CITIZEN: Jurnal Ilmiah Multidisiplin Indonesia
Vol 2, No. 5, 2022
ISSN: 2807-5994
https://journal.das-institute.com/index.php/citizen-journal

# Analysis of Road Geometrics with ASSHTO Method (Solo–Yogyakarta–NYIA Kulon Progo Toll Road Section 1 Package 1.1 Solo – Klaten (STA 0+000 – 22+300)

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**DOI: 10.53866/jimi.v2i5.212**

**Abstract**
To support National Economic Development and the development and improvement of economic activities in Java, the Solo-Yogyakarta-Nyia Kulon Progo Toll Road Section I Package 1.1 Solo – Klaten (STA 0+000 - 22+300) was built. Here the contractor is PT Adhi Karya (Persero) Tbk. This corridor has a strategic role in the Java Island toll road network system. The research on some roads is to make horizontal alignments using the manual method, which will be compared with secondary data on the Kartasura access ramp. In the research and discussion, it can be concluded that there are two horizontal alignment curves consisting of 2 SCS bends in planning. At the Spiral Circle Spiral bend, there is a difference in the parameters Lc and Lt of -27,878 m and TS of -15,956, while the other parameters Xs, Ys, K, and Es are the same. AutoCAD® Civil 3D is considered more effective in geometric road planning because it helps the process of planning drawings simultaneously, making the planning process easier and faster. Using manual calculations has a greater risk, such as arithmetic errors and inaccuracies, and requires a longer time.

**Keywords:** AASHTO, Alinement Horizontal, AutoCAD® Civil 3D, Tool Road

## 1. Introduction

Highways are one of the transportation infrastructures to support the movement of goods and people from one place to another and one of the infrastructures that is much needed in supporting development at this time (Sinaga, 2019). The contribution of transport infrastructure to economic growth and the causal relationship between them has received significant attention from empirical studies in economics. Transportation infrastructure for decision-makers has always been a political instrument reflected in government programs and then implemented through public policies to reduce disparities and inequality and encourage economic growth (Cigu, Agheorghiesei, Gavriluță, & Toader, 2018).

Due to the identified economic benefits, the construction of toll roads in Indonesia under President Joko Widodo was carried out massively. For example, between 2015 and 2019, a total of 1,235 km of roads were built, which is an increase from the 780 km built since the independence of the State in 1945 to 2014 (Siswoyo, 2020) . To support National Economic Development (PEN) and the development and improvement of economic activities in Java, the Central Government has offered the private sector investment in toll road construction. One of them is the Construction of the Solo-Yogyakarta-Nyia Kulon Progo Toll Road Section I Package 1.1 Solo – Klaten (STA 0+000 - 22+300). This toll road section is part of the Java Island network system (Trans Java Toll Road). This corridor has a strategic role in the Java Island toll road network system. The very close economic relationship between the west and east sides of Java Island needs a transportation system that can provide better service.

The construction plan for the Solo-Yogyakarta-NYIA Kulon Progo Toll Road Section I Package 1.1 Solo – Klaten (STA 0+000 - 22+300) which started in Solo City, Central Java Province, is a continuation of the Solo – Ngawi Toll Road which is part of the of the Trans Java Toll Road series. The Development Plan for the Solo-Yogyakarta-Nyia Kulon Progo Toll Road Section I Package 1.1 Solo – Klaten (STA 0+000 - 22+300) is a continuation of a program that was delayed due to the 1997 monetary crisis and is also a government program to build toll roads 1600 km for the period 2005 – 2009 and following the decision of the Minister of Public Works number: 280/KPTS/M/2006 dated 24 July 24 July 2006, concerning changes to the decision of the Minister of Public Works Number: 369/KPTS/M/2005 dated 18 August 2005, regarding the General Plan National Road Network.

The current trend relies on highly advanced computer technology for the geometry design of highways, which offers excellent precision and saves a lot of time and effort. However, highway design poses significant challenges without 3D modeling. It takes much time to cut and fill Computing (Gaikawad & Ghodmare, 2020). So geometric road calculations using the AutoCAD Civil 3D application, especially in horizontal alignment calculations, are interesting to compare with the results of manual calculations using the Bina Marga reference standard (Muhammad Luthvan, 2021).

Based on the above problems, research will be carried out on some roads (Ramp Access Ramp Simpang Susun Kartasura) Solo - Yogyakarta - NYIA Kulon Progo Toll Road Section 1.1 (STA 0+000 - 22+300) by making horizontal alignment using a manual method that will be compared with the AutoCAD Civil 3D application. The benefits of this research are as a road geometric planning solution that is effective and efficient in terms of time, cost, and resources (Muhammad Luthvan, 2021).

## 2. Literature Review

### *2.1. Toll Road*

Toll roads as freeways provide a real difference from ordinary roads. This difference is expected to provide more quality, given the increasing level of community mobility (Fahza & Widyastuti, 2019). The development of toll roads aims to facilitate traffic in developed areas, improve the distribution of goods and services to support economic growth, increase the distribution of development results and justice, and alleviate the burden on government funds through the participation of road users, with the construction of toll roads providing benefits and influencing regional development and economic improvement. Also, increasing mobility and accessibility of toll road users will benefit from vehicle operating costs. The time compared to non-toll roads and business entities return on investment through toll revenues that depend on the certainty of toll rates.

One form of the government's efforts to make it easier for people in Indonesia to carry out their mobility both economically and socially correctly and quickly is by accelerating the construction of toll roads. The construction of the Solo - Yogyakarta - NYIA Kulon Progo Toll Road Section 1 Package 1.1 Solo - Klaten (STA 0+000 - 22+300) located in Central Java province is one of the many sections that are being built. The primary function of the Solo - Yogyakarta - NYIA Kulon Progo Toll Road Section 1 Package 1.1 Solo - Klaten (STA 0+000 - 22+300) is to accelerate economic growth and improve public services. Sustainable construction projects are essential for economic and social development in modern communities.

Based on the location of the road, the planner chooses the best corridor through the geometric design of the road and makes an alignment of the main route in the field on the selected corridor. The first thing to pay attention to is the road's location, the corridor's selection, and the geometric path of the Alignment in the corridor (Douglas, 2018) . Road geometry is a shape that describes the road, which 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.
Toll roads have a relatively high risk of accidents compared to other types of roads (Irfan, Rasyid, & Handayani, 2018) . Therefore, safety is a significant factor in road design (Mandal, Pawade, Sandel, &

Infrastructure, 2019). Road infrastructure, one of the causes of traffic accidents, must be designed and built to accommodate all aspects of safety for its users to minimize the risk of traffic accidents (Pembuain, Priyanto, & Suparma, 2019) . The 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. The design process involves some drafting and some analysis and calculations. Tasks typically performed by design engineers include: making road alignments and plotting road profiles using coordinates (or bearings), stations, and elevations; calculation of sight distance, a horizontal radius of curvature, and vertical curvature length; calculation of the amount of earthwork, and various other analyzes and calculations aimed at finding optimal Alignment while meeting design standards and constraints (Raji, Zava, Jirgba, & Osunkunle, 2017).

### *2.2. Horizontal Alignment and Vertical Alignment*

There are several criteria for optimizing planning results to carry out geometric road planning. These parameters determine the level of comfort and safety produced by the geometric shape of the road. These parameters are vehicle characteristics, visibility, and design speed (Fambella, Sulaksitaningrum, Arifin, & Bowoputro, 2014).

Horizontal Alignment is the projection of the road axis on the horizontal plane. Horizontal Alignment is also known as "road situation" or "road alignment." Horizontal Alignment consists of straight lines connected by curved lines. The curved line can consist of a circular arc plus a transitional arc, only a transitional arc, or only a circular arc (Sukirman, 1999). Horizontal Alignment on the road is a collection of points that form a line (straight or curved) as a projection of the axis or axle of the road in the horizontal plane. (Suwardo & Haryanto, 2018). The geometric design of the road on curved sections is intended to compensate for the centrifugal force received by vehicles traveling at the design speed (Muhammad Luthvan, 2021).

Vertical Alignment is a projection of the axis of the road in a vertical plane through the axis of the road and consists of straight sections and curved sections. The straight sections are positive ramps (incline), negative ramps (derivatives), and zero ramps (flat) (BSN, 2004) (Chasanah, Purwanto, & Sudibyo, 2018). Vertical Alignment is defined as the projection of the vertical plane of the road axis, in the form of a longitudinal cross-section of the road. The objective of vertical alignment design is to determine the elevation of important road points to ensure proper road drainage and an acceptable level of safety (Indriani, Rachman, & Abdullah, 2020).

### *2.3. Design Speed*

Speed is the average distance that can be traveled by a vehicle on a specific road segment in one unit of time. The following factors affect the speed of a vehicle, including human factors, vehicles, and infrastructure, and are also influenced by traffic flow, weather conditions, and the surrounding natural environment. A certain speed that is used as a reference in the geometric design of safe and comfortable bends is referred to as the design speed. In other words, if a driver goes according to the planned speed, then the driver will be able to cross the corner safely and comfortably (Purwanto, Indriastuti, & Basuki, 2015).

One of the critical causes of traffic accidents under various weather conditions is improper speed selection (intentional or unintentional driver behavior) or excessive speed variations. The driver's level of driving experience and knowledge varies between the occupants of the vehicle and the truck, considering the severity of truck accidents is usually much higher than that of non-truck vehicles (Yang, Ahmed, & Gaweesh, 2019). In the Ministry of PUPR's 2021 Road Geometric Design Guidelines, it is explained that a geometric road design must adhere to the concept of effective, efficient, economical, safe, and environmentally sound in accordance with what is regulated in Permen PU No.19/PRT/M/2011 concerning requirements road technical (PTJ) and road technical design criteria (KPTJ). All PTJ must be met, which includes the design speed, road width, road capacity to channel traffic (road capacity), access roads (access), level crossings, turnaround facilities (in JRY), road auxiliary buildings (bangkapja) including bridge geometry and drainage, road equipment, road use (according to its function), and road continuity.

### *2.4. AutoCAD® Civil 3D*

AutoCAD® Civil 3D is a civil engineering design and documentation tool developed by Autodesk. AutoCAD® Civil 3D software supports building information modeling (that is, digital representation of the physical and functional characteristics of facilities). It is used for modeling, analysis, and design of various types of civil infrastructure projects, including highways, land development, railways, airports, and water. AutoCAD® Civil 3D helps civil infrastructure professionals improve project delivery, maintain more consistent data and processes, and respond more quickly to project changes, all within the familiar AutoCAD® environment (Raji, Zava, Jirgba, & Osunkunle, 2017).

The first stage in planning with AutoCAD® Civil 3D is setting up the coordinate system in AutoCAD® Civil 3D. Right before entering the contour data, coordinate arrangements must be made in advance. The coordinate system used is UTM (Universal Transverse Mercator), which is a coordinate system that refers to the flat shape of the earth through certain projections. The second stage is the Process of Entering Contour Data. The contour data is obtained from the Global Mapper software with output in csv (comma separated value)/xyz and Txt format, then input into AutoCAD® Civil 3D. Continue the third stage, namely the Surface Making Process. After the contour data has been successfully entered into AutoCAD® Civil 3D, then on the Tools page, right-click on the surface, click Create Surface, and enter the previous data point group. The fourth stage is Making Horizontal Alignment. Horizontal Alignment in AutoCAD® Civil 3D. Insert tab, then click Alignment, click Alignment from tools, enter plan name, enter plan speed, and design criteria. In alignment layout tools, for SCS planning, select free spiral curve spiral, insert Rc and Ls, then AutoCAD® Civil 3D will calculate the results. The design is then continued in the fifth stage, namely, making superelevations. For the Rc and Ls data, the results from manual planning and the stages in the planning are used.

The stages in superelevation planning in AutoCAD® Civil 3D. On the horizontal Alignment suitable, click 'edit superelevation', and click 'calculate superelevation now. Then select the road type, lane type, shoulder type, and design criteria that have been planned. The sixth stage is Making Vertical Alignment. Stages in planning horizontal Alignment in AutoCAD® Civil 3D. Home tab, click profile, click create a surface profile, and set. Then click profile, then click profile creation tools. Then draw the elevation plan according to the coordinates of each desired PVI. Then AutoCAD® Civil 3D will calculate the design results.

Moreover, the last one is to bring up the results of the Vertical Alignment and Horizontal Allinement calculations. The steps for displaying and exporting the results of horizontal and vertical alignment calculations are in the Toolbox tab. Click Report Manager. Click Alignment and Station and Curve for the horizontal alignment calculation results. Click Profile and PVI Station and Curve for vertical alignment calculation results. Export to Microsoft Excel and validate with manual calculation results so that the alignment calculation results come out (Muhammad Luthvan, 2021).

## 3. Methodology

The geometric planning of the Solo - Yogyakarta - NYIA Kulon Progo Toll Road Section 1 Package 1.1 Solo - Klaten (STA 0+000 - 22+300) is located in the Kartasura to Klaten area of Central Java Province along 22.3 Km whose contract was executed on the 25 November 2020 where the implementing contractor is PT ADHI KARYA (Persero) Tbk. The calculation of the horizontal Alignment of one of the ramp access interchanges, namely at the Kartasura interchange, will be compared with the results of manual calculations. The location of the work can be seen on the location map can be seen in figure 1.

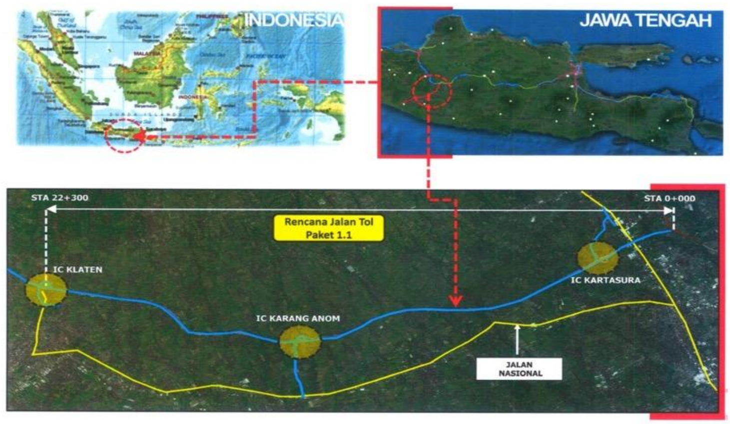



**Figure 1.** Map of study

Toll roads, which are part of national roads, were developed to support and accelerate economic growth and significantly improve the quality of public services. Of course, in realizing this, toll roads must comply with technical requirements (Rifai, Nenobais, & Darmanto, 2021) . Data is one of the main strengths in compiling research and scientific modeling (Rifai, Hadiwardoyo, Correia, Pereira, & Cortez, 2015) . The systematic scientific research process must begin with identifying the right problem (Rifai, Hadiwardoyo, Correia, & Pereira, 2016).

Secondary data was taken from the Solo - Yogyakarta - NYIA Kulon Progo Toll Road Project Section 1.1 (STA 0+000 - 22+300), and then manual road geometric planning was carried out to determine planning criteria based on the Road Geometric Design Guidelines (PDGJ) of the Ministry of PUPR 2021. The process uses AutoCAD® Civil 3D to plan horizontal Alignment after the results come out then these results will be validated with manual calculations and in horizontal Alignment planning the selection of bend types is based on Highways 1997.

The 2021 Ministry of Public Works and Public Housing's Road Geometric Design Guidelines explain ways to design road geometry which includes design criteria, general provisions, road geometric technical provisions, and road geometric design procedures, in designing road horizontal alignment, road vertical alignment, road cross sections, and coordination of horizontal and vertical Alignment of roads, for Highways, Medium Roads, Small Roads, and Freeways, both serving Inter-city traffic and intra-city traffic. General provisions and road geometric technical provisions are explained in general for Intercity roads, Urban Roads and Freeways. The geometric elements that underlie the design are generally presented in the same tables but are given information on whether they are generally applicable or only apply to Intercity roads, or Urban roads, or Freeways. Design implementation procedures are described separately, respectively, for Intercity roads, Urban Roads, and Freeways (Muhammad Luthvan, 2021).

The first manual planning stage is determining the planning route and criteria. Determine the coordinates of the points of intersection of the lines for the planned bends and then determine the planning criteria consisting of road functions, road classes, and design vehicles. The second defines the Horizontal Alignment Criteria. Determine the type of bend to be used and the selection criteria for the bend to be adjusted according to the flowchart, which are determined in the form of the type of bend, the design radius (Rc), the spiral curve/transition (Ls), and the superelevation value (e). The third stage of Calculation of Horizontal Alignment. Perform calculations to determine the value of the bend parameters that have been selected based on Bina Marga's references and determine the superelevation value and the superelevation diagram of the selected bend. And the results are obtained to be compared with the output results of AutoCAD® Civil 3D with the same Rc and Ls lengths. The final stage is the Vertical Alignment Calculation. Determine the location of the PVI point and calculate grade 1 (g1), grade 2 (g2), the difference in height between (ΔH) PVI, the difference in distance (Δx) between PVI, and determine the type of arch, whether concave or convex and for the length of the arch (Lv) adjusted to the results of AutoCAD® Civil 3D, and just validated with the output results from AutoCAD® Civil 3D with the same Lv length (Muhammad Luthvan, 2021).

## 4. Results and Discussion

As explained in the methodology chapter, secondary data was taken from the Solo - Yogyakarta - NYIA Kulon Progo Toll Road Project Section 1 Package 1.1 Solo - Klaten (STA 0+000 - 22+300) precisely at the Kartasura Interchange Ramp Access implemented by PT Adhi Karya (Persero) Tbk as the implementing contractor. Examination of the geometric parameters of the design (Ramp Interchange) includes data, namely design speed, cross-section (traffic lane width, shoulder width, median width, normal traffic lane cross slope, normal cross slope, road shoulder, free space height), Horizontal alignment (horizontal stopping sight distance, bend radius, superelevation, transitional arc length, relative surface slope) and vertical alignment (maximum ramp, minimum vertical radius of curvature, minimum vertical curvature length).

### *4.1. Planning Design Criteria*

The geometric design criteria for the Solo - Yogyakarta - NYIA Kulon Progo Toll Road Section 1 Package 1.1 Solo - Klaten (STA 0+000 - 22+300) refer to several geometric planning guidelines, namely:

1. Law no. 38 of 2004 concerning Roads;
2. Government Regulation of the Republic of Indonesia Number 15 of 2005 concerning Toll Roads, as well as the First Amendment (Government Regulation No 44 of 2009) and Second Amendment (Government Regulation No 43 of 2013);
3. Government Regulation of the Republic of Indonesia No. 34 of 2006 concerning Roads;
4. Government Regulation no. 55 of 2012 concerning vehicles ;
5. Regulation of the Minister of Public Works No. 19/PRT/M/2011, concerning Road Technical Requirements and Criteria for Road Technical Planning ;
6. Minister of Transportation Regulation No. 14/2006 concerning Traffic Management and Engineering on the Road;
7. Regulation of the Minister of Transportation No. 14 of 2007 concerning Container Transport on the Road;
8. Decree of the Minister of Transportation No. 52 of 2000 concerning Railway Lines;
9. Decree of the Minister of Transportation No. 36 of 2011 concerning Intersections and Intersections between Railways and Other Sections;
10. Regulation of the Minister of Energy and Mineral Resources of the Republic of Indonesia no. 2 of 2019, regarding free space and minimum clearances on high-voltage overhead lines, extra-high-voltage overhead lines, and direct current high-voltage overhead lines for the distribution of electric power ;
11. Regulation of the Minister of Public Works and Public Housing N0. 10/PRT/M/2018 Concerning Rest Areas and Services on Toll Roads;
12. Standards for Geometric Planning for Urban Roads, Directorate General of Highways, March 2006;
13. Highway Rule and Behaviors, Nihon Dorokodan, Japan Highway Public Corporation, 2006$^{th}$;
14. Specifications for Inter-City Road Geometric Planning Standards, Directorate, General of Highways, September 1997.

Toll road designers need to pay attention to their users' safety and the drivers' characteristics on toll roads in congested or congested traffic conditions, often using the shoulder of the road as an additional lane. Although the shoulder is only for temporary emergency maneuvers, due to the nature of the driver, the designer must pay attention to the shoulder's width. Toll roads, so as not to be divided by a long straight section with a few sharp bends, should be balanced between the length of the straight section and the length of the bend section with a large radius to allow longer visibility. This will make it easier to maneuver ahead. The geometric design of the toll road can be carried out manually or using software to assist the data processing in producing the expected final product. The design life must be determined from the beginning with the consideration that the design life must be balanced between the design life of other road elements, and if the road is prepared for a paid road, then the design life has taken into account its relationship with the business plan.

**Table 1.** Design Criteria

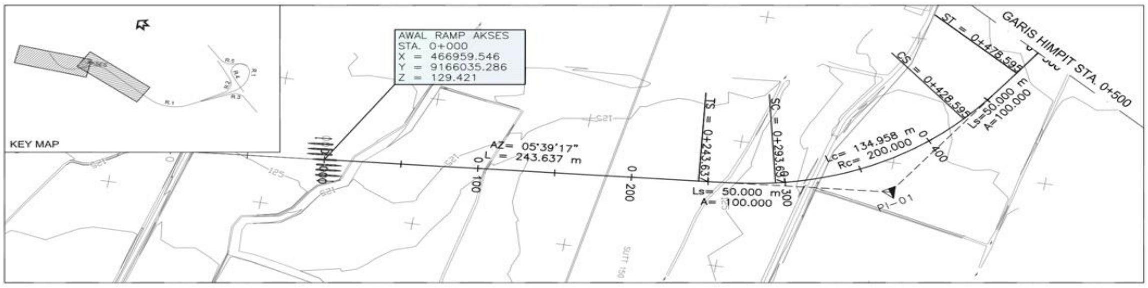
| No | Description | Unit | Criteria Design | Design |
|---|---|---|---|---|
| Kartasura Interchange Ramp Design Criteria | | | | |
| 1 | Design Speed | Km/Hour | 40 | 40 |
| 2 | Cross Section | | | |
| | • 1 Lane 1 way | | | |
| | - Lane Width | M | 4.00 | 4.00 |
| | - Outer Shoulder Width | M | 3.00 | 3.00 |
| | - Deep Shoulder Width | M | 1.00 | 1.00 |
| | • 2 Lane 1 way | | | |
| | - Lane Width | M | 3.50 | 3.50 |
| | - Outer Shoulder Width | M | 0.50 | 0.50 |
| | - Deep Shoulder Width | M | 0.50 | 0.50 |
| | • Normal Traffic Crossing | % | 2 | 2 |
| | • Road Shoulder Slope | % | 2 | 2 |
| | • Maximum Superelevation | % | 8 | 8 |
| | • Free Space Height | % | 5.10 | 5.10 |
| Interchange Horizontal Alignment Resume (Access Ramp Kartasura) | | | | |
| | Horizontal Alignment Parameters | | | |
| 1 | Minimum Horizontal Stopping Sight Distance | M | 40 | 40 |
| 2 | Minimum Bend Radius | M | 50 | 58.6 |
| 3 | Radius – Minimum Bend Radius with standard slope | M | 800 | 1200 |
| 4 | Maximum Superelevation | % | 8 | 8 |
| 5 | Transition arc length | M | 35 | 40 |
| 6 | Minimum Bend Radius Without Shifting Curvature | M | 1100 | 1200 |
| 7 | Maximum Relative Surface Slope | M | 1/125 | 1/125 |
| Vertical Alignment Resume Interchange (Ramp Access Kartasura) | | | | |
| | Vertical Alignment Parameters | | | |
| 1 | Maximum Ramps | % | | |
| | • g1 | % | 5 | 4 |
| | • g2 | % | 5 | -4 |
| 2 | The Minimum radius of curvature | | | |
| | • Convex | M | 800 | 1451.1 |
| | • Concave | M | 700 | 1425.5 |
| 3 | Minimum Arch Length | M | 35 | 50 |

### *4.2. Horizontal Alignment*

Secondary data are taken from the Final Engineering Plan drawings. One of the access ramps at the Kartasura Interchange was chosen from several access ramps. Then the data is used as a parameter to compare with manual calculations.

The following is one of the images where the data is taken, which has the SCS arch type as follows:

**Figure 1.** General Plan Alignment Layout of the Kartasura Interchange




From figure 1. In the General Plan Alignment Layout of the Kartasura Interchange above, the following data are obtained:

**Table 2.** Access Ramp

| BP | | | | PI-01 | PI-02 | EP | |
|---|---|---|---|---|---|---|---|
| X | 466959.546 | V (Km/hour) | | 40 | 40 | X | 466661.0804 |
| Y | 9166035.288 | Type | | SCS | SCS | Y | 9166848.864 |
| STA | 0+000 | Δ | | 38-39-45 | 49-10-17 | STA | 0+950.331 |
| | | R (m) | | 200.000 | 180.000 | | |
| | | A | | 100.000 100.000 | 112.250 112.250 | | |
| | | TS / TC (m) | | 124.933 124.933 | 165.240 165.240 | | |
| | | LC (m) | | 134.958 | 154.477 | | |
| | | LS (m) | | 50.000 50.000 | 70.000 70.000 | | |
| | | L (m) | | 234.958 | 294.477 | | |
| | | e max (%) | | 4% | 5% | | |
| | | PI | E | 466923.2293 | 466603.7483 | | |
| | | | N | 9166402.063 | 9166596.76 | | |
| | | TS/SS | E | 466935.5394 | 466744.8513 | | |
| | | | N | 9166277.738 | 9166510.769 | | |
| | | | STA | 0+243.637 | 0+562.553 | | |
| | | SC/TC/CC | E | 466928.5495 | 466687.6568 | | |
| | | | N | 9166327.211 | 9166550.923 | | |
| | | | STA | 0+293.637 | 0+632.553 | | |
| | | SC/TC/CC | E | 466858.0923 | 466629.3389 | | |
| | | | N | 9166439.321 | 9166688.883 | | |
| | | | STA | 0+428.595 | 0+787.030 | | |
| | | ST/SS | E | 466816.5456 | 466640.3908 | | |
| | | | N | 9166467.078 | 9166757.886 | | |
| | | | STA | 0+478.595 | 0+857.030 | | |
| AZ | | AZIMUT | | 58°38’28” | 12°48’43” | AZ | |

Dalam perhitungan manual akan dicari beberapa parameter untuk dibandingkan nilai nya, sebagai berikut:
RC : Circular arc radius ;
ΔPI1 : Bend angle ;
VR : Design speed ;
Rmin : Minimum Radius ;
LS : Spiral arch length;
θs : Spiral curve angle ;
θc : The curved angle of the circle ;
Lt : Length of bend ;
Xs : abscissa of point SC on tangent line, distance from point ST to SC ;
Ys : distance perpendicular to point SC on arc ;
K : abscissa of p on the spiral tangent line ;
P : tangent shift to spiral ;
TS : Point from tangent to spiral ;
Es : The distance from II to the circular arc

**Table 3.** Of-Ramp Access Bend Calculation 1

| **Calculation ff Spiral Circle Spiral (SCS)** | | | | |
|---|---|---|---|---|
| | | Conventional | Civil 3D | Deviation |
| | RC | 200.000 | 200.000 | - |
| | ΔPI1 | 45 | 45 | - |
| | VR | 40 | 40 | - |
| | Rmin | 50.000 | 50.000 | - |
| | LS | 50.000 | 50.000 | - |
| | | m | m | |
| θs | (90 x Ls)/(π x Rc) | 7.958 | 7.958 | - |
| θc | ΔPI1 - 2θs | 29.085 | 29.085 | - |
| Lc | ( θc/360 ) x 2π x Rc | 91.371 | 134.958 | -27.878 |
| Lt | Lc + 2Ls | 191.371 | 234.958 | -27.878 |
| Xs | Ls – (Ls&3 / (40 x Rc&2) | 49.993 | 49.993 | - |
| Ys | Ls&2 / 6 x Rc | 4.167 | 4.167 | - |
| K | Xs – Rc (sin θs) | 25.073 | 25.073 | - |
| P | Ys – Rc ( 1-cos θs) | 2.566 | 2.566 | - |
| TS | (Rc + P) x tan (ΔPI1/2) + K | 108.976 | 124.933 | -15.956 |
| Es | (Rc + P) x sec (ΔPI1/2) - Rc | 19.177 | 19.177 | - |

## 5. Conclusions

Based on the description above, the research findings and discussion can be concluded as follows: In the horizontal alignment planning, two horizontal alignment curves are obtained, which consist of 2 SCS bends. At the Spiral Circle Spiral bend, there is a difference in the parameters Lc and Lt of -27,878 m and TS of -15,956 between the results of calculations with Civil 3D and manual calculations, while the other parameters Xs, Ys, K, and Es are the same. By making a comparison between the use of the Civil 3D application and manual calculations about Highways, it is judged that using AutoCAD® Civil 3D is more effective in geometric road planning because it helps the process of plotting simultaneously so that the planning process will be easier and faster. Using manual calculations has a greater risk, such as arithmetic errors, inaccuracies, and requiring a longer time. With the development of technology, planning in the field of construction has become easier and faster.

**Bibliography**

Chasanah, K., Purwanto, M. Y., & Sudibyo, T. (2018). Evaluasi Alinyemen Vertikal dan Horizontal Studi Kasus di Depan Gedung Perpustakaan Kampus Dramaga IPB. Jurnal Teknik Sipil Dan Lingkungan. 59-68.

Cigu, E., Agheorghiesei, D. T., Gavriluţă, A. F., & Toader, E. (2018). Transport infrastructure development, public performance and long-run economic growth: a case study for the Eu-28 countries. Sustainability, 11(1), 67.

Douglas, R. A. (2018). Low-volume road engineering: Design, construction, and maintenance.

Fahza, A., & Widyastuti, H. (2019). Analisis Daerah Rawan Kecelakaan Lalu Lintas pada Ruas Jalan Tol Surabaya-Gempol. Jurnal Teknik ITS. E54-E59.

Fambella, B. C., Sulaksitaningrum, R., Arifin, M. Z., & Bowoputro, H. (2014). *Evaluasi dan Perencanaan Geometrik Jaringan Jalan di Dalam Universitas Brawijaya Malang (Doctoral dissertation, Brawijaya University).*

Gaikawad, P., & Ghodmare, S. D. (2020). A Review-Geometric Design of Highway with the Help of Autocad Civil 3D. International Journal for Research in Applied Science and Engineering Technology. 8(5).

Indriani, S., Rachman, A., & Abdullah, A. Y. (2020). Evaluasi Alinemen Vertikal Pada Ruas Jalan Desa Timbong Kecamatan Banggai Tengah Kabupaten Banggai Laut. RADIAL: Jurnal Peradaban Sains, Rekayasa dan Teknologi, 8(2), 111-120.

Irfan, A., Rasyid, R. A., & Handayani, S. (2018, June). Data mining applied for accident prediction model in Indonesia toll road. In AIP Conference Proceedings (Vol. 1977, No. 1, p. 060001). AIP Publishing LLC.

Isradi, M., Nareswari, N.D., Rifai, A.I., & Prasetijo, J. (2021)Performance Analysis of Road Section and Unsignalized Intersections in Order to Prevent Traffic Jams on Jl H. Djole–Jl. Pasar Lama. ADRI International Journal of Civil Engineering Vol 6 No 1, pp. 56-67

Mandal, M., Pawade, P., Sandel, P., & Infrastructure, R. S. (2019). Geometric design of highway using Civil 3D. *International Journal of Advance Research, Ideas and Innovations in Technology*, 5(3).

Muhammad Luthvan, S. F. (2021). Perencanaan Geometrik Jalan Menggunakan AutoCAD Civil 3d Studi Kasus Jalan Duku–Sicincin Sta 0+ 000–Sta 2+ 700 Provinsi Sumatera Barat. *(Doctoral dissertation, Universitas Andalas)*.

Pembuain, A., Priyanto, S., & Suparma, L. (2019, October). The Effect of Road Infrastructure on Traffic Accidents. *In 11th Asia Pacific Transportation and the Environment Conference (APTE 2018)* , (pp. 176-182).

Purwanto, D., Indriastuti, A. K., & Basuki, K. H. ( 2015). *Hubungan antara kecepatan dan kondisi geometrik jalan yang berpotensi menyebabkan kecelakaan lalu lintas pada tikungan.* Media Komunikasi Teknik Sipil, 21(2).

Purwanto, D., Indriastuti, A. K., & Basuki, K. H. (2015). *Hubungan antara kecepatan dan kondisi geometrik jalan yang berpotensi menyebabkan kecelakaan lalu lintas pada tikungan.* Media Komunikasi Teknik Sipil, 21(2).

Raji, S. A., Zava, A., Jirgba, K., & Osunkunle, A. B. (2017). Geometric Design of a Highway Using Autocad Civil 3d. Journal of Multidisciplinary Engineering Science and Technology (JMEST). 4(6).

Rifai, A. I., Hadiwardoyo, S. P., Correia, A. G., & Pereira, P. A. (2016). Genetic Algorithm Applied for Optimization of Pavement Maintenance under Overload Traffic: Case Study Indonesia National Highway. In Applied Mechanics and Materials . Trans Tech Publications Ltd. Vol. 845, pp. 369-378.

Rifai, A. I., Hadiwardoyo, S. P., Correia, A. G., Pereira, P. A., & Cortez, P. (2015). The data mining applied for the prediction of highway roughness due to overloaded trucks.

Rifai, A. I., Hadiwardoyo, S. P., Correia, A. G., Pereira, P., & Cortez, P. (2015). The data mining applied for the prediction of highway roughness due to overloaded trucks. *International Journal of Technology, 6(5)*, 751-761.

Rifai, I. A., Nenobais, H., & Darmanto, M. (2021). Implementasi Standar Pelayanan Minimal Jalan Tol:

Sebuah Pendekatan Kebijakan Publik. Amerta Media.

Setiaputri, H.A., Isradi, M., Rifai, A.I., Mufhidin, A., Prasetijo, J (2021) Analysis Of Urban Road Damage With Pavement Condition Index (PCI) And Surface Distress Index (SDI) Methods, ADRI International Journal of Sciences, Engineering and Technology Vol. 6 No. 1

Sinaga, J. W. (2019). Evaluasi Perkerasan Jalan Kaku (Rigid Pavement) Pada Jalan Sisingamangaraja Dengan Metode AASHTO.

Siswoyo, M. (2020). The Impact of Toll Roads Development: Ecology of Public Administration Perspective. Systematic Reviews in Pharmacy. 11(11), 152-157.

Sukirman, S. (1999). Dasar Perencanaan Geometrik Jalan. Nova.

Suwardo, & Haryanto, I. (2018). *Perancangan Geometrik Jalan: Standar Dan Dasar-Dasar Perancangan. UGM PRESS.*

Yang, G., Ahmed, M. M., & Gaweesh, S. ( 2019). *Impact of variable speed limit in a connected vehicle environment on truck driver behavior under adverse weather conditions: driving simulator study.* Transportation research record.

Yang, G., Ahmed, M. M., & Gaweesh, S. ( 2019). *Impact of variable speed limit in a connected vehicle environment on truck driver behavior under adverse weather conditions: driving simulator study.* Transportation research record.