LEADER
Civil Engineering and Architecture Journal

Civil Engineering and Architecture Journal Vol.2 No.5 (2024) 3026-622X
DOI 10.37253/leader.v2i5.10257

Redesign of Road Geometric Civil 3D® Case Study: Jl. Kadipaten-Kasokandel (STA 0+000-STA 4+800)

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ARTICLE INFO

***Keywords**:*

Road geometric design,
Sight Distance,
Autocad Civil 3D®

ABSTRACT

Geometric road planning is a component of road development planning that aims to determine the actual dimensions of the road and its function to meet traffic needs. In the geometric planning of the Kadipaten-Kasokandel road at STA 0+000-STA 4+800, geometric patterns and shapes must be planned so that the related streets can produce optimal service to traffic according to their function. Road geometric planning on the Kadipaten-Kasokandel the segment of the road from Sta 0+000 to Sta 4+800 using AutoCAD®Civil 3D using the design speed plan (VD) criteria of 80 km/hour, the terrain classification on this road section is flat terrain. In the horizontal alignment, there are four bends with three curves using the Spiral-Circle-Spiral type, while the first use the Full Circle bend type. In the vertical alignment, there are seven segments of the inclined plane.

1. Introduction

Roads serve as vital infrastructure for transporting people and goods between locations. They play a critical role in communities, ensuring the comfort and safety of users and facilitating effective maintenance (Zulfa N. R., 2022). Countries worldwide are actively pursuing road construction projects. Road repairs are crucial for maintaining road quality. In 2014, road vehicles accounted for 72.8% of transportation-related greenhouse gas emissions in Europe, with similar trends observed in the United States (Llopis-Castelló, 2018). Road construction has both positive and negative impacts.

Indonesia has seen significant infrastructure development recently, particularly in road construction. Proper geometric planning is essential, involving cross-section elements, visibility, alignment, curves, superelevations, and other physical features (Rizqi, 2022). The rapidly developing Indonesian economy impacts road effectiveness. Significant allocations toward public infrastructure, such as roads, railways, ports, airports, power plants, water and sanitation facilities, schools, and hospitals, are anticipated to rise (Nugroho, 2022). This rapid development requires a strategic approach to ensure sustainability and efficiency. The use of advanced technologies and innovative materials in road construction can enhance durability and reduce maintenance costs. Additionally, implementing comprehensive monitoring systems to oversee the performance of these infrastructures can prevent early deterioration and extend their lifespan. Collaboration between the government, private sectors, and local communities is crucial in achieving these goals, ensuring that the infrastructure meets the demands of a growing economy while considering environmental and social aspects (Mudiyono, 2022).

West Java's booming economy has led to increased transportation and extensive road construction projects, such as the Cisumdawu toll road. However, in Majalengka Regency, the benefits of road infrastructure development are still not fully felt. Road geometric design involves horizontal and vertical alignments and road sections, which are critical for successful road (Ulchurriyyah, 2022). Effective road geometric planning is essential. While the economic growth in West Java spurs large-scale projects, the uneven distribution of benefits highlights the need for more inclusive development strategies. In regions like Majalengka, comprehensive and well-planned road geometric design can ensure that infrastructure improvements are felt more broadly, fostering regional equity and connectivity (Rahman & Wibowo, 2023).

Geometric planning determines the road's dimensions and functionality to meet traffic needs. In Majalengka, road infrastructure development is not yet fully experienced. Road geometric planning is the first step in constructing connecting roads, such as the Kadipaten-Kasokandel road, which links Bandung City and Cirebon City, forming a vital part of the primary road network (Joice, 2022). Effective geometric planning is crucial for developing quality road infrastructure (R, RifaI, & M, 2022).

Advanced computer technology enhances the precision and efficiency of highway geometric design, using software like AutoCAD® Civil 3D. This technology addresses the safety and comfort of both motorized and pedestrian mobility. AutoCAD Civil 3D® aids in various Civil Engineering tasks, including designing geometric models for roads and highways (Salsabila, Rifai, & Isradi, 2022). In the Kadipaten-Kasokandel road case study, geometric planning aims to improve safety and minimize traffic accidents by optimizing road design with AutoCAD Civil 3D. The planning of STA 0+000-STA 4+800 must ensure the road provides optimal service according to its function.

2. Literature Review

2.1 Road Geometric Design

A geometric road structure is built above ground level, assuming the ground surface is not flat either vertically or horizontally. Road planning that emphasizes the structural layout of roads constitutes geometric road planning (Adiputra, Rifai, & Bhakti, 2022). Several factors must be considered in planning a geometric road design. The design should provide reasonable efficiency values, taking into account development costs and the desired future economic value (Zulfa, Rifai, & Taufik, 2022). When planning road design, attention must be given to horizontal and vertical alignment. Horizontal alignment consists of a series of points that form a straight line (tangent) or a curve (arc) as a projection of the road axis on the horizontal plane (Arifin & Rifai, 2022).

Designing the horizontal alignment poses significant challenges in highway planning, as it requires considering the road radius to create a smooth curve that meets the criteria. On the horizontal plane, the road axis is projected to form a horizontal curve (Stefanus, Rifai, & Nasrun, 2022). Additionally, the driving speed of various vehicle classifications can affect the selected road class, which is a determining factor in designing horizontal alignment and will undoubtedly impact project costs. Calculations for straightness usually include centrifugal force, degree of curve, curve radius, superelevation, curve transition, curve widening, and including the curvature of the road.

The vertical alignment, on the other hand, represents the profile of the highway, and geometric design is a pivotal stage in a highway project that directly influences construction expenses (Gunawan, Rifai, & Irianto, 2022). Several factors influence this alignment, including design speed, topography, road function and class, bridge deck elevation, and subgrade soil conditions. Properly considering these factors during the design phase can significantly improve the overall performance and safety of the road. Additionally, addressing these elements early on helps mitigate potential construction challenges and cost overruns. Effective geometric design not only ensures compliance with engineering standards but also enhances the longevity and reliability of the infrastructure.

2.1 Sight Distance

Sight distance is an important aspect of the design element from a safety perspective and is the length of the road visible in front of the driver (Nurjannah, Rifai, & Akhir, 2022). Sight distance is, of course, very much needed by the driver. The Availability of sufficient visibility allows the driver to adjust the speed and try to avoid the danger ahead. Sight distance for various operating speeds is based on a consistent design size (Godumula & Ravi Shankar, 2023).

Vehicle speed is greatly influenced by factors of the physical condition of the road, including road geometry, side clearance, traffic signs, and traffic rules. Visibility is one of highway safety's most important geometric design factor (Gargoum & Karsten, 2021). where the road's geometric design must ensure sufficient visibility along its alignment, planners need to grasp this concept to ensure safe sightlines for drivers.

There are two types of sight distance calculations: line-of-sight distance in a horizontal arc and sight distance in a vertical arc. Horizontal curvature visibility, namely the presence of visibility is very important when the vehicle goes through a bend (Said, 2022). Many cases on the road have impaired vision caused by trees, cliffs, buildings and other obstacles. Meanwhile, the visibility in the vertical arc, namely two types of longitudinal slopes, is prepared to change smoothly in every required position. This is done to reduce the shock caused by gradient changes and provide a safe stopping view when driving.

2.3 AutoCAD Civil 3D

In a rapidly evolving world with constant digital advancements, numerous computer software programs have been developed to address problems in various fields. One of these software programs is AutoCAD Civil 3D, which is a leading tool in the field of civil engineering model design (Pandey & Bajpai, 2019). AutoCAD Civil 3D® is a design and documentation software for civil engineering developed by Autodesk (Maulana, Rifai, & Isradi, 2022). This software supports modeling, analysis, and design across diverse civil engineering projects, including roads, railways, land development, water systems, and airport planning. AutoCAD Civil 3D enhances engineers' ability to handle data efficiently and promptly adapt to project modifications.

3D modeling is a key technology needed to create an integrated system to ensure road safety in large cities and industrial development globally. The development of design infrastructure worldwide is rapidly advancing (Agniya, Rifai, & Taufik, 2022). One example is the emergence of various software, including AutoCAD Civil 3D®. This software is particularly useful for geometric road planning because it facilitates simultaneous processing and drawing creation, streamlining the planning process and reducing design time. AutoCAD Civil 3D® provides a range of tools for modeling projects and offers 3D support for projects of all sizes, aiding civil engineers in visualizing project models.

This software employs dynamic modeling concepts to display the integrated design process, automatically adjusting and updating the entire process as the design progresses (Wibowo & Putra, 2022). This feature makes the geometric road design more integrated and enhances the quality of the design work. In geometric road design, AutoCAD Civil 3D® has proven to be notably more effective and efficient compared to traditional manual approaches.

3. Method

In compiling research, of course, one must have one of the main strengths: data. Data can be used so that we know the condition of the area that we are going to study. The data used in planning this geometric design uses data obtained from Google Earth which will be processed back into the global mapper and then AutoCAD®Civil3D. In this design, it is essential to have supporting data to ensure a safe and efficient outcome. Systematic scientific research is necessary to identify the correct problem. The research method used in this design involves processing quantitative data from Google Earth, Global Mapper, and AutoCAD® Civil 3D. Primary data is typically obtained through field observations. The observation method involves collecting data by observing and recording the state of the target object (Oktobrianto, Rifai, & Akhir, 2022).

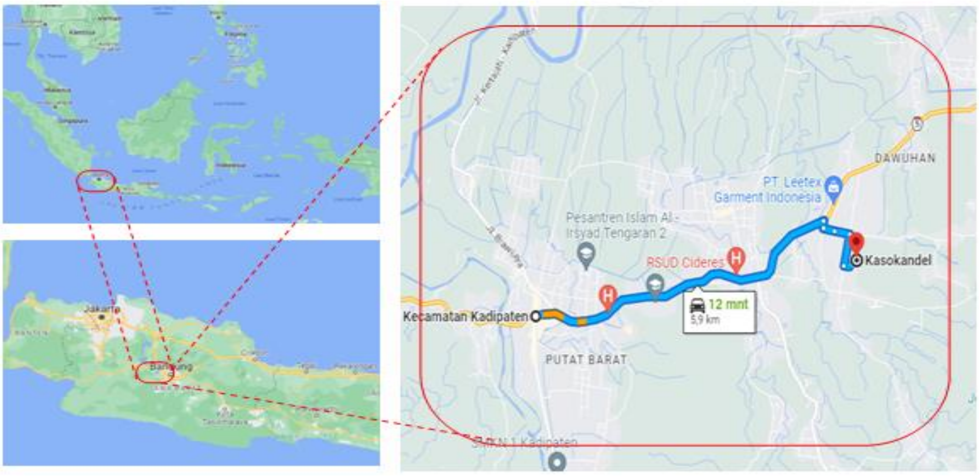

Figure 1 The area planned in this study starts from the Duchy to Kasokandel, with a distance of STA 4+800.

Source; Google Maps

Secondary data, on the other hand, is sourced from related institutions that have already conducted field observations. The data used in this study includes topographic information of the existing road and a situational map of the current location (Nurjannah, Rifai, & Akhir, 2022). This design adheres to the geometric road standards set by the Ministry of Public Works and Public Housing, Directorate General of Highways, in 2020. The outcomes of this geometric design will be illustrated using AutoCAD® Civil 3D.

4. Result and Discussion

Here is a geometric plan for the horizontal alignment of Jalan Kadipaten-Kasokandel from STA 0+000 to 4+800, utilizing the Bina Marga Method, along with the procedures followed and standards applied. Data was gathered from Jalan Kadipaten-Kasokandel spanning STA 0+000 to 4+800.For horizontal alignment calculations (spirals, circles, spirals) are class IA roads, clarification of flat terrain using the Bina Marga method (Rizki, Rifai, & Djamal, 2022).

4.1 Design Criteria

Table 1. Design Criteria

Medan Classification	Flat	
Road Classification	Public Roads (Primary Local) (Provincial Government)	
Road Network System	Primary	
Road Status Provincial Roads	Road Status Provincial Roads (Provincial Government)	
Path Configuration	2/2 T	
Plan Speed	80	km/h
RUMAJA width	24	m
RUMIJA width	25	m
RUWASJA Width	15	m
Lane Width	3,5	m
Inside Shoulder Width	0,5	m
Outer Shoulder Width	2	m
Median Width	2	m
Normal Superelevation	2%	%
Shoulder Superelevation	6%	%
Maximum Superelevation	8%	%
Maximum Slope	5%	%

4.2 Horizontal Alignment

Field measurement data is drawn or visualized using the Autodesk Civil 3D Student Version 2023 application to obtain bend-shape results. An illustration of the existing bend is shown in Figure 1. Through testing, Autodesk Civil 3D obtained Student Version 2023 bend data, and the calculation results of the horizontal alignment bend analysis can be seen in the calculation below. Calculate the minimum radius using the formula below to find the horizontal alignment yourself.

$$Rmin = \frac{Vd^\wedge 2}{127(Emaks + Fmaks)}$$

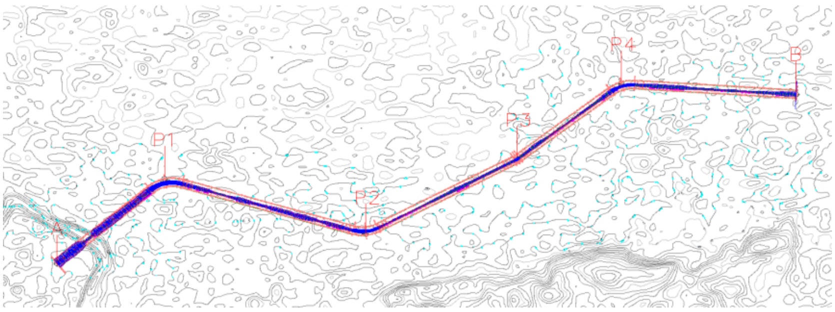

Figure 2 Horizontal alignment

Table 2. Coordinate calculation

POINT	COORDINATE		DISTANCE			Azimuth	Bend Angle
	X	Y	ΔX (m)	ΔY (m)	d (m)	α	Δ
A	186.243.685	925.117.415					
			628856	8,33E+09	8,33E+09	0,004327	
PI 1	186.872.541	9.252.136.944					**105,970**
			1179925	-337759	1227316	105,974	
PI 2	188.052.466	9.251.799.185					**43,317**
			885312	457781	996664,8	62,65722	
PI 3	188.937.778	9.252.256.966					**9,755**
			612634	463299	768092,7	52,90193	
PI 4	189.550.412	9.252.720.265					**40,673**
			1023250	-63928	1025245	93,57493	
B	190.573.662	9.252.656.337					

4.3 Superelevation

After creating horizontal paragraphs and Circle Spiral (S-C-S) curves, superelevations are made by right-clicking on the curves made and then clicking the calculated superelevations. Next, specify the lane type, road classification, shoulder configuration, and additional planning criteria.

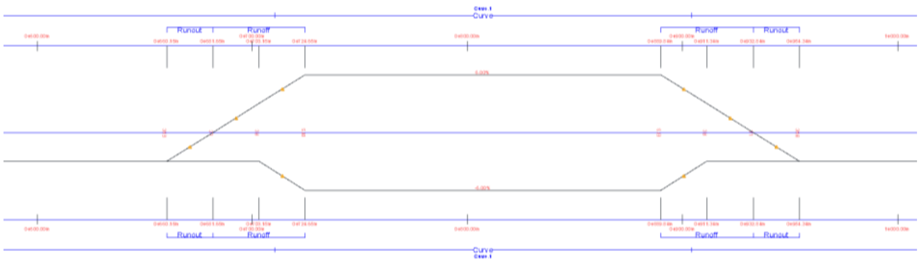

Figure 3 Superelevation P1

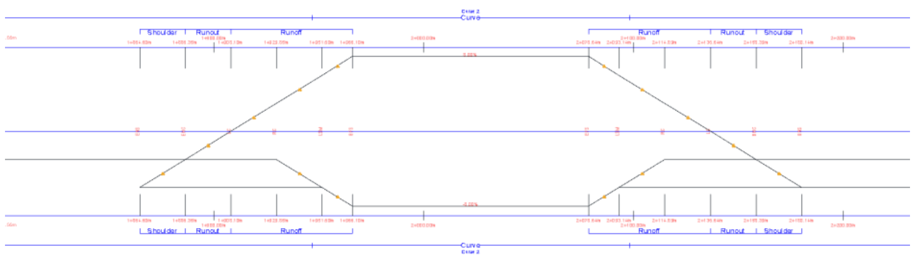

Figure 4 Superelevation P2

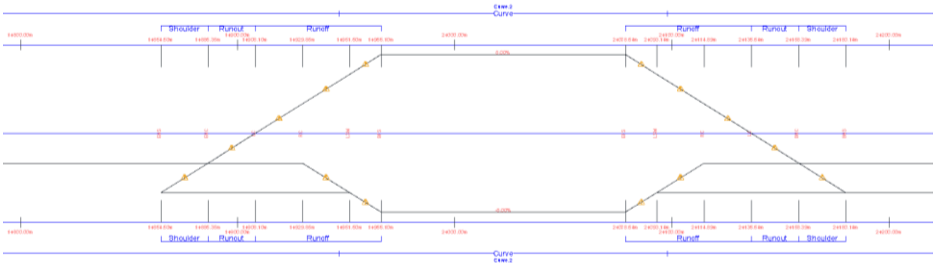

Figure 5 Superelevation P3

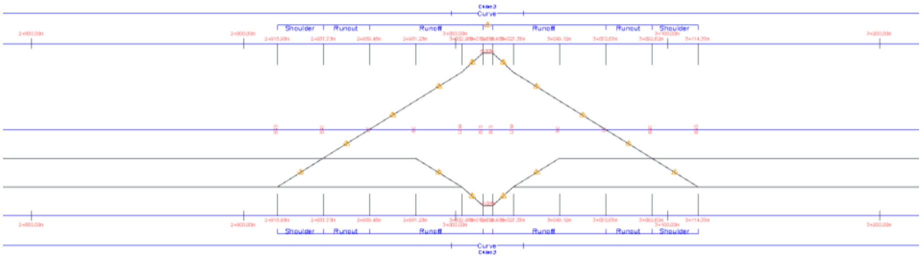

Figure 6 Superelevation P4

4.4 Vertical Alignment

Once the horizontal alignment is generated, superelevation. Next, look for a vertical alignment on the Kadipaten-Kasokandel road with Sta 0+000 to Sta 4+800. The vertical alignment on this plan is visualized using the AutoCAD Civil 3D application. For vertical alignment, images can be seen in the image below.

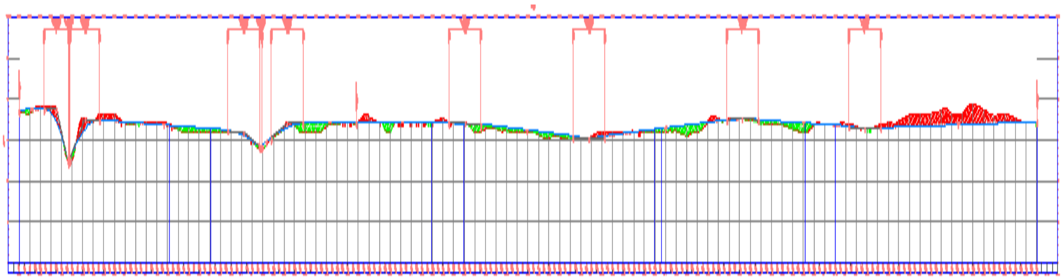

Figure 7 Vertical Alignment

Based on the picture above, it can be seen that the Kadipaten-Kasokandel road section is included in the flat terrain classification after knowing the alignment picture on this road segment. Furthermore, we can get a picture of the corridor on this road segment. Corridor images can be seen in Figure 7.

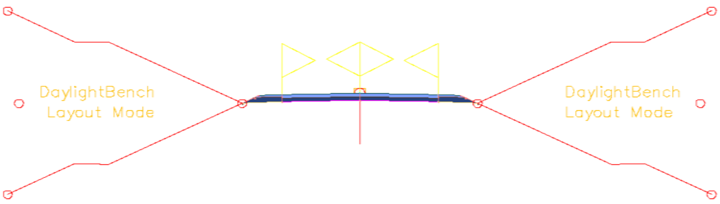

Figure 8 The Road Cross-Section Plann

The picture above is a corridor on the Kadipaten-Kasokandel road section. The corridor is visualized using the AutoCAD®Civil 3D application. Thus the drawings for vertical alignment and corridors can be found.

5. Conclusion

Geometric road planning on the Kadipaten-Kasokandel road section from STA 0+000 to STA 4+800 employs AutoCAD® Civil 3D with a design speed (VD) criterion of 80 km/hour. The terrain classification for this road section is flat. In the horizontal alignment, there are four bends, with three using the Spiral-Circle-Spiral type and the first bend using the Full Circle type. The vertical alignment consists of seven segments of inclined planes.

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