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The Horizontal Alignment Redesign of Connecting Roads in the Coal Area: A Case of the Section Sulit Air – Rawang STA 6+300 – 6+600 West Sumatera

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ABSTRACT

The construction of the Sulit Air Road - Rawang, Sawahlunto City, is expected to be a solution to shorten travel time and ensure the comfort and safety of road users. The data used in this paper uses secondary data. Using the Bina Marga method, this journal aims to redesign the Sulit Air Road – Rawang, Sawahlunto City at STA 6+300 – STA 6+600. The study results show that the Sulit Air – Rawang is a class collector primer Road with flat terrain with a width of 4.5 m, design parameters design speed (VR) of 60 km/hour, and a maximum slope (e) of 8%. From the calculations, the design radius (R) is 350 m. The curved horizontal length (Lc) is 87.120 m. In this journal, the authors take the FC (Full Circle) type of curved horizontal line that is safe for the rider according to the conditions in the field.

1. Introduction

The population continues to increase from year to year. The world's population will reach 7.8 billion people in 2021. This number has increased by 11.89% from the previous decade and is expected to continue to increase yearly. The use of motorized vehicles around the world the increase in motorized vehicle users has an impact on infrastructure development in each part of the world, ranging from those that can keep up with increased infrastructure development to even those that suffer damage to infrastructure because they cannot keep up with the growth of road users.

Indonesia this year continues to experience an increase in population. An increase in population results in an increase in the volume of vehicles which impacts traffic. This happens when there is no balance between population growth and vehicle volume with the growth of roads [1]. The population continues to increase and must be balanced with good infrastructure facilities. Viewed from various aspects as a result of the growth, the government must build transportation infrastructure that meets the requirements and fulfills its role in increasing people's productivity [2].

Highways are infrastructure pillars of a region, which can act as a means of developing existing resources and facilitating the mobility and distribution of goods from one region to another. The development in the area is evidence of the start of the development of the community's economy, with roads that can facilitate and speed up access to mobility. The definition of a road is also written in the Law of the Republic of Indonesia Number 38 of 2004, which states that a road is a transportation infrastructure that includes all parts of the road designated for traffic. Road geometric planning must also pay attention to safety factors for motorists [3]. The Sulit Air - Rawang road is an alternative road connecting Solok Regency with Sawahlunto City. With this infrastructure facility, it is hoped to shorten the time and improve the people’s economy in the Solok district. In connection with this, it is planned that the Difficult Air - Rawang road section with Geometry elements is expected to be, by standards, selected, measured, and placed with design criteria such as visibility, comfort, drainage, economy, and aesthetics [4].

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This paper's purpose is to consider the geometric planning of the road on the Sulit Air Section – Rawang, Solok Regency. Floor plan geometric road, Which Good expected can adapt to the current Then cross Which crossed with still prioritize safety. Design infrastructure road must notice all aspects That influence the user's safety [5]. This paper's purpose is to consider the geometric planning of the road on the Water Difficult Section – Rawang, Solok Regency. Floor plan geometric road, Which Good expected can adapt to the current Then cross Which crossed with still prioritize safety. Design infrastructure road must notice all aspects Which influence the user's safety [5].

2. STUDY OF LITERATURE

2.1 Road Geometric Planning

Road geometric planning describes the physical form of the road to be built, which is incorporated into several road elements. The physical description is part of road planning, intended to plan the road's physical form, which becomes the realization of road construction [6]. Things that need to be considered in the geometric planning of the road are the size of the vehicle, the nature of the movement, the nature of the driver in driving the vehicle, and traffic characteristics. This should be a reference for road planners.

Road geometric planning begins with the construction of connecting roads or alternative roads. Connecting roads brings one road together with another, intending to improve quality starting from an economic, social, educational, and other perspective that can help people's welfare. Connecting roads also provide access to infrastructure such as markets, schools, and hospitals, but the high transport costs associated with transport infrastructure often hinder development [7].

Road construction is carried out to anticipate increased traffic density, overcome accident problems, improve the quality of the road landscape, and restore existing infrastructure or a combination of these objectives. In road construction, careful geometric planning is needed to provide safety and comfort for road users [8]. Road safety will be implemented if the standards plan for the road built meets the requirements. Road geometric includes horizontal curves, vertical curves, visibility, and road classification. A traffic survey is carried out to determine the number of lanes, the width of the road, and the material design. The main objective of a traffic survey is to determine the amount of traffic density that impacts the geometric planning of the road [9].

2.2 Horizontal Alignment

In the geometric planning of the road, there are two alignments, consisting of a vertical alignment and a horizontal alignment. Horizontal alignment is an image made flush with the horizontal plane of the road [10]. Horizontal alignment is a straight line that is continued by curved lines. In horizontal alignment planning, security and safety for road users must be prioritized. Factors influencing horizontal alignment design include terrain classification, speed, vehicle volume, topographical conditions, level of service, and design criteria such as minimum radius, degree of slope, and visibility.

The geometric characteristics of the road, in the form of design speed, super-elevation, and horizontal curvature radius, are stated in the AASHTO regulations. Then it also mentions the geometric characteristics of other roads, such as the width of the road starting from full circle curves and spirals – circles-spirals, lateral friction. Horizontal alignment planning, in general, consists of two types of bends, namely circle (Full Circle), Spiral – Circle – Spiral (SCS) [11].

Technical provisions in designing road geometrics include design criteria, visibility, determining corridors, road cross sections, and element coordination. The design criteria are the basis for determining visibility, horizontal alignment design, and typical road cross-sections. Each traffic lane

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must comply with the Stopping Sight Distance (JPH) throughout the horizontal alignment design. Along the horizontal alignment design, you should avoid matching or monotonous road shapes as much as possible and make the horizontal alignment design straight with a significant bend radius [12] [13] [14].

2.3 Road Classification

Highways have various classifications even though their purpose is designated traffic facilities and infrastructure. According to UUD No. 38 of 2004, roads are classified into two types based on their function and type. Then the roads are further divided based on their functions into four, namely arterial roads, collector roads, local roads, and environmental roads. The theoretical basis for highways is based on horizontal and vertical alignment, many factors. This road division is hoped to meet regional needs to support operations and improve the regional economy [15] [16].

The division of roads based on status gives the government authority to build roads with facilities and regional governments to develop their areas according to regional autonomy principles [17]. Primary collector roads connect national activities or activities with the region. Water Difficult Road – Rawang is a primary collector road that has a design speed of 70 m/s with a road section of 4.5 meters wide and a distance of 7 kilometers.

Road terrain is classified based on the characteristics of the physical geometric shape and the function of the road users. From these characteristics, a balance is produced between one and the other. In the initial planning, the cross-section of the road has an impact on determining the vertical alignment. The topography of the road terrain is grouped into three terrains: flat, hills, and mountains [18] [19] [20]

2.4 Manual Method

Manual road planning is a design calculated and based on applicable regulations. Currently, Indonesia uses the Road Geometric Design Guidelines (PDGJ 2021) as a manual analysis covering planners, designs, road geometric technical provisions, and operation of traffic services, roundabouts, urban roads, and out-of-town roads. The main objective of this manual design is intended so that planners can consider traffic behavior in certain traffic conditions, geometric and environmental conditions [21].

In geometric road planning, taking horizontal and vertical alignments must follow the requirements that have been determined. Comparison of the use of AutoCAD® Civil 3D in the geometric design of roads using the manual method has far more effective correction than planning using the manual method [22]. Therefore, the calculation process manually requires accuracy and quite a long time when compared to using the help of a computer program.

3. Method

Air Difficulty Road – Rawang is located in the province of West Sumatra, which connects Solok Regency with the City of Sawah Lunto. Sulik Aia District This is a provincial road with the function of primary collector 4 (JKP-4). It has a total length of 7 km and a pavement width of 4.5 m. The following is a map of the Air Difficulty Road – Rawang location obtained from the Google Earth application.

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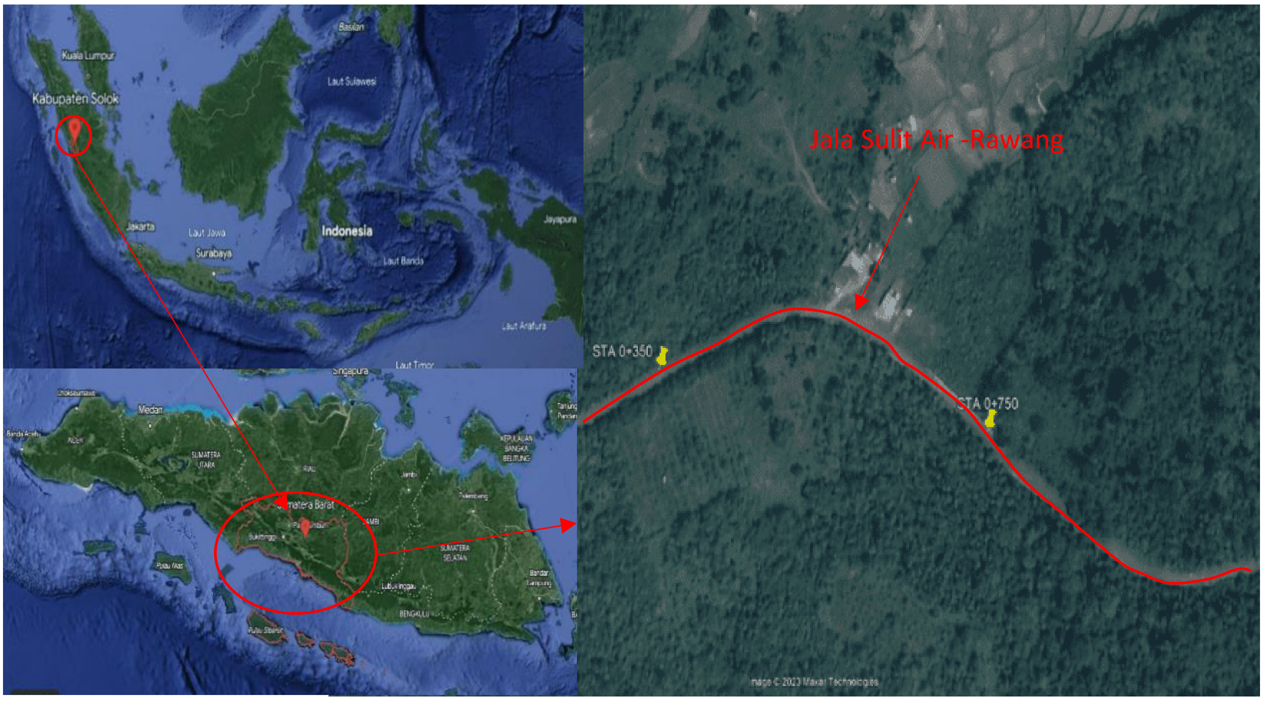

Figure 1. Location of Difficult Water Road – Rawang

This writing begins with data collection and identifying problems with constructing the Difficult Air Road - Rawang. Systematic scientific research must begin with identifying the right problem [23]. The basis for planning is to choose research and data collection methods. The first stage of research is to find and collect the data needed. Data is vital in compiling research and scientific method [24]. The conditions in the hypothesis determine data collection that the data can be in the form of images, sounds, letters, numbers, language, or symbols. This research writing method uses secondary data from multiple sources or indirectly to complement research data needs [25].

4. Data analysis

The author's data collection method involves interviewing the planning consulate, PT Jasa Reka Mandiri, and taking pictures through the Google Earth application. The data needed in the geometric planning of horizontal alignment roads is secondary data obtained from PT. Jasa Reka Mandiri, namely the LHR of the Sulit Air Road Section - Rawang, road network data, and contour data. After obtaining the secondary data, then the geometric planning of the road is carried out manually.

4.1 Determination of Road Classification

Based on its function, the Sulit Air Road - Rawang is a primary collector road, classification according to road terrain can be an average slope of 12.2%, whereas the road terrain includes hills. Table 1 shows the road classification based on the terrain's slope.

Table 1. Classification of Road Terrain

No.	Terrain Type	Notation	Terrain Slope %
1	Flat	D	<10
2	Hill	B	10-25
3	Mountain	G	>25

Source: Road Geometric Design Guidelines, Bina Marga 2021

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Sulit Air Road – Rawang consists of STA 0+000 – STA 6+612, the author only reviews STA 6+300 – STA 6+600. Table 2 shows the results of the calculations from the classification of the Sulit Air – Rawang road terrain at STA 6+300 – STA 6+600.

Table 2. Calculation of Road Terrain Classification

No. –	STA	High EVs	Low EVs	(Δh/L)*100%
1	6 +300	335	325	10%
2	6+400	330	319.5	10.5%
3	PI	333	320.5	12.5%
4	6+500	328	318	10%
5	PI2	327	318	9%
4	6+600	326	317	9%

$$\frac{\sum s}{n} = \frac{61\%}{6-1} = \mathbf{12.2\ \%}$$

4.2 Design Speed and Road Characteristics

Determination of the design speed based on the main design criteria table, for hill road terrain and inter-city road functions, the recommended speed is 30 – 70 km/hour, and the value of Rc = 350 m. Determination of the characteristics of the road begins with determining the width of the road and the planned shoulders, which are obtained from the average LVHR data and then calculated using the formula.

$$LHR_{awal\,UR} = (1+i)^n\ x \sum kendaraan\ x\ SMP$$

Where :

i = traffic growth (%)

n = Planned life of the road

Determination of the characteristics of the average daily traffic is described in Table 3, namely in calculating the average daily traffic on the Sulit Air Road - Rawang, Sawahlunto City. The calculation is carried out at the LHR at the end of the design life.

Table 3. Calculation of Average Daily Traffic

No.	Transportation type	$(1+i)^n$ x ∑ Vehicle X Initial LHR	Results
1	Light Vehicle 2 tons	$(1+0.06)^{10}$ x 200.45	358.80
2	buses	$(1+0.06)^{10}$ x 100.15	179.27
3	Truck 2 axles	$(1+0.06)^{10}$ x 250.12	447.71
4	Truck 3 axles	$(1+0.06)^{10}$ x 100.45	179.81
5	Four axle trucks	$(1+0.06)^{10}$ x 50.87	91.06
			1256.65

From the calculation results, the LHR = 1256.65 is obtained, less than 1860 SMP / day, so the ideal lane width for the Hard Air - Rawang road is 4.5 meters, and the ideal shoulder is 1.5 meters.

4.3 Horizontal Alignment Calculation

Calculation of horizontal alignment begins by determining the distance between the previously planned points and then determining the coordinates of each point, which has also been previously determined.

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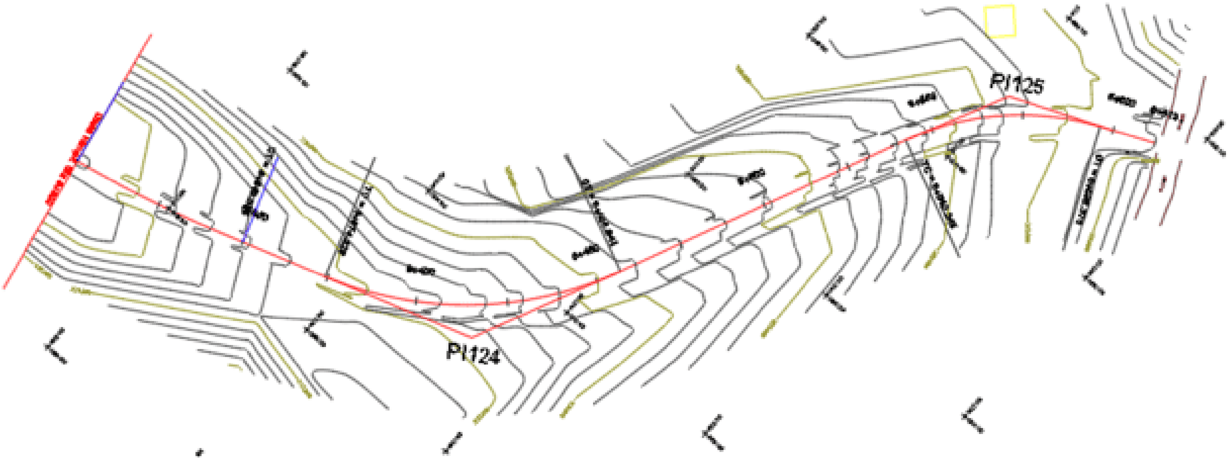

Figure 2. Road Trace Planning

4.3.1 Coordinate point

The determination of coordinate points is described in Table 4, which lists the coordinate values at each specified point.

Table 4. Coordinate Points

No.	Point	Coordinate	
_		X	Y
1	PI124	689875,688	9932991.137
2	PI125	689985.609	9933028.083
3	PI126	690050.026	9933171.782

4.3.2 Distance Calculation

The distance calculation is carried out for each section, an example of the calculation that will be carried out is at the PI124 point with the following formula :

$$\boldsymbol{D} = \sqrt{(X2 - X1)^2 + (Y2 - Y1)^2}$$

$$\text{(d1) dA – PI124} = \sqrt{(X2 - X1)^2 + (Y2 - Y1)^2}$$

$$= \sqrt{(689985{,}609 - 689875{,}688)^2 + (9933028.083 - 9932991.137)^2}$$

$$\mathbf{= 115.786\ m}$$

4.3.3 Azimuth calculation

$$\alpha \text{ API1 } = arc\ tan\left(\frac{x2 - x1}{y2 - y1}\right)$$

$$= arc\ tan\left(\frac{689985{,}609 - 689875{,}688}{9933028.083 - 9932991.137}\right)$$

$$= 14\,°17'06''$$

4.4 Bend Planning

Based on the availability of land, There is Bend Which in the plan is Full Circle (FC) with data – data planning as follows example calculation arch, Which will in do on No Pi 124. See the longitudinal section of the Sulit Air – Rawang road, you can see it in Figure 3 below This.

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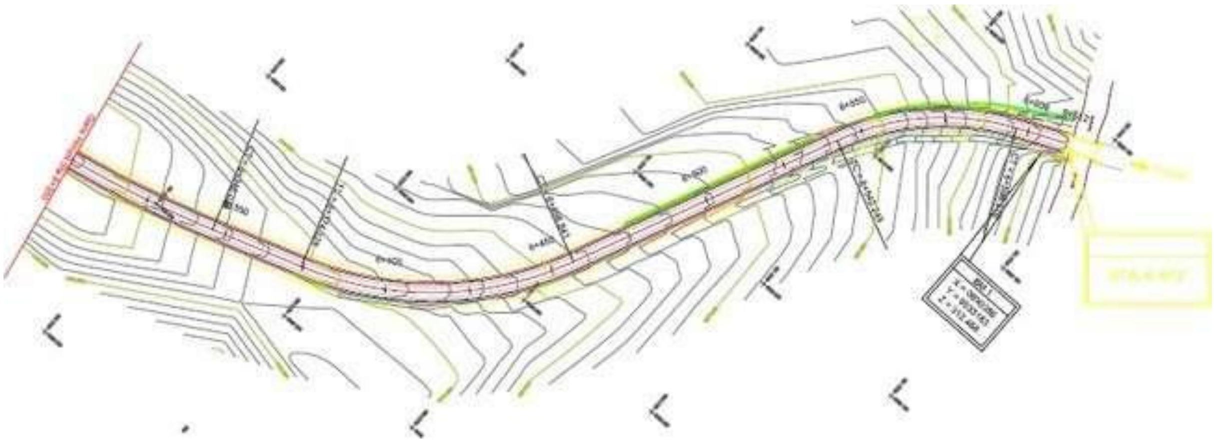

Figure 3. Longitudinal Cut

Data - data needed to plan Horizontal alignment are as follows:

STA 6 + 302,132

X = 689875.688

Y = 9932991.137

VR = 70 km / O'clock

$\Delta = 14°17'56''=14.298°$

Distance (D) = 115.786 m

Rc = 350 m

Plan the Full Circle bend using the formula equationfollowing This

$Tc = Rc \tan \ ½ \Delta$ .... (1)

$E\ c = T\ c \tan \ ¼ \Delta$ .... (2)

$L\ c = \frac{\Delta 1.2.\pi.Rc}{360°}$ .... (3)

Where :

Δ = corner Bend

PI = Point of intersection

R = radius of the circle

CT = Tangent Circle

tc = Circle Tangent

TC = long tangent distance from TC to PI or PI to CT

LC = Arc length Circle

EC = Distance Straight from PI to arc circle

Calculate the value using the above equation as follows:

$Tc = Rc \tan \ ½ \Delta = 350 \text{ x } \tan ½\ 14.298 = 43.092$ m

$Ec = Tc \tan \ ¼ \Delta = 43.92 \text{ x } \tan ¼\ 14.298 = 2.743$ m

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$$Lc = \frac{\Delta 1.2.\pi.Rc}{360°} = \frac{14.298\ x\ 2\ x\ 3.14\ x\ 350}{360°} = 87{,}382\ \text{m}$$

Figure 4 below shows a full circle curved plan for Water Difficult Road – Rawang, Sawahlunto City.

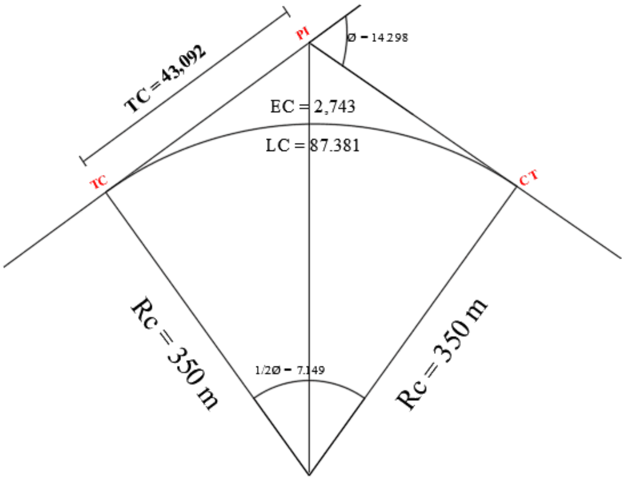

Figure 4. Full Circle Bend

to determine whether the planned bend can be used, use equality following Tc < distance = 43,902 m < 115,786 m so thatthe planned bend can be used. the following is the result Horizontal alignment calculations at STA 6 + 300 – 6 + 600 can be seen in table 5 following.

Table 5. Horizontal Alignment Calculation Results

PI No	124	125	126	units
STA	6+302,132	6+413,072	6+568,071	m
X choir	689875.688	689985609	690050026	m
Y choir	99.2991.137	9933028.083	9933171.782	m
Distance	115,768	110,940	154.99	m
V	70	65	60	kms/h
Delta	14 17 56	47 16 36	41 21 10	°'"
Rc	350	100	75	m
Ls	87,120	80,192	52,963	m
Ts/Tc	43,092	43,769	28,305	m
Es/Ec	2,743	9.159	5.163	m
Lc	87,382	82,547	54,152	m
e	Ns	8.3	8.0	%

4.5 Superelevation Diagram

method to do superelevation, namely changing the slope of the transverse section, is done by formula ng profile from edge pavement Which is rounded but recommended Enoughtake a straight line. Figure 5 displays the superelevation Water Hard road diagram – Rawang City of Sawahlunto.

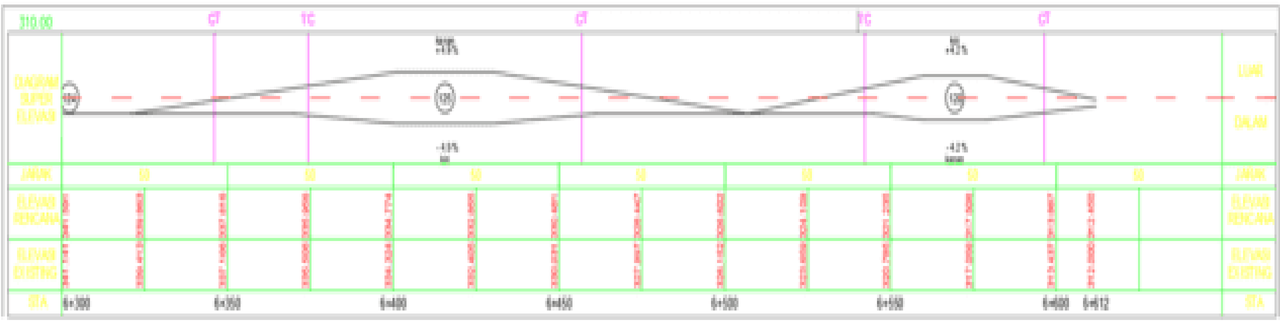

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Figure 5. Superelevation diagram

5. Conclusion

From the results of the calculation of the Sulit Air Road – Rawang, Sawahlunto City, STA 6+300 – 6+600, it can be concluded that the author can draw that the Sulit Air – Rawang road is a primary collector road with a design speed of 70 km/hour and a maximum slope (e) of 8%. From the calculations, the curved horizontal length (Lc) is 87.382. In this journal, the author takes the Full Circle bend with land area, Which There is.

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