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THE GEOMETRIC DESIGN OF HORIZONTAL CURVED ON JALAN DRONO – NGANOM, WONOGIRI USING AutoCAD CIVIL 3D®

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ABSTRACT

An efficient network of highway infrastructure is a decisive factor in promoting the socio-economic development of a region. Road construction is intended to connect isolated areas and promote economic growth through good population mobility considering comfort, safety, and smoothness by keeping abreast of transportation technology developments. They were planning the geometric design of the highway through the process of selecting the appropriate geometric aspects as well as design controls that govern the critical elements of the highway design. The current trend of planning for geometric road design is directed at using computer programs to make the results more precise and save time and effort. In this geometric planning, the author plans a geometric horizontal curved road on the Jalan Drono - Nganom, Ngadirojo District, Wonogiri Regency, using AutoCAD Civil 3D®. The creation of this road aims to facilitate the flow of transportation and economic equality of the area with two SCS (Spiral–Circle–Spiral) type bends, a radius of 400 m, a plan speed (Vr) of 80 km/h, a maximum slope of 0.06 and a friction coefficient of 0.14.

INTRODUCTION

In the development of the construction world, an efficient network of highway infrastructure is a decisive factor in promoting the socio-economic development of countries and regions. The highway was built to provide comfort and safety for road users and the smooth movement of vehicles. The highway's geometric design consists of selecting the appropriate geometric aspects and the design controls that govern the key elements of the highway design that are critical for safety and efficiency. In road traffic, the regulation of traffic safety and required facilities can provide a guarantee of vehicle driving safety (Castañeda, Sánchez, Herrera, & Mejía, 2022); (Pandey, Atul, & Bajpai, 2020); (Findley, 2017); (Cui, 2022).

The increasing traffic flow in Indonesia is due to economic growth that continues to develop following the government's plan. Therefore, so that the increase in traffic flow does not become a problem in the future, it is necessary to have facilities and infrastructure that collect so that the distribution of goods and services between regions can run smoothly. Road construction in developing countries aims to connect isolated areas and promote economic growth through better population mobility. Therefore, the government needs to be encouraged (Suprayoga, Witte, & Spit, 2020) to be more responsive in carrying out maintenance management of the available national road network due to the limited choice of these roads and excessive load irregularities (Rifai, Hadiwardoyo, Correia, & Pereira, 2016) With the process of developing transportation technology. It is expected to ensure user comfort and provide safety in driving to minimize traffic accidents (Mandal, Pawade, Sandel, & Infrastructure, 2019).

A complete life in the countryside is only possible with an infrastructure that is the basis of people's livelihoods. On the other hand, the lack of basic infrastructure makes the country's existence a place to live and where people work not promising. However, if the road used for traffic is in good condition, it can support the improvement of the community's economy and the welfare of the community. Therefore, in planning the construction of highways, special attention is needed so that geometric planning of roads is necessary before construction so that the roads built can serve traffic flow optimally (Bryzhko & Bryzhko, 2019); (Syaiful & Rusfana, 2022).

The road's geometry is widely designed considering the use of stop visibility models, aiming to provide sufficient time to avoid accidents efficiently. The geometric design of the road can be divided into three main parts, namely horizontal, vertical, and cross-sectional alignment. These three things will provide a three-dimensional layout for the highway. Horizontal alignment has three geometric components: curves, tangents, and transitions. The vertical alignment is the longitudinal part, along with geometric additives such as the curve of the peak, the curved curve, and the gradient that connects it. Geometric planning focuses on fulfilling the essential functions of the road that provide comfortable traffic flow according to the planned speed using horizontal and vertical alignment (Aryal, 2020); (Raji, Zava, Jirgba, & Osunkunle, 2017); (Gaikawad & Ghodmare, 2020); (Paikun, SP, Destaman, & Winardi, 2021).

In earlier times, drawing was still manual, time-consuming, and prone to errors. However, the current trend for road geometry design is geared towards using computer programs that offer precise results and save a lot of time and effort (Chakole & J.Wadhai, 2022). In the digital world undergoing rapid and continuous improvement changes, many computer software has been developed to solve problems in various fields. One of the software in the geometric area of this road is *AutoCAD Civil 3D*®, a superior software for designing models related to Civil Engineering. This *AutoCAD Civil 3D*® can be used to draw road, highway, location, and rail designs (Autodesk Inc., 2022); (Pandey, Atul, & Bajpai, 2020).

In this geometric planning, the author will make a geometric plan of the horizontal curved road on the Jalan Drono – Nganom using *AutoCAD Civil 3D*®. The creation of this road aims to open isolation and economic equality between 2 regions, namely Drono and Nganom, by facilitating the mobility of transportation equipment.

LITERATURE REVIEW

AutoCAD Civil 3D

Today any enterprise that builds infrastructure facilities must lay new federal routes, highways, local roads, bridges, and tunnels and design various complex territories. *AutoCAD Civil 3D*® is a new and original product in the building software market. The program is becoming more popular in design organizations involved in developing and designing the overall plan. By analyzing the stages of design and exploration functions of AutoCAD Civil 3D, it was determined that this software allows for significantly reduced project time and reduced labor costs. At the same time, the quality of work remains high. The program's main feature is modeling territory with all facilities, with the ability to dynamically update the image when designers make changes to the survey results until the release of project documentation (Valeryevna & Vitalievna, 2018). Along with current technology development, the software is expected to help speed up the design compared to the manual method. Therefore, using software in infrastructure design will be more efficient and effective in terms of time, cost and resources. One of the software used in this planning is *AutoCAD Civil 3D®* (Davenport & Voiculescu, 2015; Frans et al., 2020).

AutoCAD Civil 3D® is a 3D software developed by Autodesk. *AutoCAD Civil 3D®* is an application software used by civil engineers and professionals to plan and design projects. These devices are generally used to minimize design time and evaluate various situations. In addition, this software can also be used to generate 3D models on transportation, water, or land projects related to data sources, such as contours, corridors, and grading (Chakole & J.Wadhai, 2022). *AutoCAD Civil 3D®* provides a rich set of geodetic tools and add-ons to dramatically accelerate the post-processing, visualization, and analysis of surveyed data. Drone-based laser scanning accelerates the data collection stage of the workflow and, when compared to aerial photogrammetry, offers a much faster turnover of physical quantities. *AutoCAD Civil 3D®* makes it possible to calculate the volume and generate a profile display in hours, so the number of recorded stocks will be accurate on the specified day. The device also allows the creation of TIN surfaces from points in RCS point cloud format scanned objects created with Autodesk ReCap (Mijic, 2019).

The 3D modeling is one of the leading technologies required to create a unified system to ensure road safety in a large city. *AutoCAD Civil 3D®* can be a civil engineering design and documentation solution that allows road designers to provide viable solutions and improve project performance following other regulations, which are certainly much faster than traditional methods (Eliseev, Tomchinskaya, Lipenkov, & Blinov, 2017); (Parsakhoo & Ezzati, 2017).

Horizontal Arch

Along with the development of digital technology, especially for planning design, accuracy and speed in carrying out calculations in every planning are highly expected, especially in geometric road planning, which requires complete data on the alignment. Road amenities are essential to the road's planning and design stages, significantly influencing the surrounding environment. The main task of the horizontal alignment design is to determine the tangent cut point, circular curve, and transition curve. Once the parameters of these elements are determined, the road's center line is determined (Zhao, Liu, & Mbachu, 2019); (You, Yu, Huang, & Hu, 2022).

Visibility on curves in geometric design, significant concerns are the geometric design of roads such as lane width, the horizontal radius of curves, SAG vertical and peak vertical curves, extra dilation, deterioration distances, and intersections, making the road safer for vehicles to travel comfortably. The geometry of the road is widely designed using the stop visibility model, which provides sufficient time to avoid accidents and is efficient (Aryal, 2020).

The geometric design of the road involves tasks such as creating a road alignment and plotting the alignment profile using bearings or coordinates (east and north), stations, and point elevations along the proposed route, such as the calculation of visibility, the radius of the horizontal arch, the length of the vertical arch, the calculation of the number of earthworks, and various other analyzes and calculations aimed at finding the optimal alignment while meeting design standards and constraints (Vishwas & GR, 2021).

Horizontal arching is one of the most critical aspects affecting road efficiency and safety. A good design will result in higher speeds and reduced road performance in terms of safety and comfort. The central aspect of the horizontal alignment design is to determine the tangent cut point, circular curve, and transition curve (Sukalkar & Pawar, 2022). Then, the design is selected with Horizontal Alignment, which combines these three factors and forms a cross-section or alignment. The main design of such Alignment or cross sections is to determine the cut-off points of tangents, circular curves, and transition curves. Finally, with the determination of the parameters of such factors or elements, the orbit axis is entirely determined, or the midline of the road is determined entirely (You, Yu, Huang, & Hu, 2022).

From a visibility perspective, the minimum radius of the curve or horizontal arc also required changes when autonomous vehicles' stop visibility value changes due to almost zero reaction time values (about 0.2 seconds). The minimum radius of the horizontal curve depends on several factors such as superelevation, friction factor and stopping visibility, the presence of a visual barrier, etc. When the horizontal line of sight offset (HSO), also called the deterioration distance value, is low, it affects the stop visibility value, and the radius of the required curve increases. On the contrary, if the HSO is higher, the required curve radius is reduced. Also, if it is required that the visibility value is increased and the hitch is fixed, the minimum curve radius required increases (Aryal, 2020).

Highway

A highway is an infrastructure consisting of buildings and other complementary designs to maintain traffic above and below ground and water level. It is usually built to move people, goods, and services from one place to another. It is also important to note that roads are designed to support the economic growth of a region through contributions to the production process (Setyawan, et al., 2021).

Highways have been the most effective means of transportation for several centuries, and advances in road transport are underway. Road transport has various advantages over other means of transportation. However, also, it comes with some challenges that need to be addressed for sustainable transportation. It comes with a significant number of traffic accidents and daily fatalities in traffic accidents because human error is the cause most of the time (Aryal, 2020).

Highways are expected to guarantee the convenience and safety of users, enable efficient traffic operations, and at the same time, attract the minimum possible costs in construction and maintenance. In addition, highways are also expected to cause minimal environmental damage and be aesthetically pleasing in their final form (Vishwas & GR, 2021).

Traffic safety is the most crucial factor in the field of transportation. Traffic safety issues are getting more severe and can threaten the development of the transportation sector. With the development of the automotive industry, motor vehicles have emerged on the streets in large numbers, which causes a series of problems such as urban traffic jams and traffic accidents. The efforts undertaken by highway design engineers include the manufacture of alignment and road profiles consisting of coordinates and elevations, the radius of horizontal curves, length of vertical curves, calculations of visibility and quantity of earthworks calculations, and various calculations and analyses planned for optimal alignment while meeting design standards and limitations (Lihong, Tongshuai, & Wei, 2018); (Gaikawad & Ghodmare, 2020).

For this reason, it is necessary to carry out precise and optimal geometric highway planning. However, traditional data acquisition methods for traffic accidents have long, incomplete, and other constraints that lead to poor evaluation credibility. Therefore, to obtain a long-term application, it is necessary to look for methods that can quickly identify, accurately, and efficiently determine the type of traffic conflict.

METHOD

Data is one of the main elements in compiling scientific research and modeling. In the geometric planning of this road, the data collection method uses quantitative research methods by taking data from google earth and global mapper, then analyzing using AutoCAD Civil 3D, where the data is secondary data in this study (Rifai, Hadiwardoyo, Correia, Pereira, & Cortez, 2015).

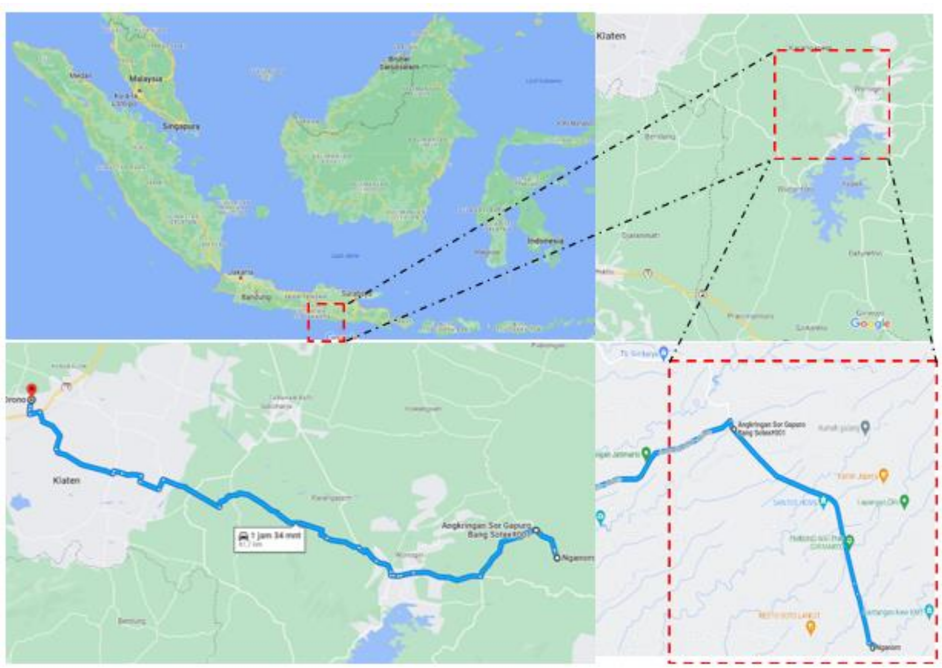

Figure 1. Location of Jalan Drono - Nganom
(Source: Google Maps, 2022)

The horizontal curved geometric planning connecting Jalan Drono and Nganom is located in Ngadirojo district, Wonogiri regency using the *AutoCAD Civil 3D®* method to open up isolation and economic equality between 2 regions, namely Drono and Nganom by facilitating the mobility of transportation equipment. The road will be discussed in geometric planning from STA 0 + 000 to STA 3 + 150. The location of the planning is shown in Figure 1. The data is taken from Google Earth and Google Maps, which are then used for road design in the region.

Based on data obtained by Jalan Drono - Nganom is a class II (second) arterial road. It is planned that the vehicles passing by are medium vehicles with a maximum axis weight of 10 tons. This road is located on a flat area and hills consisting of 2 lanes, and the availability of contour data on the road from Google *Maps*, *Google Earth*, and *Global Mapping*. The following are the criteria for designing the horizontal alignment of Jalan Drono – Nganom based on the Table on the Highway Design Standard-Indonesia.

Table 1. Road Planning Data

Road Data		
Location	Jalan Drono – Nganom	
LHRT Plan Year	< 27,100	Junior High School/Day
Road Classification	Secondary Artery II	
Specifications for Provision of Road Infrastructure	Moderate Road	
Design Criteria		
Road Function	Secondary Artery Road	
Classification	Flat	
Road Type	2/2-TT	
Plan Speed	80	km/h
Rumaja Width	13	m
Rumija Width	15	m
Ruwasja Width	15	m
Lane Width	7	m
Road Body Width	11	m
Road Shoulder Width	1,5	m
Median Width	Without	
Maximum Superelevation	6	%

RESULTS AND DISCUSSION

In this discussion, conduct geometric re-planning of the Jalan Drono-Ngano, especially Horizontal Alignment with AutoCAD Civil 3D. Here are the steps taken in geometric planning and using applicable standards.

The determination of road terrain classification is based on terrain slope conditions. The slope of the terrain is obtained by creating a new trace perpendicular to the left and right of the main trace so that the distance between the new trace points is received at 100 m. In *AutoCAD Civil 3D®*, there are results of land elevation of both trace and using the following formula obtained the slope of the terrain for each stationing and the result of the slope of each stationing. Based on the calculations with the above formula, the average slope of the Jalan Drono-Nganom traffic is 3.53%. Therefore, the slope of the terrain <10% is classified as flat terrain following the geometric planning regulations of intercity roads according to the Highway Design Standard-Indonesia.

Road Trase Planning

The Jalan Drono-Nganom trace will be planned to have two corners with a trace length starting from STA 0 + 000 - STA 3 + 150. Figure 2 shows the planning trace of Jalan Drono-Nganom.

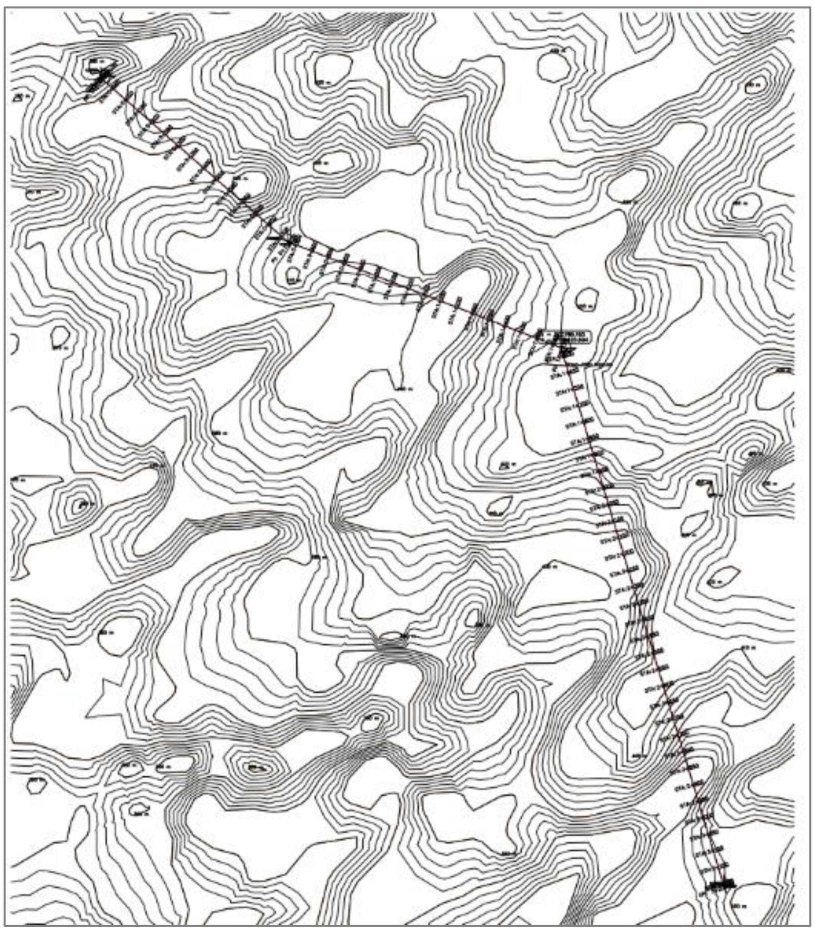

Figure 2. Trace of Jalan Drono – Nganom

Based on road traffic planning, coordinate points, distances between points, and angles between bends are obtained from *AutoCAD Civil 3D®*.

Table 2. Coordinate, Distance, and Corner PI

Coordinate	Distance	Corner PI
A=(504452,315 ; 9140203,067)	d A-1 = 720.29 m	Δ 1 = 19,59 °
PI-1=(504994,067 ; 9138728,400)	d 1-2 = 850.00 m	Δ 2 = 51,55 °
PI-2=(505786.165 ; 9139420,694)	d 2-B =1632.00 m	
B=(506258,628 ; 9137859,141)		

1. Horizontal Alignment Planning

Horizontal alignment geometric planning consisting of bend planning and superelevation is intended to compensate for the centrifugal force received by vehicles traveling at plan speed (V_R). Horizontal alignment consists of three types: Full Circle, Spiral Circle Spiral, and Spiral Spiral.

2. Design Planning Criteria

The design planning criteria used in the geometric planning of the Jalan Drono-Nganom concerning the RSNI T-14-2004 Geometric Urban Road are a plan speed of 80 km/h, a maximum superelevation of 6%, a friction coefficient of 0.14, and a minimum bend radius of 250 m. Based on the relationship of the parameters of horizontal arch planning with the plan's speed, a radius range of bends 300 –7000 m.

3. Bend Design

The selection of the type of bend using the provisions of the AASTHO, based on the provisions of the AASTHO, will first be reviewed the components of the spiral–circle–*spiral* bend. Considerations used in bend planning:

1. Rmin obtained 250 m, so planning using R=300 to R=1200
2. Consider the compound bend rules contained in the RSNI Geometric Urban Roads regulation 2004 that the compound bend requirement has a distance between two bends of at least 30 m.

Here are the steps used in determining the bend finger used by knowing the components of the bend.

1. Determine the initial data, i.e., plan speed, bend angle, normal superelevation, maximum superelevation
2. Calculating Ls (Spiral arch)
   a. Calculate Ls based on travel time

$$Ls1 = \frac{v_r}{3.6} x\ T \qquad \text{...} \qquad (1)$$

   b. Calculates Ls based on the degree of achievement of the change in a slump

$$Ls2 = \frac{(e_d - e_n)v_r}{3.6\ re} \qquad \text{...} \qquad (2)$$

3. Calculate components on a horizontal alignment curve by using SCS bends

$$\theta s = \frac{Ls}{2R}\frac{360}{2\pi} \qquad (3)$$

$$\Delta c = \Delta - 2\theta s \qquad (4)$$

$$Lc = \frac{\Delta c}{360} 2\pi R \qquad (5)$$

$$Yc = \frac{Ls^2}{6R} \qquad (6)$$

$$Xc = Ls - \frac{Ls^3}{40R^2} \qquad (7)$$

$$k = Xc - R\ sin\theta s \qquad (8)$$

$$Ts = (R+p)\tan\left(\frac{\Delta}{2}\right) + k \qquad (9)$$

$$Es = \frac{R+p}{\cos\left(\frac{\Delta}{2}\right)} - R \qquad (10)$$

$$Ltotal = L + 2Ls \qquad (11)$$

4. Checking Lc and p components to determine the type of bend used

$$Lc < 25 \rightarrow SS\ dan\ Lc > 25\ \rightarrow SCS$$
$$p < 0.2 \rightarrow FC\ dan\ p > 0.2\ \rightarrow SCS$$

Information:

Ls	= Length of switching curve
θs	= Spiral curved angle
Δ	= Bend angle
Lc	= Arc circle length
Xc	= Abscissa of the SC point on the tangent line
Yc	= Perpendicular distance to the point of SC on the arch
p	= Tangent shift toward the spiral
k	= Abscissa of p on the spiral tangent line
Ts	= Tangent length from PI point to TS point or ST point
Ec	= Distance between PI point and circle arc

After calculating and checking the conditions, two types of bends were obtained that connect the Jalan Drono - Nganom, namely the Spiral-Circle-Spiral with two fingers of 400 m. Here are the components on each bend, along with images from Civil 3D.

SUMMARY		
Component	Bend 1	Bend 2
ncana (km/jam)	80.00	80.00
Δ (°)	19.99	51.93
e_{normal}	0.02	0.02
e_{max}	0.06	0.06
e_{desain}	0.05	0.05
R (m)	400.00	400.00
Ls1	44.44	44.44
Ls2	42.67	42.67
Ls Desain	45.00	45.00
θ_s (°)	3.223	3.223
Δ_c (°)	13.545	45.487
Lc (m)	94.564	317.558
Yc (m)	0.844	0.844
Xc (m)	44.986	44.986
k (m)	22.498	22.498
p (m)	0.211	0.211
Ts (m)	93.033	217.403
Es (m)	6.379	45.148
Ltot (m)	184.564	407.558
CEK (Lc)	SCS	SCS
CEK (p)	SCS	SCS
CEK (e)	SCS	SCS
d (x0 - xi)	720.290	849.789
Cek d	OK!	OK!
d (xi - x(i+1))	849.789	1631.462
Cek d	OK!	OK!

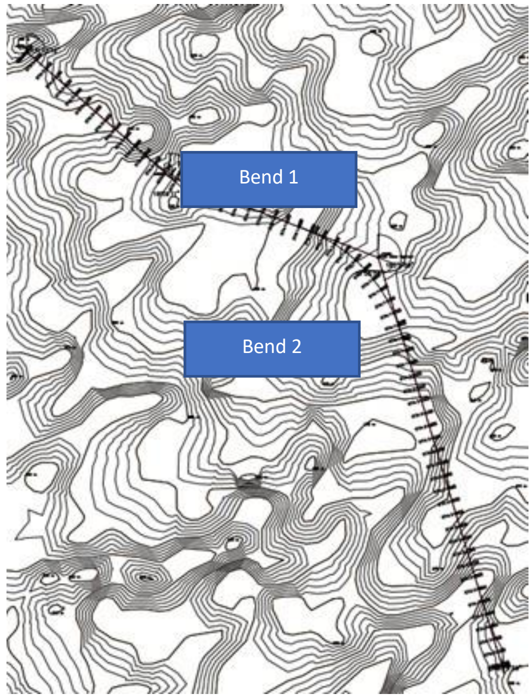

Figure 3. Results of Bend Planning Using Civil 3D

4. Superelevation Diagram

The superelevation diagram depicts the change in the superelevation value in the straight-curved and straight sections along the bend. The design of the superelevation diagram aims to compensate for the centrifugal force received by the vehicle when going through a corner to provide safety and comfort when driving. The following are the results of the superelevation and stationing diagrams of each of the corners designed.

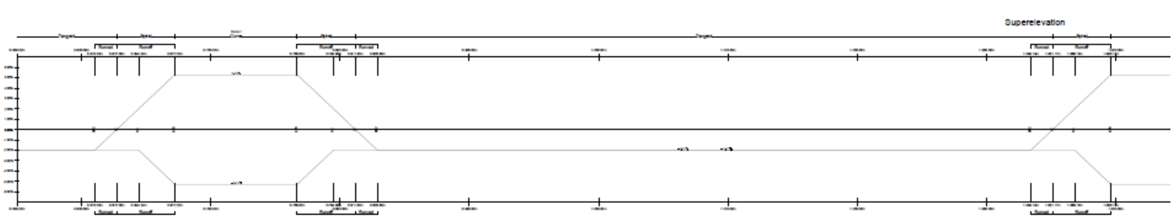

Figure 4. Superelevation diagram of Jalan Drono-Nganom

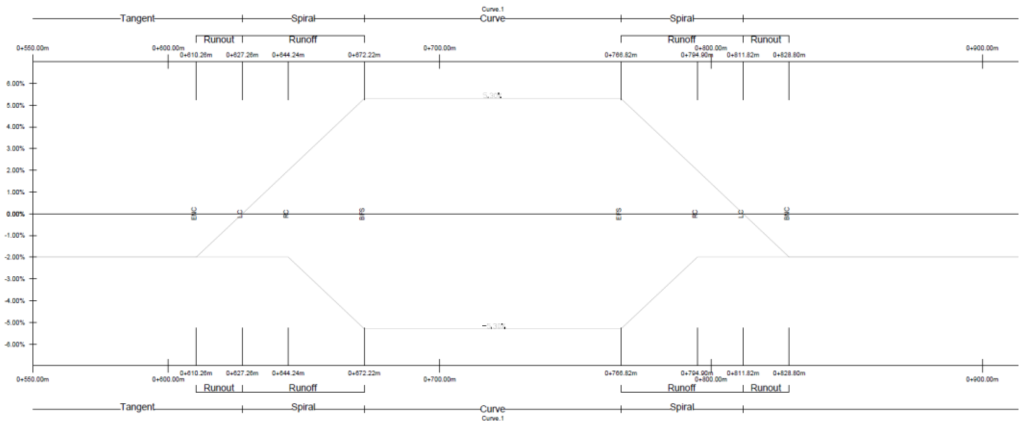

Figure 5. Bend Superelevation Diagram 1

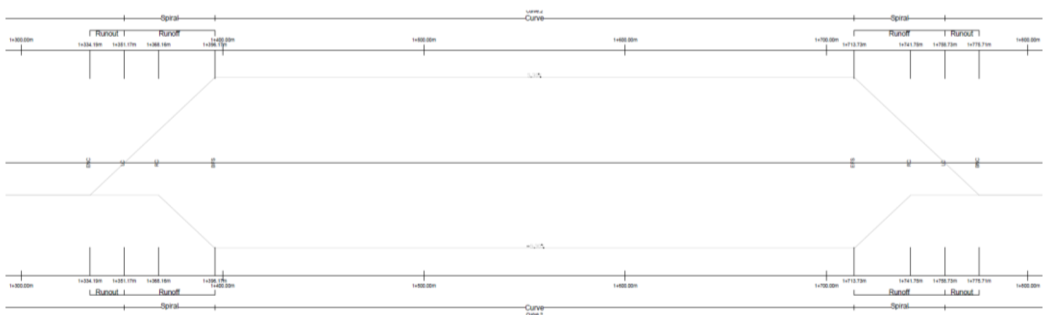

Figure 6. Bend Superelevation Diagram 2

CONCLUSION

Geometric planning using *AutoCAD Civil 3D®* with the section reviewed Jalan Drono – Nganom is a class II Secondary Arterial Road, with a road type of 2/2 TT, along 0 + 000 - 3 + 150, aims to facilitate mobility. The road section is designed geometrically horizontally with two plan bends using the SCS type (Spiral – Circle – Spiral) with a radius of 400 m so that the superelevation design is 5.6%.

REFERENCE

Adiputra, D. S., Rifai, A. I., & Bhakti, S. K. (2022). Design of Road Geometric with AutoCAD 2D®: A Case Wirosari-Ungaran Semarang, Indonesian. *Citizen: Indonesian Multidisciplinary Scientific Journal*, *2*(5), 729-738.

Arifin, A., & Rifai, A. I. (2022). Geometric Design of Upper Cisokan Hydroelectric Power Plant Access Road with AutoCAD Civil 3D® (STA 3+ 000-STA. 4+ 800). *Citizen: Indonesian Multidisciplinary Scientific Journal*, *2*(5), 851-858.

Aryal, P. (2020). Optimization of geometric road design for autonomous vehicle. *Digitala Vetenskapliga Arkivet*.

Bryzhko, V. G., & Bryzhko, I. V. (2019). Comprehensive assessment of the impact of road infrastructure development in a rural municipal area (Russia). *Revista Espacios, 40(37)*.

Castañeda, K., Sánchez, O., Herrera, R. F., & & Mejía, G. (2022). Highway Planning Trends: A Bibliometric Analysis. *Sustainability*.

Chakole, H., & J.Wadhai, D. (2022). A Review on The comparison of geometric design using Civil 3D software and manual method. *International Journal for Modern Trends in Science and Technology*.

Cui, T. (2022). Construction Journal. *Research on design technology of safety facilities in highway traffic engineering*, 1.

Philanthropist, W. B., Rifai, A. I., Ramadan, A. H., & Isradi, M. (2021). Analysis of Pedestrian Facility Services on Shopping Mall Areain Satellite City During Pandemic COVID-19. *ADRI International Journal of Sciences, Engineering and Technology, 6*(2), 99-107

Eliseev, M., Tomchinskaya, T., Lipenkov, A., & Blinov, A. (2017). Using 3D-modeling technologies to increase road safety. . *Transportation Research Procedia, 20,* 171-179.

Findley, D. J. (2017). Highway Geometric Design. *Construction Journal*.

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*.

Gunawan, R. Y., Rifai, A. I., & Irianto, M. A. (2022). AutoCAD 2D® for Geometric Design of Big Flygi–Pematang Bake Highway (Sta. 28+ 650–Sta. 53+ 650). *Citizen: Indonesian Multidisciplinary Scientific Journal*, *2*(5), 757-765.

Lihong, L., Tongshuai, Y., & Wei, Z. (2018). Methods of Traffic Conflict and Definition. *In Proceedings of the Asia-Pacific Conference on Intelligent Medical 2018 & International Conference on Transportation and Traffic Engineering 2018*, pp. 67-71.

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. *International Journal of Advance Research, Ideas and Innovations in Technology*, 5(3).

Mijic, N. (2019). Application of the Airborne LIDAR Technology on the Quarry Using AutoCAD Civil 3D Software. *Springer Nature*, 6(3).

Nurjannah, S. N., Rifai, A. I., & End, A. F. (2022). Geometric Design for Relocation of National Road Sei Duri-Mempawah Section, West Kalimantan using AutoCAD 2D®. *Citizen: Indonesian Multidisciplinary Scientific Journal*, *2*(5), 692-702.

Paikun, SP, R. W., Destaman, F., & Winardi, D. (2021). Road Geometric Feasibility In Road Sagaranten–Tegalbuleud Km. BDG 175+ 100. *ASTONJADRO: CEAESJ.*

Pandey, S., Atul, E., & Bajpai, Y. (2019). PLANNING, DESIGNING AND PROPOSING A FLYOVER ROAD USING AUTOCAD CIVIL 3D SOFTWARE. *PLANNING.*

Pandey, S., Atul, E., & Bajpai, Y. (2019). PLANNING, DESIGNING AND PROPOSING A FLYOVER ROAD USING AUTOCAD CIVIL 3D SOFTWARE. *Planning*.

Pandey, S., Atul, E., & Bajpai, Y. (2020). Planning, Designing and Proposing a Flyover Road Using Autocad Civil 3D Software. *PLANNING.*

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)*.

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. *Applied Mechanics and Materials (Vol. 845) (* pp. 369-378). Trans Tech Publications Ltd.

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.

Rizki, R., Rifai, A. I., & Djamal, E. Z. (2022). Geometric Redesign of Jalan Cisauk–Jaha, Banten with Manual Method (Sta. 0+ 000-Sta. 0+ 350). *Citizen: Indonesian Multidisciplinary Scientific Journal*, *2*(5), 859-864.

Rizqi, M., Rifai, A. I., & Bhakti, S. K. (2022). Design of Road Geometric with AutoCAD Civil 3D®: A Case Jalan Kertawangunan–Kadugede, Kuningan-Indonesia. *Citizen: Indonesian Multidisciplinary Scientific Journal*, *2*(5), 879-887.

Setyawan, A., Yusep, M. P., Setiawan, B., Muandululman, F. F., Setiawan, A. G., & Prabowo, G. R. (2021). The Evaluation of Deflection and Tensile Stress in Jointed Plain Concrete Pavement for a Damaged Road. *In Journal of Physics: Conference Series (Vol. 1912, No. 1, p. 012057) IOP Publishing*, 1-8.

Shevriyanto, B., Rifai, A. I., & Chiang, Z. (2021). Street Furniture in Batam: Inspirations from Natural and Cultural Inheritance. *工業設計*, (144), 47-51.

Stephen, S., Rifai, A. I., & Nasrun, N. (2022). Implementation Autocad® Civil 3D for Horizontal Alignment Design of Indramayu-Jatibarang Highways. *Citizen: Indonesian Multidisciplinary Scientific Journal*, *2*(5), 739-747.

Sukalkar, V. G., & Pawar, K. (2022). A Study and Design of Two Lane with Paved Shoulder in Green Filed Corridor, By Using Civil 3D. *International Journal of Scientific Research in Science, Engineering and Technology*, 202-211.

Suprayoga, G. B., Witte, P., & Spit, T. (2020). Coping with strategic ambiguity in planning sustainable road development: balancing economic and environmental interests in two highway projects in Indonesia. *Impact Assessment and Project Appraisa*.

Syaiful, S., & Rusfana, H. (2022). Rigid Pavement Planning In Traffic: Case Study In Ciherang Road And Pemuda Road, Bogor Regency, INDONESIA. *Journal of Applied Engineering Science, 20(2),*, 485-487.

Valeryevna, M. A., & Vitalievna, C. V. (2018). Designing the territory of the cottage village in AutoCAD Civil 3D. *AlfaBuild*, 3(1), 33-45.

Vishwas, J. S., & GR, D. M. (2021). Geometric Design and Validation of Road Corridor Modelling Using Civil 3d Software. *SSRN*.

You, K., Yu, Q., Huang, W., & Hu, Y. (2022). Safety-Based Optimization Model for Highway Horizontal Alignment Design. *Mathematical Problems in Engineering*, 1-15.

Zhao, L., Liu, Z., & Mbachu, J. (2019). Highway alignment optimization: an integrated BIM and GIS approach. *SPRS International Journal of Geo-Information*, 8(4), 172

Zulfa, N., Rifai, A. I., & Taufik, M. (2022). Road Geometric Design used AutoCAD Civil 3D®: A Case Study Jalan Campaka-Wanaraja Garut, Indonesia. *Citizen: Indonesian Multidisciplinary Scientific Journal*, *2*(5), 843-850.