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The Horizontal Alignment Design Using Autocad® Civil 3d on The Ciawi Tasikmalaya Regency Alternative Road

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ABSTRACT

The choice of road lanes is a determining element in the financial improvement of a country. The mobility of suburban residents from isolated areas is linked to their economic activities by road construction, taking into account factors of comfort, safety, and smoothness of roads. Inside the geometric making plans of the road, it is important to decide the design standards that govern the vital elements of the road design. Computer software is used to facilitate and increase the level of planning precision. The author plans a horizontal alignment on Ciawi Tasikmalaya Regency Road using AutoCAD® Civil 3D in this geometric plan. Making this road aims to provide an alternative road by avoiding the congestion lane from the road that passes through the centre of the economy. This alternative road plan uses two SCS (Spiral-Circle-Spiral) type bends with a radius of 700 m, a design speed (V_r) of 80 km/hour, and a maximum slope of 6%.

1. Introduction

The highway/road is one of the main infrastructures that people/goods use to mobile from one place to some other by reducing travel duration. On the side of monetary improvement, human welfare additionally increases, so the intensity of road use increases [1] [2]. The increase of connectivity infrastructure pursuits to integrate the financial system between regions with the aid of increasing efficiency and expediting the waft of goods and offerings [3] [2]. Indonesia's improvement is centred on huge cities and has started accomplishing far-flung rural areas. Its application calls for integrated planning primarily based on the desires of a place. The desires of an area can be visible from the conditions and capabilities that occur in the region [2].

Based totally on the region road, the planner or designer selects the nice route thru the geometric layout of the road and makes alignments on the chosen course. Consequently, the matters that have to be considered are the road's area, the course's selection, and the road geometry of the selected lane alignment. Road terrain in Indonesia is classified based totally on the circumstance that most terrain is sloped while measured perpendicular to the contour lines. Therefore, the diversity of road terrain situations has to be considered with the uniformity of terrain situations consistent with the road plan paragraph by ignoring the small elements change of the road plan [4]. In road traffic, traffic safety arrangements and the necessary facilities can guarantee vehicle driving safety [5]. Road planning should pay close attention to rainwater runoff. The pavement layer is easily damaged due to standing water due to the essential nature of the asphalt mixture itself. This condition is caused because asphalt has properties that are not too strong against water immersion [6].

In developing countries, road construction aims to connect remote areas and encourage economic growth through better population mobility [7]. Tasikmalaya Regency is a district in West Java Province

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and one of the developing areas in Indonesia. This district is considered the largest district and plays an important role in the East Priangan region. Most of the area is green, especially agriculture and forestry, while farmers make up most of the population [8]. The Ciawi Tasikmalaya Protocol Road is a road that connects the cities of Garut and Ciamis. The road passes through the economic centre in the Ciawi Tasikmalaya Regency, namely the main square and the Ciawi Tasikmalaya Grand Mosque. In that area, there are intersections with unsignalized intersections, so congestion often occurs and slows down the speed of vehicles passing through the area. In addition, although there is an alternative road that does not pass through the economic centre of Ciawi Tasikmalaya Regency, namely Pasar Ciawi Road, there is also a market and terminal crowded with visitors daily. Therefore, an alternative road is needed that connects the Pamoyanan and Ciawi Tasikmalaya Regency areas which connect the City of Garut and the City of Tasikmalaya. The Ciawi Tasikmalaya Regency route does not pass through the two existing roads.

Road construction in developing countries requires careful planning and geometric design calculations of the roads. The road has a geometric design that can be divided into three main parts, which are horizontal alignment, vertical alignment, and other sections, they provide a three-dimensional layout for roads. [9] [10]. The modern-day trend is to depend upon the incredibly superior computer era for the geometry design of roads and highways, which gives great precision and saves loads of effort and time. However, road design poses full-size challenges without 3D modelling. Cutting and filling Computing takes plenty of time [11] [12]. So, road geometric calculations using the Autocad® Civil 3-d utility, specifically in horizontal alignment calculations, are exciting to compare with the consequences of manual analyses of the usage of the Bina Marga reference general [13] [12].

2. Literature Review

2.1 Roadway

Roads are land transportation infrastructure covering all elements of the path, including auxiliary buildings and systems intended for traffic, which are at, above, and below ground level and or water level, and above water level, except railroads: fires, lorries, and cableways. Public roads are roads designated for public traffic. According to their status, public roads are grouped into; national, provincial, regency, city, and village roads [14]. Road geometric design is part of a design that focuses on engineering the physical and analytical form of the road so that it can fulfil the road's essential functions. Road geometric design elements include horizontal and vertical alignment dimensions, cross sections, intersections, and pedestrian and cyclist facilities. The main object of the geometric design is to create a path that is safe, efficient, and economical in maintaining its aesthetics and environmental quality. The geometric design of the road is influenced by the number of vehicles and the traffic characteristics of the drivers. So that a good geometric design is needed by considering these factors in the future [15].

2.2 Horizontal Alignment

Horizontal alignment is one of the hardest aspects of road and highway-making plans, but geometric layout is an essential component of the system. Whilst restricting road length and output, considering the radius can produce a horizontal curve of roads that meet the criteria [16]. Horizontal curvature is one of the most critical conditions affecting planned road efficiency and safety. Poor design of the road will result in lower speed and decreased road performance in terms of safety and comfort, essential elements of horizontal curvature, one of which is Curved Horizontal Radius (Vr) [17].

There will generally be two road sections in horizontal alignment planning: a straight section and a curved section, commonly called a bend. Regarding road users' safety factor, in terms of driver fatigue, the maximum length of a straight section of road must be travelled in no more than 2.5 minutes (according to VR). 3 (three) types of bends can be used, namely:

Full Circle (FC) is a type of bend that only consists of part of a circle. FC bends are only used for large R (bend radius) to prevent fractures because a small R requires a large superelevation (Hidayatulloh & Ariostar, 2022), shown in Figure 1.

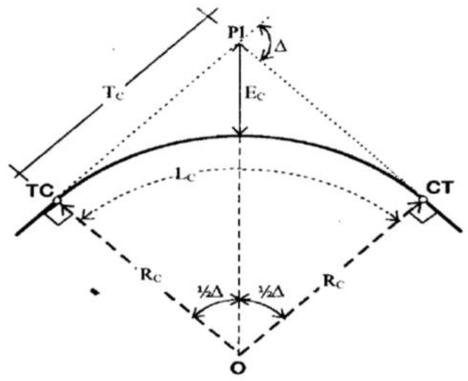

Figure 1 Horizontal alignment: Full Circle
Source: Perencanaan Teknik Jalan Raya [18]

Spiral-Circle-Spiral (SCS) is a transitional curve made to avoid a surprising change in alignment from an instant form to a round form, so this transitional curve is located among the straight phase and the circular section, particularly before and after the arc-shaped bend circle [19], shown in Figure 2.

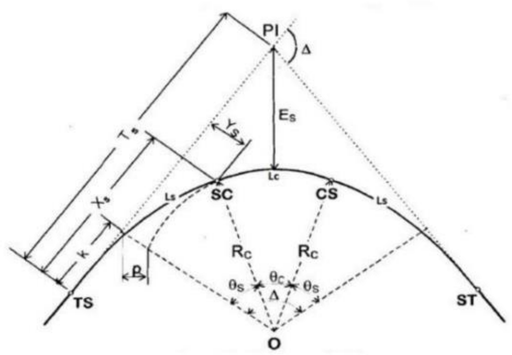

Figure 2 Horizontal alignment: Spiral-Circle-Spiral
Source: Perencanaan Teknik Jalan Raya [18]

Spiral-Spiral (S-S), a curve consisting of a combination of two transitional arcs without using any circle to the road, is shown in Figure 3.

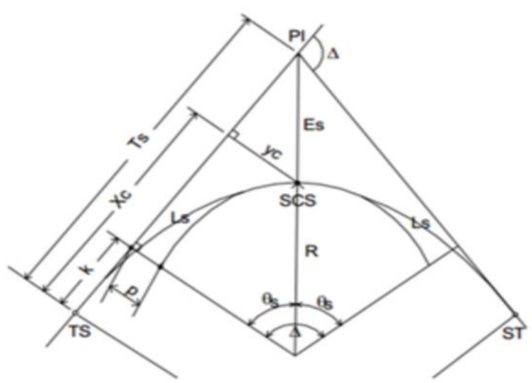

Figure 3 Horizontal alignment: Spiral-Spiral

Source: Perencanaan Teknik Jalan Raya [18]

2.3 Autocad® Civil 3D

Autocad® Civil 3D is one of the BIM software applications used by civil engineers and other professionals to plan and design building construction projects, road and highway engineering projects, and water construction, including dams, harbours, canals, barriers, etc. Creating designs using Autocad® Civil 3D can significantly reduce the time needed to implement design changes and evaluate various situations. Changes made can immediately update an entire project and help complete tasks faster, smarter, and more accurately [20]. Road planning using this one of the BIM software is more powerful, effective, efficient, accurate, and cost-effective than manual planning. Furthermore, this software application program has main parameters, such as road design guidelines, one of which is the visibility of the road design [21].

Autocad® Civil 3D has the ability to create 3D project models and helps adopt them for large and small-scale projects. AutoCAD® has an important function in simplifying and assisting in visualizing the results of properly making plans. Objects can be graphics or images that many people without difficulty recognize [22] [23] [24]. This software program is multi-useful in diverse fields and might integrate factors that include architecture, structure, and construction to make it easier for workers to recognize a design. In today's modern society, computerization is very common, and the use of AutoCAD® Civil 3D is similarly important for every engineer and other professional in planning and visualization of roads and other infrastructures [14].

Several steps in basing roads with Autocad® Civil 3D ought to be considered in structural planning. Those steps need to cowl a number of factors, specifically preparing a road design model that is later to be used, figuring out the deliberate roadway along with its profile, 3D modelling the road, and calculating the quantity of labour and output documentation [25]. Through the calculation and processing of quantitative data, it is able to be determined whether or not the concept meets the project requirements, engineering factors, and financial factors, can reduce project requirements and demolition expenses, improve energy efficiency, maximum return on funding, limit capacity dangers and safety hazards, can carry out more than one simulation experiments and received the excellent approach to increase work efficiency [16].

3. Method

Data is one of the leading forces in compiling scientific research and modelling [26] [27] [28] [29] [30]. The technique of systematic scientific analysis research ought to begin with figuring out the right issue [31]. The horizontal alignment design being studied in this journal is located on Ciawi Tasikmalaya Regency Road, with a planned road length of 3.25 km as an alternative to the existing road. The design planning location can be seen in Figure 4.

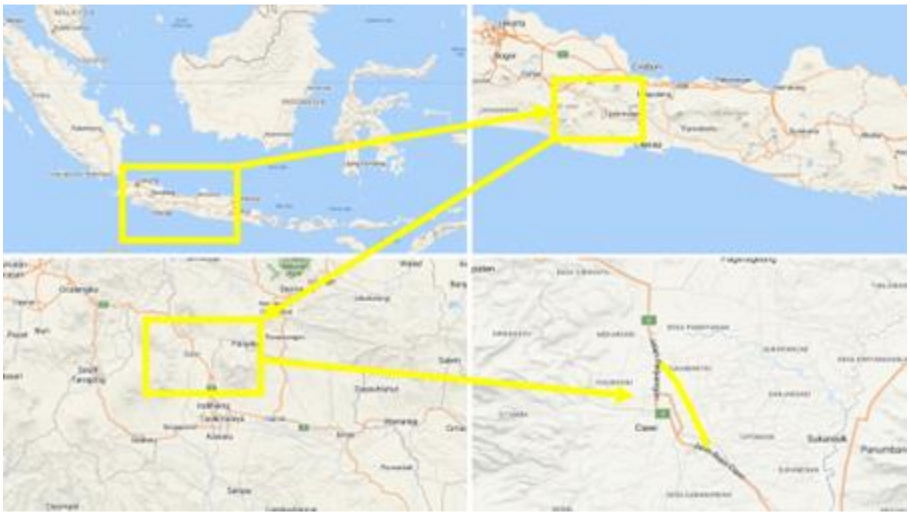

Figure 4 Location Map of the Horizontal Alignment Design on Ciawi Tasikmalaya Regency Road

The secondary data was obtained from the relevant agencies as well as some data from previous journals for the geometric horizontal alignment design of this road. It includes a map of the Tasikmalaya Regency Road network. Map of the design planning location for Ciawi Tasikmalaya Regency Road with coordinates -7.143168320332958, 108.14754528211142 and ends at coordinates -7.167949252141774, 108.16102344257341, terrain contour of the location data obtained from Google Earth and processed into a software format with Global Mapper version 24, after getting the data secondary, designed horizontal alignment road geometry using Autocad® Civil 3D software to plan the horizontal alignment, compared with manual calculations previously studied in some journals [21].

4. Result and Discussion

4.1 Design Criteria

The geometric planning of Ciawi Tasikmalaya Regency Road used the design planning criteria based on PERMEN PUPR NO 5 2023 concerning Road Technical Requirements and Road Technical Planning are road design speed of 80 km/hour, road maximum superelevation of 6%, road friction coefficient of 0.14, and road minimum bend radius of 350 m. Based on the correlation between horizontal curve planning parameters and design speed, the turning radius is 700 m. Table 1 is a breakdown of the planned road design criteria.

Table 1 Road Design Criteria

Road Data Planning		
Road status	Collector	
LHRT	57000	SMP/day
Design Criteria		
Road terrain classification	Flat	
Road Configuration	4/2-T	
Speed design	80	km/h
Rumaja width	20	m
Rumija width	25	m
Ruwasja width	5	m
Body width	3,5	m
Inside shoulder width	0,75	m
Outer shoulder width	1	m
Median width	1,1	m
Normal superelevation	2	%

Shoulder superelevation	5	%
Maximum superelevation	8	%
Maximum slope	5	%

4.2 Trace Planning

The road planning in this study uses a design speed of 80 km/hour, with a road width of 3.5 m. road traffic-making plans are executed using AutoCAD® Civil 3D based on the contour data received. As shown in Figure 5, road traffic is acquired, divided into four points of interest, starting from STA 0+000 and ending at STA 3+261. The following is a picture of the route planning map.

Figure 5 Trace planning

4.3 Horizontal Alignment

Horizontal alignment geometric planning including making road designs and superelevation is intended to compensate for the centrifugal force obtained by vehicles travelling at design speed (V_R) [5]. After the alignment is made, the calculation analysis is carried out as data to make a horizontal alignment using AutoCAD® Civil 3D, one of which is to calculate the minimum curvature (R_{min}) as described in formula (1). Next, calculate the required minimum arc (R_{min}) with road design speed (V_r) of 80 km/hour, road maximum superelevation slope (e_{max}) of 8%, and road cross-sectional friction coefficient (f) of 0.14.

$$R_{min} = \frac{Vr^2}{127(emaks+fmaks)} = 229{,}062 \text{ m} \qquad (1)$$

$R_c = 700$ m

After calculating the minimum curve (R_{min}), then calculate the transition curve (L_s) primarily based on the maximum mobile time on the transition curve described in Formula (2). The braking reflection value (T) is taken at 3 seconds. Formula (2):

$$L_s = \frac{Vr}{3{,}6}.T = 120 \text{ m} \qquad (2)$$

From the calculation of the curve, the Ls value is 120 m. After analysis, the results obtained from calculating the two Points of Interest (PI) for road traffic planning are as follows. The summary from the analysis results can be seen in Figure 6.

Summary		
Point Intersection	PI1	PI2
Δ	39,845	39,845
R (m)	700	700
ed tabel (%)	4,6	4,6
Ls 1 (MRG)	54,886	54,886
Ls 2 (Table)	50	50
Ls 3 (GALA)	13,044	13,044
Ls 4 (Min, DC)	57,966	57,966
Ls max	129,615	129,615
Ls desain	120,00	120
Ltr	52,17391	52,17391
Θs	4,911	4,911
Δc	30,023	30,023
Lc (m)	366,803	366,803
Yc (m)	3,429	3,429
Xc (m)	119,912	119,912
k (m)	59,985	59,985
p (m)	0,859	0,859
Ts (m)	314,006	314,006
Es (m)	45,473	45,473
L total	606,803	606,803
A	289,828	289,828
d (A-PI1)	1171,633	1171,633

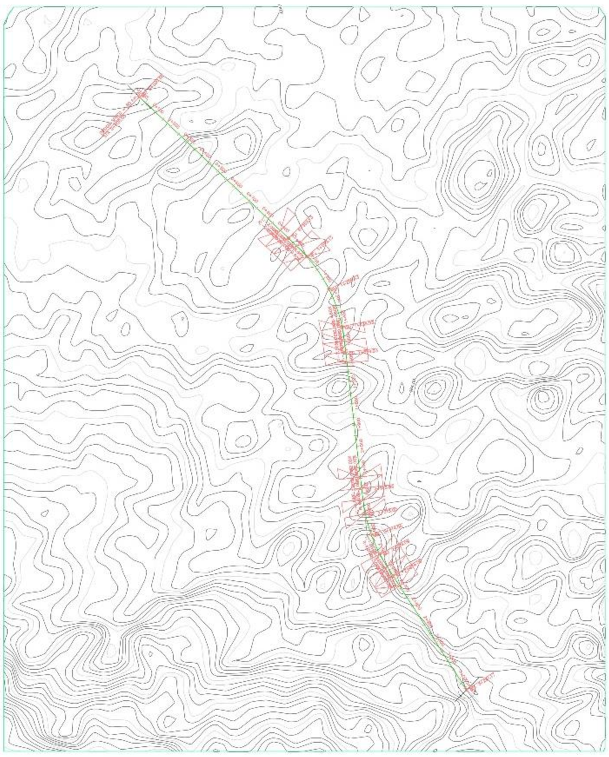

Figure 6 Road bend planning results using AutoCAD® Civil 3D

4.4 Superelevation

The superelevation diagram depicts the change in superelevation value on the Spiral-Circle-Spiral section along the planned bend. The superelevation diagram describes the centrifugal force a vehicle receives when passing a curve to provide safety and comfort while driving. A range number of maximum superelevation rates can be used after consideration of numerous elements such as climate situations, terrain situations, and frequency of very slow-moving vehicles. Consideration of those elements collectively has led to numerous charges in preference to a single rate of maximum superelevation in establishing design controls for road curves. The following figure is the result of superelevation and stationing diagrams from each designed angle that is previous calculations taken from AutoCAD ® Civil 3D.

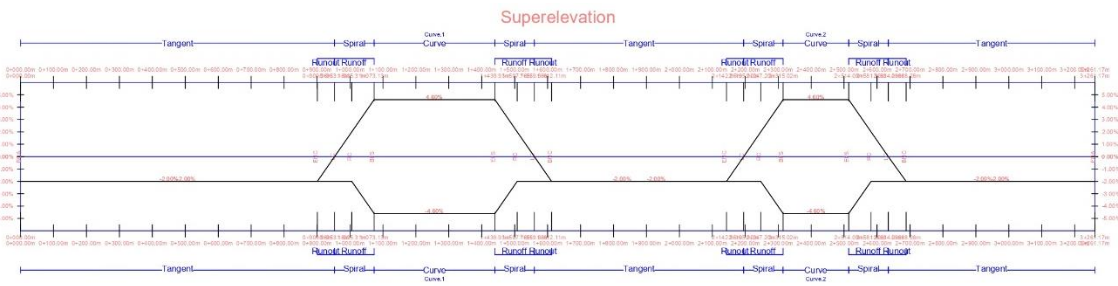

Figure 7 Superelevation diagram for Ciawi Tasikmalaya Regency Road

5. Conclusion

The planning of the geometric design of the horizontal alignment road for the Ciawi Alternative Road Tasikmalaya Regency is a Secondary Collector Road, with a 4/2-T road type, 0+000—3+261 long, aiming to provide an alternative collector road that does not pass through the economic centre of Ciawi Subdistrict so that it can be passed with less travel time. Planning uses AutoCAD® Civil 3D to streamline various aspects of design planning. The road sections are planned geometrically horizontal with two common design bends using the SCS (Spiral–Circle–Spiral) type with a radius of 700 m each so that the design superelevation is 4.6%.

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