DESIGN OF ROAD GEOMETRIC WITH AUTOCAD® CIVIL 3D: A CASE JALAN KERTAWANGUNAN–KADUGEDE, KUNINGAN-INDONESIA

Pebri Tri Anugraha[1], Yusra Aulia Sari[2], Adinda Fajarika[3]
[1]Faculty of Civil Engineering, Universitas Majalengka, Indonesia
[2]Faculty of Civil Engineering and Planning, Universitas Internasional Batam, Indonesia
[3]Faculty of Engineering, Universitas Mercu Buana, Indonesia
Email korespondensil: anugrahapebri@gmail.com

ARTICLE INFO	ABSTRACT
Keywords: Alignment horizontal, alignment vertical, AutoCAD® Civil 3D, corridor, cut and fill	In today's globalized world, much software is developed to make work easier to implement. This software is demonstrated using AutoCAD Civil 3D® to demonstrate how geometric road design can be completed briefly. In this case, the purpose of geometric planning is to evaluate the effectiveness of manual geometric planning using AutoCAD Civil 3D®. This journal's geometric road planning implements qualitative methods. The geometric planning of the road that became the subject of this journal's research is located on Jalan Kertawangunan - Kadugede, with a road plan length of 9.3 km as an additional alternative to Kuningan Regency's new outer ring road. The calculation of horizontal alignment required the minimum bend (Rmin) and transition arch (Ls) values. Therefore, it is necessary to plan the assembly ahead of time before planning the corridor. The corridor's function is to determine the location of cut and fill based on road planning. As a result, planning a path with AutoCAD Civil 3D® is more effective and efficient, and it can retrieve the necessary data quickly. There are four points of interest with different types of curves in road traffic planning. The plan speed (Vr) was set to 60 km/h, the maximum superelevation slope (e-maks) was set to 0.08, and the transverse friction coefficient (f) was set to 0.153. The average excavation volume obtained from this planning is approximately 1,900,000 m3

1. Introduction

Road networks dominate transportation infrastructure in most countries (Gibbons, Lyytikäinen, Overman, & Sanchis-Guarner, 2019). Development is essential for increasing a country's economic productivity (Rifai, Surgiarti, Isradi, & Mufhidin, 2021). The availability of adequate infrastructure provided by the government influences the country's productivity (Rifai, Latief, & Rianti, 2018). Highways are an essential part of daily life because they provide human access to travel and connect regions in a location. This critical component focuses on achieving balanced inter-regional development and national security to achieve national development. It will be difficult for humans to carry out activities with various parties if they do not have adequate access. As a result, proper standards must be used when designing the highway. Highways are required to ensure the comfort and safety of users as well as the efficient movement of traffic (Gaikawad & Ghodmare, 2020).

Highways are separated into National Roadways, Provincial Roads, Regency Roads, City Roads, and Village Roads following Law of the Republic of Indonesia No. 38 of 2004 and Government Regulation No. 34 of 2006 regarding the status of roads. Correct geometric criteria are necessary for

road planning. The standard was developed to evaluate how well roads are designed. The geometric design of highways pertains to the design of cross-sectional elements, visibility, alignment, curves, super elevations, and other related factors that are physically apparent on roadways (Veer, Gupte, & Juremalani, 2018). When creating roads to ensure road users' safety, security, and comfort, a road design engineer must be aware of certain aspects of geometric road design. Additionally, it is essential to comprehend geometric design elements so that planning may be done correctly and the road can last long.

The utilization of technology is getting more advanced in the contemporary globalized era. As a result, many pieces of software, including one for highway engineering, are developed to make work easier to implement, particularly in civil engineering. This software is demonstrated by using AutoCAD® Civil 3D to demonstrate how geometric road design can be completed quickly, efficiently, and precisely, inspiring civil engineering professionals in underdeveloped nations to adopt road design software. AutoCAD® Civil 3D can maximize the geometric design of roads with various practical concepts. Additionally, AutoCAD® Civil 3D offers 3D project modeling and aids with project adaptation for both small and large-scale projects (Mandal, Pawade, Sandel, & Infrastructure, 2019).

This case study's geometric road planning is located in the Kuningan Regency. To assist with the government's planned road performance, Kuningan Regency must create new road infrastructure access (Yuono & Sugiyanto, 2016). Students from Unswagati Cirebon already performed this geometric planning using manual calculations in the construction journal article "Geometric Planning of the Kertawangunan-Kadugede Road Section of Kuningan Regency" from 2016.

The goal of geometric planning in this case study is to compare and evaluate the efficiency of manually performed geometric planning using AutoCAD® Civil 3D. Planning to create efficient road traffic will therefore be put to best advantage. The government will find it simpler to balance the welfare of the surrounding community with the help of the new access road.

2. Literature Studies

2.1 AutoCAD® Civil 3D

AutoCAD® Civil 3D is a product developed by AutoDesk. The product was developed by a multinational company located in California and founded by John Walker and Drake. AutoCAD® Civil 3D includes dynamic, applicable, and innovative software as one of the devices used to design buildings, highways, and other industrial products. AutoCAD® Civil 3D is an application used by a professional in the field of Civil Engineering to design and plan a construction project and road engineering, including port construction and dams. To design Civil Engineering work easily, AutoCAD® Civil 3D is already widely used as a documentation tool developed by Autodesk in the current era of globalization. AutoCAD® Civil 3D is used to analyze, model, and design various types of civil infrastructure projects, including highways (Raji, Zava, Jirgba, & Osunkunle, 2017) . In geometric planning, AutoCAD Civil 3D® has a role that presents road design procedures in detail so that the results are better than manual geometric design (Chakole & Wadhai, 2022).

The use of AutoCAD® Civil 3D can save cost and planning time. Flyover planning in India using AutoCAD® Civil 3D software becomes more effective, efficient, accurate, and cost-effective than manual planning (Pandey, Atul, & Bajpai, 2019) . In addition, this software has the main parameters as a road design guideline, one of which is visibility. By using AutoCAD® Civil 3D in the journal "Visibility Analysis for Autonomous Vehicles in Civil 3D," a road model has been designed to check the visibility

that can be obtained from sensors such as LIDAR, cameras, and also radar at several radius points® (Khaska & Miletics, 2021).

2.2 Road

A highway is an infrastructure consisting of buildings and complementary designs for maintaining traffic above and below ground and water level (Setyawan, Setiawan, & Prabowo, 2021). Highways have an essential role as a means of transportation in various community activities in urban and rural areas. In addition, highways have an essential impact as infrastructure for the movement of people and goods. In recent years, green highways have been built in China to control the negative impact of highway construction on the environment (Dong, Zhaoming, Zhiqiang, & Minmin, 2019).

Based on the designation of roads, roads are designated as public roads and particular roads. Public roads are designated for public traffic, including JBH and toll roads, managed by the government. Particular Roads are roads that are not intended for public traffic, only intended for the benefit of and for direct benefit to specific individuals, community groups, business entities, or agencies. Non-governmental organizations carry out the implementation of particular roads according to the arrangements. In contrast, related guidance, supervision, business, and operation can be carried out by government agencies, private or private individuals, or specific community groups. Unique road ownership can be owned by individuals, certain community groups, business entities, and or certain agencies, including government agencies.

2.3 Road Geometric Planning

Geometric roads are buildings of road bodies above ground level vertically and horizontally, assuming the ground level is uneven. Geometric planning is essential in designing new alignments on the road following current trends (Sukalkar & Pawar, 2022) . Road geometrics also has an essential role as a factor causing accidents. The leading causes of death and injury in the United States are caused by motor vehicle accidents, resulting in enormous socioeconomic losses (Milton & Mannering, 1998).

According to Road Safety Audit research in the journal (Sahu, Mishra, Barik, & Sahu, 2022), road accidents and deaths are a worldwide phenomenon, and the main factor responsible is the current mixed traffic on India's multilane highways. This mixed traffic can occur due to interactions between different types of vehicles. The effect of traffic on improper lane changes is identified as a significant source of road congestion and accidents (Liu, Guo, Taplin, & Wang, 2017). Therefore, in building roads, it is necessary to have proper geometric planning so that the roads built provide comfort and safety for users.

A safe road is a road that is planned and designed to meet standards, and this is highly trusted by many road designers   (Rizaldi, Dixit, Pande, & Junirman, 2017). Standards that must be present in geometric road planning must include design criteria, general provisions, and geometric procedures of roads. These design criteria consist of horizontal alignment ends, vertical alignments, and cross-sectional sections of roads on highways, freeways, and roads that serve traffic within or outside the city.

2.4 Alignment

The horizontal alignment of a road is generally a series of straight and curved sections of the road in the shape of a circular arc, which is connected by a transitional arch or without a transitional arch. Linear segments connected by curves are part of the horizontal alignment of the road (Sushma, Roy, Prasad, & Maji, 2020). In the implementation in the field, an engineer, when designing the first designed highway alignment, a horizontal alignment, then a vertical alignment according to the conditions of the horizontal alignment   (Maji, 2017) . Horizontal alignment should be optimally designed as a better connectivity provider between cities.

Horizontal alignment has become one of the materials for evaluating the safety of geometric feature design based on actual driver behavior (Xu, Lin, & Shao, 2017). According to research on road alignment in journals (Zhou, Huang, Jiang, Dong, & Yang, 2021) , highway alignment is defined by AASHTO as a particular set of parametric curves having distinctive road geometric characteristics, such as superelevation, gradient, and curvature. The journal also explains the 3D highway model as a high-resolution digital representation of the highway. In current studies, 3D modeling on highway alignment promotes various transport practices as an essential part.

Vertical alignment is the intersection of the surface plane of a road pavement that is influenced by several considerations, such as the base soil's condition, the road's function, the flood water level, and possible slump. A vertical alignment is a longitudinal profile along the road's middle line, formed from a series of segments with longitudinal slumps and vertical arches. In planning the vertical alignment road, one must pay attention to the elevation of the puddles in the surrounding places so that when it rains, there will be no inundation that will endanger the safety of road users. The design of vertical alignment influences the volume of earthworks to be carried out. This design will find out what soil to dig up and what volume to stockpile. The vertical alignment design on the highway involves the specifications of the vertical slope and the length at which the slope occurs (Tang, Chen, Cheng, Ghahari, & Labi, 2018).

3. Methodology

Data is one of the main strengths in compiling scientific research and modeling   (Rifai, Hadiwardoyo, Correia, Pereira, & Cortez, 2015) . The systematic scientific research process must begin with identifying the right problem   (Rifai, Hadiwardoyo, Correia, & Pereira, 2016). Geometric road planning in this study using qualitative methods. The qualitative method is a method of approaching research naturally and interpretively (Mulyadi, 2011). The geometric planning of the road that became the research of this journal is located on Jalan Kertawangunan - Kadugede, Kuningan Regency, with a road plan length of 9.3 km as a further alternative to the new outer ring road of Kuningan Regency.
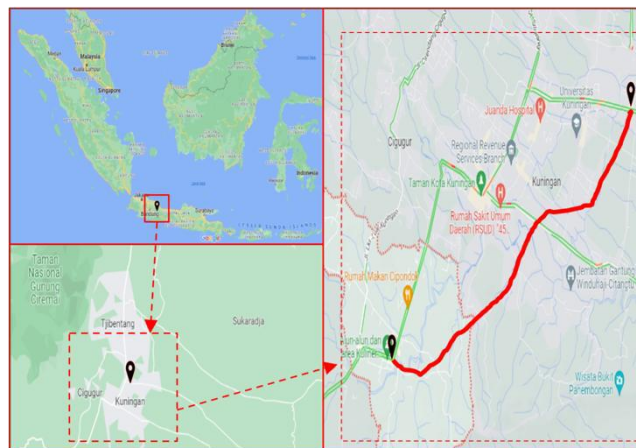

Figure 1 Map of the location of the case study of Jalan Kertawangunan-Kadugede

The data used in the geometric planning of this road is secondary data obtained from related agencies/ organizations and takes some data from previous journals. The secondary data includes the Kuningan Regency Road Network Map, Road planning location map (Jalan Kertawangunan – Kadugede, with initial coordinate points X: Y= 226418: 9228499 and ending at coordinate points X: Y = 218779: 9224982), Contour data of Kertawangunan – Kadugede area obtained from Google Earth and processed using Global Mapper software Version 18. After obtaining secondary data, perform

geometric road planning using AutoCAD® Civil 3D to plan horizontal and vertical alignment, which is then compared with manual calculations previously studied in the journal (Yuono & Sugiyanto, 2020).

4. Result and Discussion

Geometric planning of the Kertawangunan – Kadugede Road section using AutoCAD® Civil 3D is as follows, with planning equipped with standard steps used.
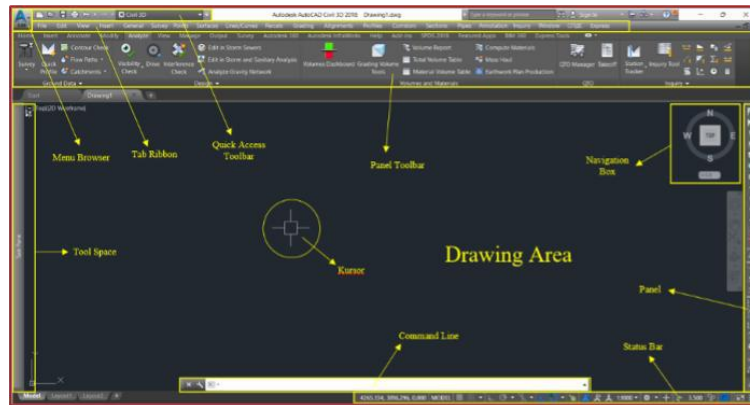

Figure 2. Display of the work area on AutoCAD® Civil 3D

4.1 Trace

The road planning in this study used a planned speed of 60 km/h, with a road width of 3.5m and a value of Rc= 130 m. Road traffic planning is carried out using AutoCAD® Civil 3D based on the contour data obtained. Road traffic is obtained as in figure 3, divided into four points of interest starting at STA 0 +
000 and ending at STA 8 + 838.

Figure 3. Planning of trase

4.2 Alignment Horizontal and Vertical

After the Trace path is created, perform calculation analysis as data to create horizontal alignment using AutoCAD® Civil 3D one of which calculates the minimum arch (Rmin) as described in

formula (1). Calculate the minimum arc (Rmin), and it requires a plan speed (Vr) of 60 km/h, a maximum superelevation slope (e-maks) of 0.08, and a transverse friction coefficient (f) of 0.153.

Formula (1):

$$R_{min} = \frac{Vr^2}{127(e_{maks} + f)} = 121,67 \ m \ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(1)$$

$$R_c = 130 \ m \ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(2)$$

After calculating the minimum arch (Rmin), it further calculates the switching arch (Ls) based on the maximum travel time on the switching arch as outlined in formula (2). The braking reflection value (T) is taken at 3 seconds. Formula (2):

$$L_s = \frac{Vr^2}{3.6} . T = 50 \ m \ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots(3)$$

From the calculation of the intermediate arch obtained, the value of Ls by 50 m. After the analysis, the calculation results of the four points of interest (PI) for planning the road traffic are obtained as described in table 1.

Table 1 Horizontal alignment calculation results

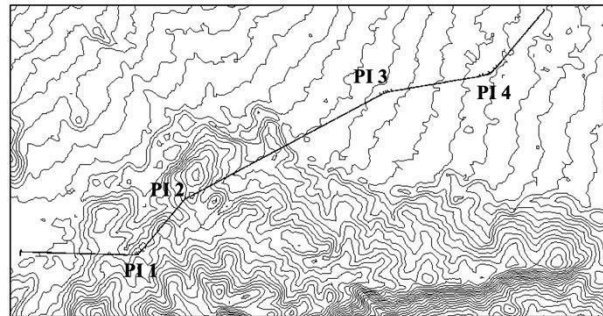| Bends		STA	Δ	Vr	Rc used	Rc	Ls	e	Control	Arch Type		
			(o)	(km/hour)	(m)	(m)	(m)	(m)	Ltot<2Ts	FC	SCS	SS
LEFT	1	1+705	51	60	130	130	50	0.08	OK	NOT OK	OK	NOT OK
LEFT	2	2+760	22	60	130	130	50	0.08	OK	NOT OK	NOT OK	OK
RIGHT	3	6+077	18	60	358	130	50	0.08	OK	NOT OK	OK	NOT OK
RIGHT	4	7+680	40	60	358	130	50	0.08	OK	NOT OK	OK	NOT OK

Figure 4 Horizontal alignment design planning

The following is the horizontal alignment design shown in figure 4, resulting from planning using AutoCAD® Civil 3D. Planning vertical alignment using AutoCAD Civil 3D®, a vertical alignment design or long pieces will be obtained as in figure 5
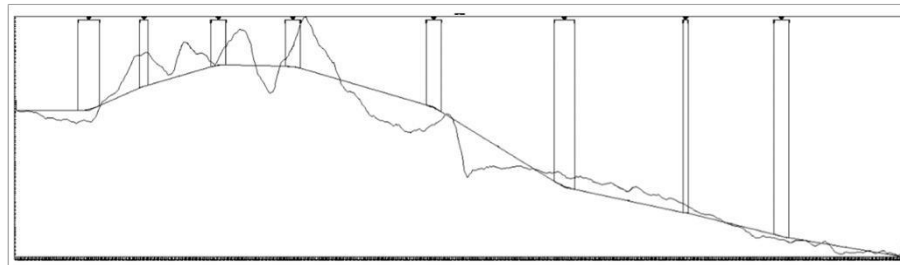

Figure 5. Horizontal alignment design planning

4.3 Assembly

Assembly needs to be planned before creating corridors. Plan the assembly by creating the assembly in the toolbar area, then adjusting the style based on planning; after clicking OK, the assembly sign will appear, then rectangle the assembly mark to make it easier when looking for it. The following are the results of the assembly planning shown in figure 6.
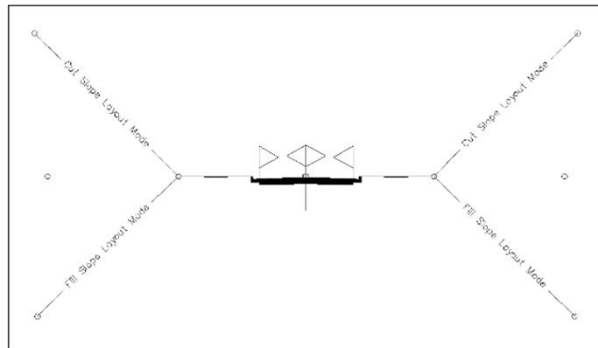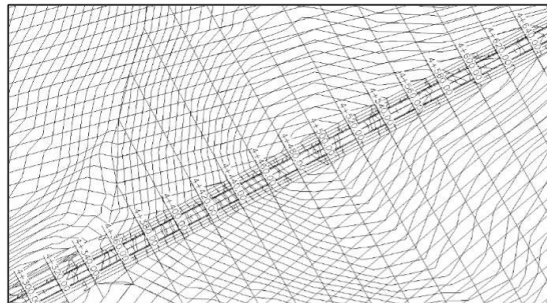

Figure 6. Assembly design planning

4.4 Corridor

After planning the next assembly plans the corridor by creating a corridor. The purpose of planning the corridor is to find out the area of stockpiles and excavations for the placement of the road body to be planned. The following is an example of the planned corridor shown in figure 7.

4.5 Cut and Fill

In the final stage of road planning, using AutoCAD® Civil 3D, that is, it raises the volume of cuts and fills. The Quantity Surveyor Engineer can use this volume to calculate the costs required for land grading work because land grading work will cost a substantial amount. From the planning in this study, the volume of excavations and heaps was obtained, shown in figure 7 screen capture of the volume of cut and filled heaps from AutoCAD Civil 3D®

Total Volume Table						
Station	Fill Area	Cut Area	Fill Volume	Cut Volume	Cumulative Fill Vol	Cumulative Cut Vol
8+760.00	23.21	0.50	490.25	10.09	2453701.20	1935670.51
8+780.00	19.19	1.20	423.96	16.97	2454125.16	1935687.48
8+800.00	30.75	0.26	499.39	14.65	2454624.55	1935702.13
8+820.00	27.93	0.00	586.78	2.64	2455211.33	1935704.77
8+837.88	3.94	0.99	284.95	8.89	2455496.28	1935713.66

Figure 7. Planning corridor design

5. Conclusion

Geometric design of Kertawangunan – Kadugede Road section using AutoCAD® Civil 3D is more efficient than manual planning. This planning can also generate the necessary data quickly and precisely. There are four points of interest in road traffic planning with different curves. The deliberate speed (Vr) used was 60 km/h, the maximum superelevation slope ($e-ma$ks) was 0.08, and the transverse friction coefficient (f) was 0.153. The average value of the excavation volume obtained from this planning is about 1,900,000 m.

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