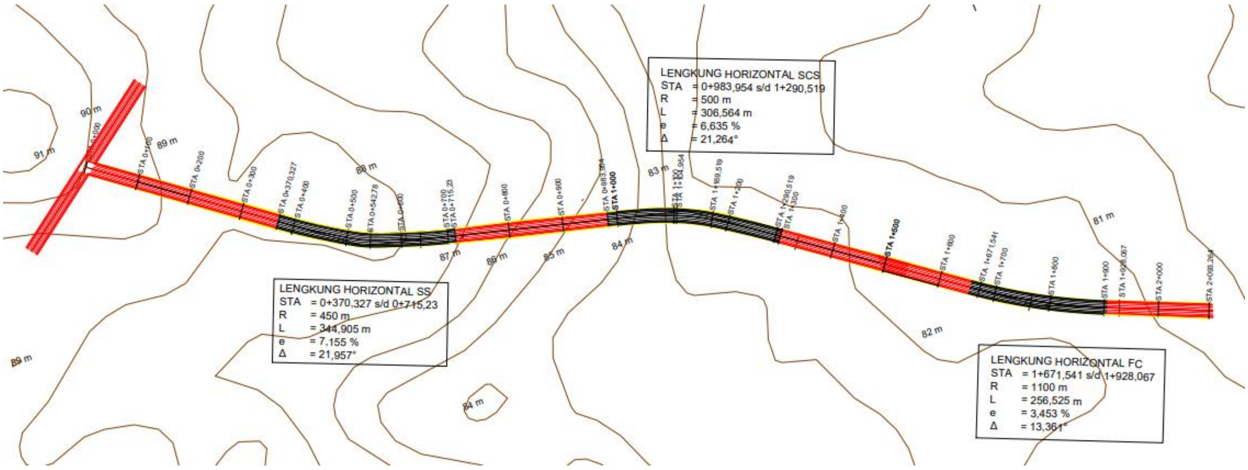

Figure 2. Horizontal alignment design

Figure 2 shows the results of the calculation design and illustration of the connecting road between Jalan Samarang and Jalan Simirih using AutoCAD® 2D.

5. Conclusion

In the planning of inner-city highways that connect Jalan Samarang - Jalan Simirih, Garut Regency, West Java, spanning from STA 0+000 to STA 0+715 the planning calculations are obtained which refer to the applicable provisions. Road geometry planning, the length of the road is 0,715 km, and The bends (horizontal alignment) are spiral spiral curves.

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