Geometric Redesign of Jalan Cisauk–Jaha, Banten with Manual Method (Sta. 0+000-Sta. 0+350)

1Rizki, 2Andri Irfan Rifai, 3Endry Z. Djamal
1Faculty of Engineering, Universitas Mercu Buana, Indonesia
2Faculty of Civil Engineering & Planning, Universitas Internasional Batam, Indonesia
3Directorate General of Highway, Ministry of Public Works & Housing, Indonesia
E-correspondence: rizkixy@gmail.com

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DOI: 10.53866/jimi.v2i5.201

Abstract

Expected to guarantee user comfort and safety, enable efficient traffic operations, and simultaneously attract the minimum possible costs in construction and maintenance. The construction of the Jalan Cisauk-Jaha in Banten Province is one of the projects of the Public Works and Planning Office of Banten Province. This paper aims to redesign a safe horizontal alignment for motorists to pass on the Jalan Cisauk-Jaha using the Bina Marga method at STA 0+000 – 0+350 where there is one bend or horizontal alignment. The method used in planning is the Bina Marga method. The research results of the horizontal alignment and geometric planning for the Cisauk–Jaha Highway STA 0+000 – 0+350 time attract the minimum possible costs in construction and maintenance. The construction of the Jalan Cisauk-Jaha in Banten Province is one of the projects of the Public Works and Planning Office of Banten Province. This paper aims to plan a safe horizontal alignment for motorists to pass on the Jalan Cisauk-Jaha using the Bina Marga method at STA 0+000 - 0+350 where there is one bend or horizontal alignment. The method used in planning is the Bina Marga method. The results can be concluded that the Cisauk–Jaha Highway is a class II A collector road with a width of 7 meters and design speed (VR) of 80 km/hour, design parameters, and a maximum slope (e) of 8%. From the calculation, the design radius (R) is 210 m, with the intersection angle (°) of 48°, the horizontal curved length (Lc) of 196.43 m, the maximum slope (e) of 8%, and the road terrain class being a flat area.

Keywords: Geometric Design, Horizontal Alignment, Manual Method

1. Introduction

Highways are expected to guarantee user comfort and safety, enable efficient traffic operations, and at the same time, attract the minimum possible costs in construction and maintenance. Roads are also expected to minimize environmental damage and be aesthetically pleasing in their final form. The construction of highways in a developing world requires careful planning and calculating geometric road designs. The geometric design of a road can be divided into three main parts, including horizontal alignment, vertical alignment, and cross sections, which provide a three-dimensional layout for the highway (Raji, Zava, Jirgba, & Osunkunle, 2017). The Bina Marga Method is a planning method used by civil and professional engineers in Indonesia to plan and design projects for building construction and road engineering projects, including the construction of dams, harbors, canals, and embankments.

Indonesia currently has a population of over 230 million people, and the country's economic growth has driven increased demand for transportation and vehicle ownership. Similar figures can also be seen in Jakarta, the capital city of nearly 10 million people. The figure is even higher during the day due to commuters from remote areas and some supporting cities (i.e. Jakarta, Bogor, Depok, Tangerang, Bekasi) (Soehodho, 2017). The state that really needs economic development to improve the standard of living and welfare of the people. To achieve this goal, the government needs various supporting factors, one of which is infrastructure. The need for infrastructure development will increase along with the increased economic activity. One result of changes in the development of a nation is the condition of infrastructure (Sepirillina, Yusida, Narmaditya, & Chung, 2021).

Roads have an important influence on economic growth, especially in Banten Province. Over time and with use, the road will experience damage, both minor, moderate, and severe (Rosdiyani, Noor, & Iswan, 2019). The construction of the Jalan Cisauk-Jaha in Banten Province is one of the projects of the Public Works and
Planning Office of Banten Province. One of the objectives of constructing the Jalan Cisauk-Jaha is to increase economic growth around Banten Province. Therefore, it is essential to plan and design roads safely, efficiently, economically, and quickly for traffic movement and collect different study details. The geometric design plays a significant role in every road and weighs the road alignment (Chakole & Wadhai, 2022).

The national road network is the main link for every economic activity that involves all stakeholders (Rifai A., 2021). The authors will make the Cisauk-Jaha Road, which has been built in Banten Province, for geometric planning using the Highways Method at STA 0+000 - 0+350. Bina Marga Method describes ways to design road geometries, including design criteria, general provisions, road geometric technical provisions, and road geometric design procedures for designing road horizontal and vertical alignment. The authors of this journal provide planning constraints, specifically only horizontal alignment geometric planning. The most critical part of a horizontal alignment is the curve.

This journal presents the geometric planning design of the horizontal alignment of the Jalan Cisauk-Jaha STA 0+000 - 0+350 using the Bina Marga Method. This planning aims to determine a safe bend or horizontal alignment for motorists to pass on the highway. The perspective of the balance of costs and safety is critical to consider in planning the geometry of the road (Li, Ding, & Zhong, 2019). Using the Bina Marga Method, one can calculate integrated checks for transition length and visibility to analyze horizontal geometry. Road geometry design in horizontal alignment, often called a bend, is considered in determining the proper road to pass.

2. Literature Review

2.1. Highways

Highways are the main roads that connect one region to another in the transportation sector, especially for the continuity of the distribution of goods and services. "Public roads" are roads designated for public traffic. The implementation of public roads is carried out by prioritizing the construction of a road network in production centers and roads connecting production centers to marketing areas. According to their status, public roads are grouped into national roads, provincial roads, district roads, city roads, and village roads. Road geometric design has the principle that road alignment must be designed in such a way that its geometric elements. Also, it must optimize effectiveness and efficiency between fulfilling the quantity and quality needs of the movement of vehicles that will pass through it with the availability of resources, the environment, and society, as well as referring to the applicable laws and regulations.

Road construction must fulfill the elements of proper road geometry planning. Road geometric planning aims to connect two or more locations precisely, namely by considering the safety and comfort conditions of road users as well as the technical-economic conditions of the area to be traversed by the road (Lopes E. C., et al., 2019). The safety evaluation should be considered according to the recommended alignment transition values at the design speed (Ying, Zhang, & Zhong-yin, 2020). Road construction is a type of government effort to assist people in Indonesia in carrying out their mobility in a proper and timely manner, both economically and socially. Roads provide critical social and economic functions and services to human society, including transportation, travel, cultural exchange, and the flow of materials and information (Feng, et al., 2021).

Sustainable construction projects are essential for economic and social development in modern communities (Alshboul, et al., 2022). One of the construction projects in Indonesia that are being stepped up is the construction of a highway. Highways are one of the alternatives used to deal with increasing traffic jams in Indonesia. Road construction projects are increasingly stepped up to balance the movement of people who are constantly moving from one place to another. The increasing traffic accident rate is caused by drivers and improper geometric designs (Xie, Wu, Lyu, & Duan, 2019). Traffic accidents have caused severe economic and social harm (Aldala’in, Sukor, & Obaidat, 2019). Therefore, it is necessary to plan a road geometry design under applicable rules.

Road geometry is a shape that describes the road and includes cross sections, longitudinal sections, and other aspects related to the physical form of the road. The design of road geometry is one part of road design that is focused on designing the physical form of the road so that it can produce a road shape that can be utilized for traffic operations quickly, smoothly, safely, comfortably, and efficiently. The geometric design itself consists of horizontal alignment and vertical alignment. Roadway geometry elements are expected to be selected, sized, and positioned in such a way as to meet design criteria such as visibility, vehicle stability, driver comfort, drainage, economy, and aesthetics.

2.2. Horizontal Alignment

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Road geometry design is part of road engineering, which is focused on engineering the physical form of the road so that it can fulfill the primary function of the road. The road geometry is designed by considering traffic safety and comfort issues that are adapted to the road's function. The geometric design of the highway is concerned with the design of the visible physical features of the highway, which consist of cross-sectional elements, visibility, alignment, curves, superelevations, and other features (Veer, Gupte, & Juremalani, 2018). Road geometry design products consist of horizontal, vertical, and cross sections of the road. Horizontal alignment is the projection of the axis of the road without a median or the projection of the inner pavement edge roads with a median. The consistency of the horizontal geometry design can reduce the number of traffic accidents (Hamilton, Himes, Porter, & Donnell, 2019).

Traffic accidents have become one of Indonesia's most common causes of death and injury (Rifai., Al-Rasyid., & Handayani, 2018). For this reason, in planning the road's geometry, the road users' safety factor must be considered. To optimize the safety of road users, at the initial stage of the design, the design speed and the design vehicle must be determined by considering the operational characteristics of the design vehicle (including the driver and the ratio of engine power to the weight of the vehicle) following the specified design speed. The higher the design speed, the more technical requirements it must meet. The horizontal alignment design significantly affects the characteristics of the riders who pass through the road (Wang, Cai, & Liu, 2019).

The horizontal alignment of highways determines their location and orientation in the plan view. It consists of three geometric elements: tangents (straight sections), circular curves, and spiral transitions between tangents and curves. Horizontal alignment design requires determining the minimum curve radius and length and calculating the horizontal offset from the tangent to the curve to facilitate the placement of the curve in the field. Safety is a significant factor in road design (Mandal, Pawade, & Sandel, 2019). To design a horizontal alignment, the first thing to do is determine the function and class of the road, which are based on the nature and volume of traffic that passes on that road and the terrain conditions. In choosing the alignment of a road, planners tend to choose a straight road because a straight road has a short total length.

The theory and methodology of road alignment must be able to support the performance of modern vehicles and meet users' driving habits (Xu, Lin, & Shao, 2017). There are various principles for forming horizontal alignments in planning a road alignment. The first rule is to stick to straight-line segments. Then, at each intersection, a curve is given, which is relatively short. In this case, the line becomes decisive while the curve is relatively short. The second principle is curved lines connected by a few straight lines. The third principle is to use curves instead of straight lines. The geometric design of a road acquires a technical quality when executed in a particular computer program. However, it is necessary to know the basic or manual planning techniques before executing the plan in a computer program.

3. Methodology

The Jalan Cisauk-Jaha Project in Banten Province was built in 2011. The Jalan Cisauk-Jaha is 10,441 kilometers long, with STA 0+000 - STA 10+441. In this journal, the authors only plan one horizontal alignment bend from STA 0+000 to 0+350. This project is for the Office of Highways and Spatial Planning for the Government of Banten Province. This project is in Cisauk District and Jaha District, Tangerang Regency, Banten Province. The following is the location of the Cisauk–Jaha Highway project in figure 1.

Figure 1. Map of case study

The systematic scientific research process must begin with identifying the right problem (Rifai, Hadiwardoyo, Correia, & Pereira, 2016). This journal aims to plan safety bends or horizontal alignments for
motorists to pass on the Cisauk-Jaha STA highway using the Bina Marga Method at STA 0+000 - 00+350 where there are two bends or horizontal alignments. Many methods can be used in geometric road planning. In Indonesia, the most used method is the Bina Marga method, as stated in the Procedures for Geometric Planning for Inter-City Roads (TPGJAK) and the 2021 Road Geometry Design Guidelines. Using the Bina Marga Method, one can calculate integrated checks for transition length and visibility to analyze geometry horizontally. Planning the road geometry in horizontal alignment is considered in determining the proper road to pass.

The method used in planning the geometry of the horizontal alignment of the Jalan Cisauk-Jaha in Banten Province is the Bina Marga method. This Bina Marga method is outlined in the 2021 Road Geometry Design Guidelines. These guidelines refer to A Policy on Geometric Design of Highways and Streets (AASHTO, 2001), Road Design Guidelines (VicRoads, 2002), and Guide to Road Design Part 3: Geometric Design (Austroads, 2016). In addition, this guideline revises several guidelines and procedures regarding road geometry planning that have been used so far. The revisions include the presentation structure, which refers to the Indonesian National Standard, and the addition of content to meet the needs of both central and regional road operators. This revision was prepared to accommodate challenges and obstacles in road construction in Indonesia.

Data is one of the main strengths in compiling research and scientific modeling (Rifai, Hadiwardoyo, Correia, Pereira, & Cortez, 2015). This horizontal alignment geometric planning journal for the Jalan Cisauk-Jaha STA 0+000 - 00+350 uses secondary data from the Bina Marga and Spatial Planning Office of Banten Province. In the data that the author obtained, there is no horizontal alignment calculation. However, class IIA roads, flat terrain clarification, design speed (Vr) of 80 km/h, road width of 7 m, and road contour drawings are among the data obtained by the authors.

4. Result and Discussion

The following is the geometric plan for the horizontal alignment of the Jalan Cisauk-Jaha STA 0+000 - 00+350 using the Bina Marga Method, which is equipped with the steps taken and the standards used. The data obtained from the Cisauk-Jaha Highway STA 0+000 – 0+350 for horizontal alignment calculations (spiral, circle, spiral) are as follows: class IIA road, clarification of flat terrain with the Bina Marga method. Design speed 80 km/h, radius mn (Rmin) 210 m, transition curve (ls) 70 m, superelevation slope (e) 8 % standard
cross slope (en) 2 %, road width 7 m, design radius (Rc) and α 48°.

Table 1. Horizontal Alignment Calculation Results

<table>
<thead>
<tr>
<th>Formula</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>0s</td>
<td>6,3040</td>
</tr>
<tr>
<td>0c</td>
<td>35,3920</td>
</tr>
<tr>
<td>Lc</td>
<td>196,43 m, Check Lc &gt; 70 m (OK)</td>
</tr>
<tr>
<td>L</td>
<td>336,43</td>
</tr>
<tr>
<td>θs</td>
<td>6,009244, K = 0,4997974 (interpolation from table 4.10 page 129 of Silvia Sukirman’s book)</td>
</tr>
<tr>
<td>P</td>
<td>0,647108</td>
</tr>
<tr>
<td>K</td>
<td>34,985818</td>
</tr>
<tr>
<td>TS</td>
<td>176,8567, L &lt; 2 Ts = 336,43 &lt; 353,71 (OK)</td>
</tr>
<tr>
<td>Es</td>
<td>30,803 m</td>
</tr>
<tr>
<td>Relative Slope</td>
<td>0,01</td>
</tr>
</tbody>
</table>

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From the results of Table 1, the calculation results above obtained values to determine the horizontal alignment curve at the STA 0+000 - STA 0+350 bend. This calculation is guided by the Circular Letter of the Ministry of Public Works and Public Housing from the Director General of Highways concerning Guidelines for the 2021 Road Geometric Design. Calculation values can be calculated in figure 2, Horizontal Alignment.

![Figure 2. Horizontal Alignment](image)

Based on the calculations and recapitulation above, Jalan Raya Cisauk – Jaha at the horizontal alignment bends of STA 0+000 – 0+350 is of the spiral – circle – spiral type. With a relative slope of 0.01 and value TS 176,8567 m. Value \( P^* = 0.009244 \), \( K^* = 0.4997974 \) obtained from interpolation from table 4.10 page 129 of Silvia Sukirman's book with a value of \( \Theta s 6,30^\circ \). The horizontal alignment curve that has been visualized in Figure 2 is then made into a superelevation diagram, which is outlined in figure 3.

![Figure 3. Diagram of Super Elevation](image)

5. Conclusions

From the research results of the horizontal alignment geometric design for the Jalan Cisauk-Jaha STA 0+000 - 0+350 it can be concluded that the Jalan Cisauk-Jaha is a class IIA collector road with a width of 7 meters and design parameters of design speed (VR) 80 km/hour and maximum slope (e) 8%. From the calculation, the design radius (R) is 210 m, with the intersection angle (\( \alpha \)) = 48°. The horizontal curved length (Lc) is 196.43 m, the maximum slope (e) is 8%, and the road terrain class is a flat area. In this paper, the authors take the SCS (Spiral Circle Spiral) curved horizontal alignment type, which is safe for the rider according to field conditions. This plan is in accordance with calculations that are guided by the Circular Letter of the Ministry of Public Works and Public Housing of the Director General of Highways concerning the 2021 Road Geometric Design Guidelines

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