Implementation Autocad® Civil 3D for Horizontal Alignment Design of Indramayu-Jatibarang Highways

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Abstract
The geometric planning of the road has been made more convenient by technological advances in construction, which have led to innovations that are still growing. With the use of Autocad® Civil 3D, the process of planning the Indramayu-Jatibarang roadways is complete. This paper aims to explain how to plan roadways geometrically with Autocad® Civil 3D and to provide the reader a knowledge of how Autocad® Civil 3D can speed up and simplify work processes. The approach in this planning uses many programs, including Google Earth for determining the coordinates, Global Mapper for obtaining the site contour, and Autocad® Civil 3D for concluding the horizontal alignment. The process of designing with Autocad® Civil 3D is one of the results of this planning.

Keyword: Autocad® Civil 3D, Horizontal Alignment, Highways

1. Introduction

Transportation is essential to human life and the global development of construction. Some nations have concentrated on advancements in construction technology science. Tiongkok is one of the countries with highly rapid transportation development; this development is a turning point for Tiongkok's transportation development, especially considering the large highway construction. (Xu, Fan, & Xu, 2021). Creating transportation technology is anticipated to guarantee user comfort and offer driving safety (Mandal, Pawade, Sandel, & Infrastructure, 2019). Highway comfort and safety must create. This planning is done according to the correct criteria.

For standards to achieve ideal highway planning. Indonesia has highway planning standards regulated by the Kementerian PUPR Dirjen Bina Marga (Kementerian PUPR Dirjen Bina Marga, 2021). Road classification, status, grouping, type, and other considerations and regulations in the development of a road, including highways, are all governed by the regulation. Numerous factors must be considered while designing the road's geometric design, beginning with the planning of horizontal and vertical alignments and cross sections (Gaikawad & Ghodmare, 2020). Road geometry planning is done to maximize safety and save expenses (Chakole & Wadhai, 2022). The significance of planning and uniformity in highway design is to produce safe and comfortable driving surfaces.

One of the cities in Indonesia that is expanding socially and economically is Indramayu. The city of Indramayu will eventually have a denser population overall. It is believed that the growth of this group would destabilize Indramayu. Because of its advantageous location, most of those who work in Indramayu prefer to reside in the city of Jatibarang, which contributes to the city's growing population. Additionally, relatively reduced land costs can cause a rise in the population. As a result, Indramayu's city will see an increase in the volume of traffic that passes through it.

Additionally, accidents frequently happen in this region. Thus regular reviews should be done

(Sugandi, 2021). When the nature of traffic jams is a routine occurrence, the result will not only affect the inefficiency of resource use but also disrupt activities in the existing environment (Rifai, Surgiarti, Isradi, & Mufhidin, 2021)

Technological advances in the construction world have made innovations that continue to grow and provide convenience in geometric road planning. Building Information Modeling (BIM) is a popular innovation in the digital age, providing many conveniences in the construction world. Dr. Chuck Eastman of the Georgia Institute of Technology of the United States in 1975 first proposed the technique of modeling using BIM. Then this was developed by Jerry Laiserin by complementing and standardizing modeling with BIM. This process continues and evolves with time (Zhou, et al., 2017). Autocad® Civil 3D is one of the BIM software, which has provided convenience, and support in the field of infrastructure planning, especially in the geometric planning of roads (Raji, Zava, Jirgba, & Osunkunle, 2017).

This paper aims to explain the process of geometric road planning with limitations in the form of horizontal alignment design planning on the Indramayu – Jatibarang toll road. This plan is made to reduce the problems in Indramayu and can be used as a solution to congestion and accidents. In addition, this paper is expected to provide an understanding of the geometric planning of roads by using Autocad® Civil 3D and open the reader's insight. Autocad® Civil 3D can simplify work and streamline work time.

2. Literatur Review

2.1 Autocad® Civil 3D

Autocad® Civil 3D is a documentation application developed by Autodesk®. Autocad® Civil 3D is very supportive in providing information modeling. In the civil world, it is usually used for modeling, analysis, and design of various types of projects in the form of civil infrastructure, ranging from Highways, land development, railways, and airports (Raji, Zava, Jirgba, & Osunkunle, 2017). The process of designing the Indramayu-Jatibarang highways will be done with the help of the Autocad® Civil 3D Software application. Autocad® Civil 3D is used as a road design tool with all the elements to outline a complete road infrastructure. Autocad® Civil 3D also provides a summary table view for the volume work of excavation, backfilling, and pavement layers (Biancardo, Capano, de Oliveira, & Tibaut, 2020). In structurally planning, several steps in basing the road with Autocad® Civil 3D must be considered. These steps should include several things, namely, preparing a road design model to be used, determining the road route in the plan along with its profile, 3D modeling of the road, and calculating the volume of work and output documentation (Merentsova, 2020).

Several advantages are offered if we use Autocad® Civil 3D, among others. Through the calculation and quantitative data processing, it can be determined whether the proposal meets the requirements of the project, engineering factors, and financial factors, can reduce project requirements and demolition costs, improve energy efficiency, maximum return on investment, minimize potential hazards and safety hazards, can be done some simulation experiments and obtained the best solution increased work efficiency (Liu, 2021). Autocad® Civil 3D can automatically describe the profile and display design modeling in visual 3D (Sukalkar & Pawar, 2022). Autocad® Civil 3D can also analyze the need for earthworks, both backfilling and excavation, and can also analyze visibility, superelevation, and validate data. Calculation of work items in the world of construction requires a high level of accuracy, especially in the calculation of earthworks requires a very high level of accuracy. The journal "Geometric Design and Validation of Road Corridor Modelling Using Civil 3D Software" says that the features in Autocad® Civil 3D allow it to perform soil calculations that can be done in just a few seconds. Autocad® Civil 3D application Software is beneficial in the design process in a straightforward way (Vishwas & GR, 2021).

2.2 Horizontal Alignment

A horizontal alignment is one of the most challenging aspects of planning roadways, yet the geometric design is a fundamental component of the process. While limiting the length of the road and expenditures, taking the road radius into account might result in a horizontal curve of the road that satisfies the criteria (Sushma & Maji). The road axis is projected on a horizontal plane to create horizontal

curvature. This horizontal alignment, made up of straight lines joined by curved lines, is also known as "road situation" or "road track." A circular arc, an arc transition, and an arc circle make up the curved line (Pau & Aron, 2018) . This horizontal alignment joins a straight stretch of road with a straightforward, constant-radius curve. Horizontal alignment makes driving in cars safer and more convenient. There are several horizontal curved designs, including Full Circle, Spiral-Circle-Spiral, and Spiral-Spiral. When designing a horizontal alignment, the determination of the exact radius of the curve, the exact location of the curve, and the location of the curve transition should be considered (Aryal, 2020).

The functional clarity of the road topography, design speed, traffic volume, environmental circumstances, and the degree of service necessary are only a few of the numerous contributing elements for horizontal alignment throughout the design stage (Abdulhafedh, 2019). With functions that are by the site being developed, some aspects that affect designing this horizontal alignment seek to obtain the maximum horizontal alignment. Designs for horizontal alignment must adhere to several design requirements, including the alignment's minimum radius, level of superelevation, and visibility. In hilly areas, horizontal alignment can reduce the speed of vehicles and light trucks because of the high engine power to vehicle weight ratio (Xu, Lin, & Shao, 2017). In addition to the horizontal alignment, the driving speed with different vehicle classifications can affect the selected road class, which is a decisive factor in designing the horizontal alignment and will undoubtedly affect the cost of the project work.

A crucial consideration when constructing a horizontal alignment is the expense of the road. Road planning often considers engineering expenses, road topography, and design codes. According to data on traffic accidents, the radius and length of the horizontal alignment play a significant role in ensuring the safety of the road. However, the risk of about two traffic accidents per year might be associated with the optimal horizontal alignment design (You, Huang, & Hu, 2022).

2.3 Highway

Highway building is seen as a necessary component of daily life, and the development of toll roads is crucial to the sustainability of urban growth. (Kachhawah & & Deulkar, 2022). Therefore, it frequently happens for certain nations to begin concentrating on domestic infrastructure improvement. Governments worldwide are increasingly prioritizing infrastructure expenditures, particularly for the construction and maintenance of highways (Castañeda, Sánchez, Herrera, & Mejía, 2022) . Highways are constructed to achieve the balanced development of the region, the equitable distribution of development and its outcomes, and the fairness that can be attained by fostering a road network whose funds are provided by road users and which aims to increase the efficiency of distribution services to support economic improvement, particularly in those with high levels of development.

A strategically important area, Indramayu has a rising population growth rate. The number of automobiles increased along with the population rise. Building these roads is to lessen the turmoil brought on by Indramayu's growing population of people and vehicles. Road safety is one of the key justifications for building the highway in Indramayu. The degree of vehicle mobilization, road improvements, populous regions, traffic management, rising living levels, and societal norms all impact traffic safety on the road (Karpova, Sigova, Kruglova, & Kelbakh, 2017) . Therefore, traffic safety should be implemented after access or a solution to the contextual.

3. Methodology

The systematic scientific research process must identify appropriate problems (Rifai, Hadiwardoyo, Correia, & Pereira, 2016) . This data gathering comes next, following the preparation period, before the research is conducted. The data were acquired by the study's plan for exact and appropriate data (Rifai, Rafianda, Isradi, & Mufhidin, 2021) . The planning location is in Indramayu (Indramayu Regency) - Jatibarang (Jatibarang District. They are considering the high population and vehicle usage, making this location suitable for highway development planning to reduce congestion and accident rates. Data is one of the main strengths in preparing scientific research and modeling (Rifai, Hadiwardoyo, Correia, Pereira, & Cortez, 2015) . There are many applications with which we can easily find the coordinates of a location worldwide, including this planning location. Data collection on this plan utilizing Google Earth software.

Page | 741

With data collection techniques using Google Earth, we can get the location coordinates of any point, including the planning location in Indramayu – Jatibarang. In addition to Google Earth, the author uses Global Mapper as an application software to obtain elevation data point locations. This application makes it easy to get the actual data on land size. In addition to google earth and global mapper, to obtain data used, several supporting regulations support the planning obtained from the regulations.

Figure 1. Location of research

In designing a road, the author utilizes software issued by Autodesk to simplify the process of designing roads. Autocad® Civil 3D 2020 is an application selected by the author. Autocad® Civil 3D can create contours based on data obtained from the Global Mapper. Autocad® Civil 3D can create a road track, vertical alignment, horizontal alignment, and road corridor and issue cut and fill calculations. Autocad® Civil 3D application software is shown in figure 2.
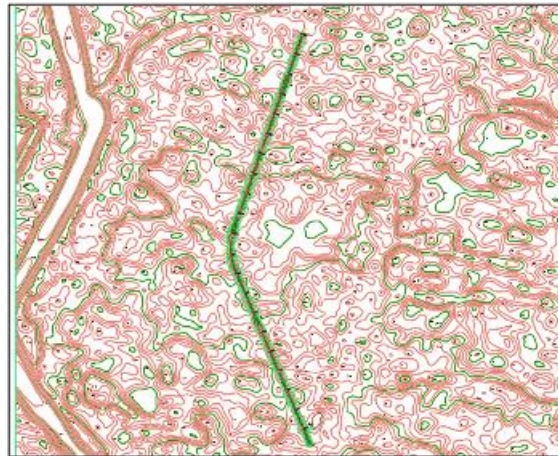

Figure 2. Autocad® Civil 3D application software

4. Analysis and Discussion

The highways planning project will be built in Indramayu-Jatibarang, with the classification of freeways and the status of roads, namely national roads. Roads in the construction site area are straight roads with a slope of <10%. The planned road function is an arterial road with a 4/2D road type (four lanes – two directions), has a lane width of 3.5 meters with a planned speed of 80km/hour. With rumaja 30 meters, rumija 35 meter, and ruwasja 40 meter. The design of this highway has a median that is in the center road, with a pavement width of (2 x 3.5 m) x 2, a shoulder width in the road is 0.5 meters, a shoulder width outside of 3.5 meters, and this design an E max of 6% and E standard 2%.
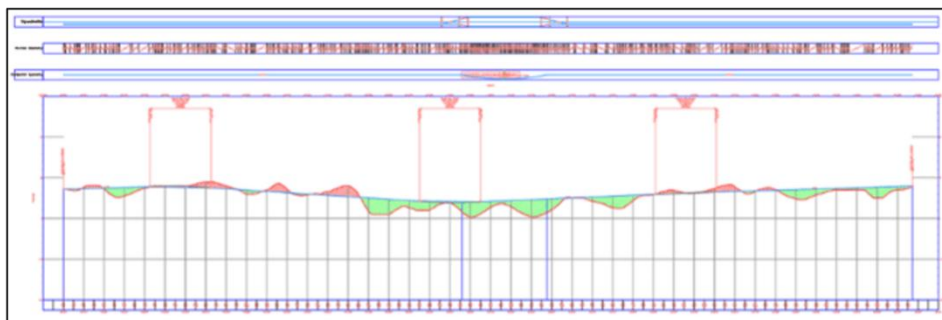
Figure 3. Horizontal alignment planning

The first step in our initial planning should be to find the contours of the planning area. If the contour is already obtained, we export it into the Autocad® Civil 3D 2020 application. In making a horizontal alignment, we must determine the planning point of the horizontal alignment first. We can create horizontal alignment according to the Planning points that we define. Horizontal alignment can be created with the help of the menu provided by Autocad® Civil 3D 2020, which is in the "Alignment" menu. In the alignment menu, several things must be considered; we must enter the data in the form of planned road speed. This speed is determined from the category of road plans. In this planning category, the road is a freeway with flat terrain <10%, so the speed range is obtained at 80-120km/hour, and the planning speed is 80km/hour (Kementerian PUPR Dirjen Bina Marga, 2021).

Next, in making the curve can use the toolbar "Tangent-Tangent with Curve," where in this menu, we will design a horizontal curve automatically according to the design criteria made and with the ideal horizontal curve that will be drawn directly automatically. The radius created on this horizontal curve is the minimum radius according to the design criteria we plan.

Figure 4. Longitudinal profile and diagram of vertical alignment

In the next step, we will take out the longitudinal profile of the horizontal alignment that we have created, and we can take advantage of the"Create Profile from Surface" menu provided by Autocad® Civil 3D. In this menu, what must be considered is the contours and roads that the planning data will issue profiles. Next, activate the "Clip Vertical Grid" and "Clip Horizontal Grid," after that we change the "Band Set" to "Profile Data with Geometry and Superelevation," where later a longitudinal profile will appear accompanied by a diagram of superelevation of the planning path as shown in figure 4.

Alignment vertical we can create with the help of the menu "Profile Creation Tools," and then

we select "Draw Tangents with Curves" at this stage, what needs to be considered when creating a vertical curve is the slope of the plan by the rules of reference, in this planning the slope for flat terrain <10% with the classification of freeways that is equal to 4% (Kementerian PUPR Dirjen Bina Marga, 2021). After that, we will display the cut and fill view of the planning path by clicking on the "Profile View Properties" menu, then activate "Cut Area" and "Fill Area," and then apply.

Next, we will output the superelevation diagram by utilizing the "Superelevation " menu, then select "Calculate/Edit Superelevation." In the next stage, several road designs will appear; select the design according to the road model we want to make. A "Divided Planer with Median" model will be made in this planning. At the next stage, we are asked to enter the width of the road plan to be planned. In this case, the width of the road is 3.5 meters with a standard slope of -2%, then input the data shoulder width is 3.5 meters. At the next stage, we will input the reference design criteria. We refer to "AASHTO 2011 Metric eMax 8%" in this design with the "Lane 4 lane" criterion. The superelevation Diagram is already defined in figure 5.

Figure 5. Diagram of superelevation

In the next stage, we will make a road assembly, wherein making a road assembly. We must already have horizontal and vertical alignment. We can use the "Create Assembly" menu in its creation. We will appear in the assembly, and we will make the assembly by planning. The stages we will design start from the median, lanes superelevation AOR, shoulder extend all, shoulder extend subbase, and finally, we design for the side ditch. When finished, we will get the road assembly as in figure 6
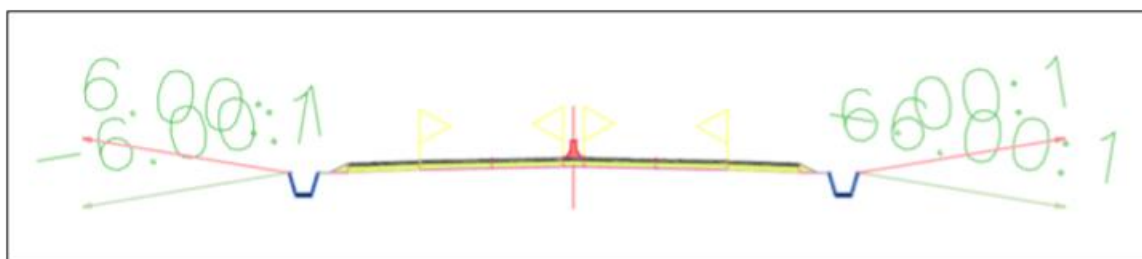

Figure 6. Assembly road plan

After creating the road assembly, we will create a road corridor with the help of the "Create Corridor" menu. In this section, we must pay attention and ensure that horizontal alignment has been made. Then, on the selected vertical profile is made, the road corridor will be drawn automatically on the road plan as in figure 7.

Figure 7. Corridor of road

The road corridor determines the slope area of cuts and fills made for the placement of the road plan. Next, we can simulate the road created with the help of the "Drive " menu and then select a horizontal alignment. Road simulation will be drawn in figure 8.
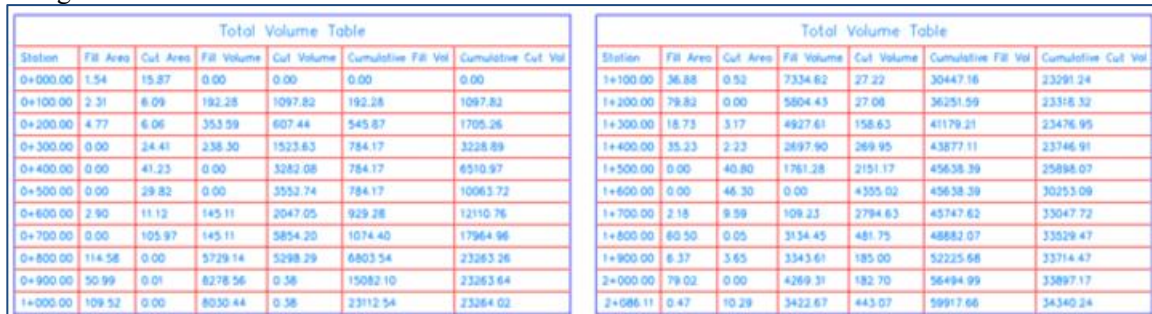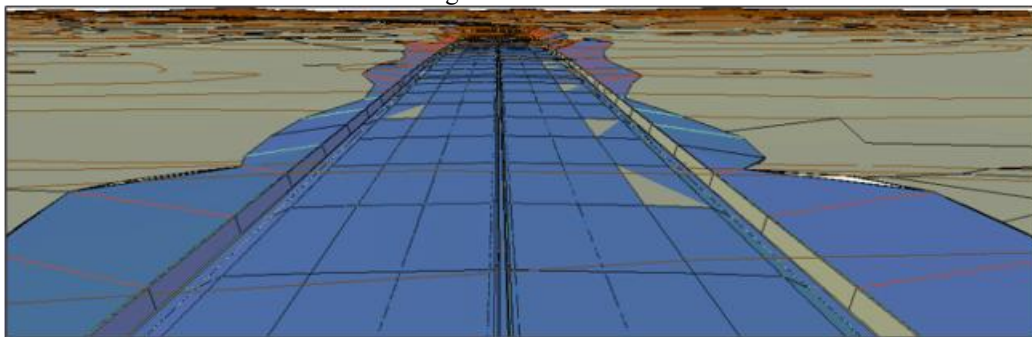

Figure 8. View drive-in road

In the next step, we will create a " Cross Section" the first step is to create a sample line using the menu "Create Sample Line Group." Next, we select "By Range of Station," then we will set the value in the range of the sample line area, taking the most comprehensive corridor. In the menu option "sampling Increments," set along tangents to 50, along curves to 25, and along spirals to 25. This aims to produce cross-sections according to the plan. To display the cross-section, click the "Section View" menu, then "create multiple views." The cross-section view will be drawn as in figure 9.
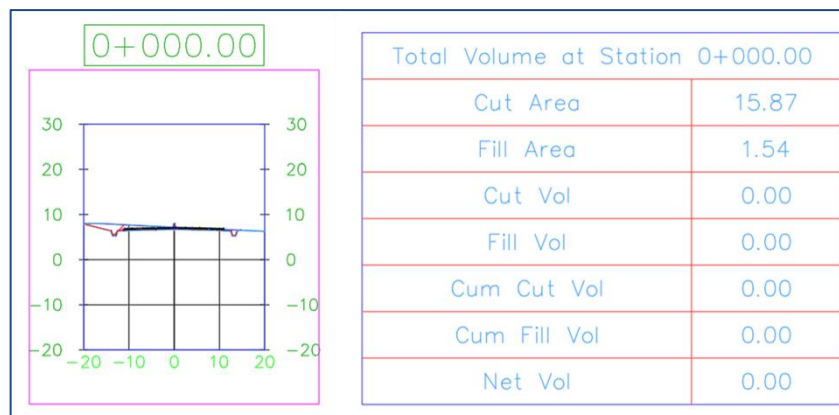
Figure 9. Section cross at Sta 0+0.00 and total volume at station 0+0.00

At the final stage, we will display the cut and fill volume of the road plan that has been made. Click "Total Volume Table," then make sure the table style is selected, cut, and fill. The cut and fill volume table will be defined from the beginning to the end of the planned path and attached, as shown in Figure 10.

Total Volume Table							Total Volume Table					
Station	Fill Area	Cut Area	Fill Volume	Cut Volume	Cumulative Fill Vol	Cumulative Cut Vol	Station	Fill Area	Cut Area	Fill Volume	Cut Volume	Cumulative Fill Vol	Cumulative Cut Vol
0+000.00	1.54	15.87	0.00	0.00	0.00	0.00	1+100.00	36.88	0.52	7334.62	27.22	30447.16	23291.24
0+100.00	2.31	6.09	192.28	1097.82	192.28	1097.82	1+200.00	79.82	0.00	5804.43	27.08	36251.59	23318.32
0+200.00	4.77	6.06	353.59	607.44	545.87	1705.26	1+300.00	18.73	3.17	4927.61	158.63	41179.21	23476.95
0+300.00	0.00	24.41	238.30	1523.63	784.17	3228.89	1+400.00	35.23	2.23	2897.90	269.95	43877.11	23746.91
0+400.00	0.00	41.23	0.00	3282.08	784.17	6510.97	1+500.00	0.00	40.80	1761.28	2151.17	45638.39	25898.07
0+500.00	0.00	29.82	0.00	3552.74	784.17	10063.72	1+600.00	0.00	46.30	0.00	4355.02	45638.39	30253.09
0+600.00	2.90	11.12	145.11	2047.05	929.28	12110.76	1+700.00	2.18	9.59	109.23	2794.63	45747.62	33047.72
0+700.00	0.00	105.97	145.11	5854.20	1074.40	17964.96	1+800.00	60.50	0.05	3134.45	481.75	48882.07	33529.47
0+800.00	114.56	0.00	5729.14	5298.29	6803.54	23263.26	1+900.00	6.37	3.65	3343.61	185.00	52225.68	33714.47
0+900.00	50.99	0.01	8278.56	0.38	15082.10	23263.64	2+000.00	79.02	0.00	4269.31	182.70	56494.99	33897.17
1+000.00	109.52	0.00	8030.44	0.38	23112.54	23264.02	2+086.11	0.47	10.29	3422.67	443.07	59917.66	34340.24

Figure 10. Screen capture total volume result

5. Conclusion

The conclusion of this paper shows complete horizontal planning using Autocad® Civil 3D on the Indramayu – Jatibarang toll road. The process of designing using Autocad® Civil 3D for toll roads to be faster by utilizing the advantages of Autocad® Civil 3D. The design also displays some of the data we need, ranging from a horizontal alignment, vertical alignment, longitudinal profile, superelevation diagram, cross-section, road simulation, and the total cut and fill volume.

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