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GEOMETRIC DESIGN OF ROAD AT SERI KEMBANGAN, SELANGOR USING AUTODESK CIVIL 3D

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ABSTRACT
Road planning and design involve tasks of understanding different criteria in road geometry. The tasks involved in road design are extracting the heights from the detail and topography drawing, generating the surface to show the contour, designing the horizontal alignment, generating profile along the horizontal alignment, designing the vertical alignment, generating cross sections, creating an assembly, creating corridors and generate the earthwork volume of the design. This study presents a complete geometrical road design of a typical urban road using Autodesk Civil 3D. The results obtained show that Autodesk Civil 3D is applicable in road design such as generating horizontal and vertical alignments, computing the earthwork volume along the alignment and generating 3D views of the alignment.

Keywords:
Road design, Autodesk Civil 3D, horizontal alignment, vertical alignment, earthwork volume

INTRODUCTION

The geometrical design of the road consists of horizontal alignment and vertical alignment. Safety, operational quality, and project costs are important factors in the design of horizontal and vertical alignments. The horizontal alignment consists of straight lines and curves. The types of curves used in horizontal alignment are circular curves, spiral curves, composite curves and reversed curves (Uren & Price, 2018; Manoj et al., 2019; Mojtaba, et al., 2015; Pangesti, et al., 2022; Farid, et al., 2022).

Vertical alignment consists of vertical curves that provide a transition between two slopes at the road. These curves are parabolic and assigned chainages based on the horizontal axis (Khaja, et al., 2017; Raji, et al., 2017; Zulfa, et al., 2022; Ranjit & Yong, 2024).

The earthwork in a road design is to estimate the volume of cut and fill of the soil along the alignment. Ideally, the amount of cut and fill of the soil should be balanced where the amount of cut is equal to the amount of fill (Uren &. Price, 2018; Chakole & Wadhai, 2022; Rifai, et al., 2024; Ranjit & Loh, 2023).

This study will be using Autodesk Civil 3D in designing the horizontal alignment, designing the vertical alignment and estimating the volume of cut and fill along the designed alignment. The objectives of this study are as follows:-

i. To design horizontal and vertical alignment by using Autodesk Civil 3D at Seri Kembangan, Selangor.
ii. To estimate the earthwork volume along the alignment.

METHODOLOGY

The road is designed on a detail and topography drawing of the area of the proposed road. Basically, the procedure of road design consists of determining the design criteria, designing the horizontal alignment, designing the vertical alignment and estimating the earthwork volume.

Design criteria

The design criteria of the road are based on Public Works Department Malaysia (2015) as below:-

i. The design speed is 50 km/h.
ii. The design standard is U2.
iii. The minimum radius of the curve is 90 m.
iv. The minimum length of the spiral curve is 33 m.
v. The marginal strip width is 0.25 m.
vi. The minimum k value for the crest curve is 10.
vii. The minimum k value for the sag curve is 13.
viii. The maximum gradient is 7%.
ix. The lane width is 3.0 m.

Designing the Horizontal Alignment

The survey data comprising points with easting, northing and elevations are imported into Autodesk Civil 3D to generate the surface of the ground. The horizontal alignment is designed on the generated surface based on the design criteria. The profile is then generated along the horizontal alignment.

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Designing the Vertical Alignment

The vertical alignment is designed on the generated profile based on the design criteria. The gradients of the vertical alignment should be less than six percent.

Generating Cross Sections, Creating an Assembly and Creating Corridors

The cross sections are generated along the horizontal alignment at 20 m chainage intervals. The assembly of the road is created based on the U2 design standard. The corridors are then created along the alignment. The assembly of the road is included in the cross sections for earthwork volume estimation.

Earthwork Estimation

The earthwork volume table is generated along the designed alignment at 20 m chainage intervals. The vertical alignment intersection point can be edited to obtain a balanced cut and fill volume for the alignment.

RESULTS

The road is designed based on the U2 design standard as shown in Figure 1. The road carriageway width is 3.0 m, shoulder is 2.0 m, landscape corridor is 3.75 m, drain reserve is 1.5 m and service reserve 3.0 m. The total width of the road is 30 m.

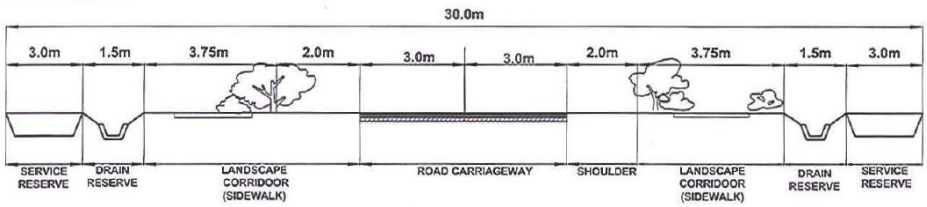

Figure 1: U2 Design Standard (Public Works Department Malaysia, 2015)

The existing ground surface is generated in Autodesk Civil 3D using the coordinates and elevations extracted from the detail and topography drawing of the study area at Seri Kembangan, Selangor. Figure 2 depicts the surface created from the detail and topography drawing.

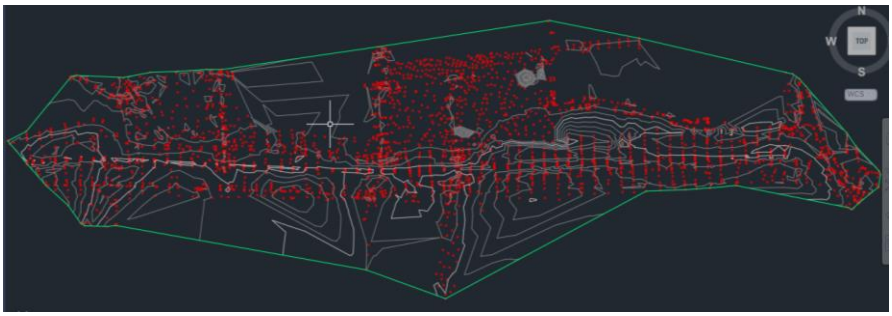

Figure 2: Created Surface of the Study Area

The horizontal alignment is then designed on the created surface (Figure 2) based on the determined design criteria. The length of the designed horizontal alignment is 650.22 m. There are nine horizontal curves along the horizontal alignment which have a radius larger than the minimum radius of 90 m. Figure 3 shows the horizontal alignment of the proposed road.

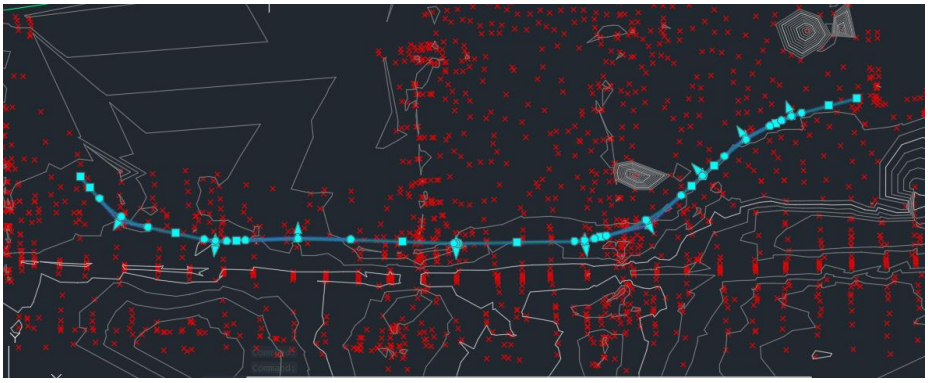

Figure 3: Horizontal Alignment of the Proposed Road

The profile is then generated along the horizontal alignment. The vertical alignment is designed on the generated profile. The gradient of the designed vertical alignment for this study is less than the maximum gradient of seven percent. There are five crest curves and four sag curves along the vertical alignment which have K values larger than 10 and 13 respectively. Figure 4 depicts the profile and the vertical alignment along the proposed road.

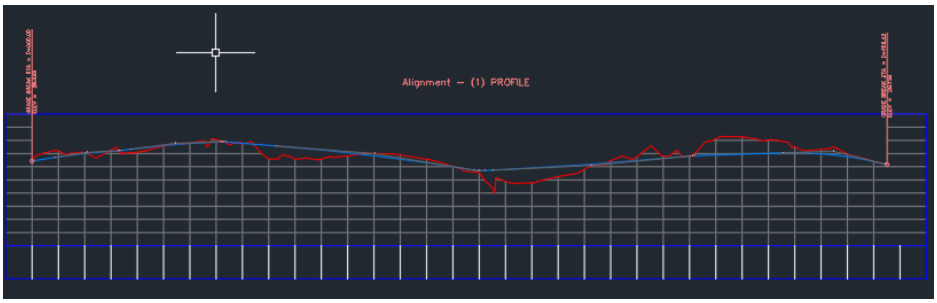

Figure 4: Profile and Vertical Alignment of the Proposed Road

The cross sections are then generated along the designed horizontal alignment at every 20 m chainage internal with offset distance of 50 m. There are 33 cross-sections generated along the designed road. Figure 5 shows the cross section generated at chainage 20 m.

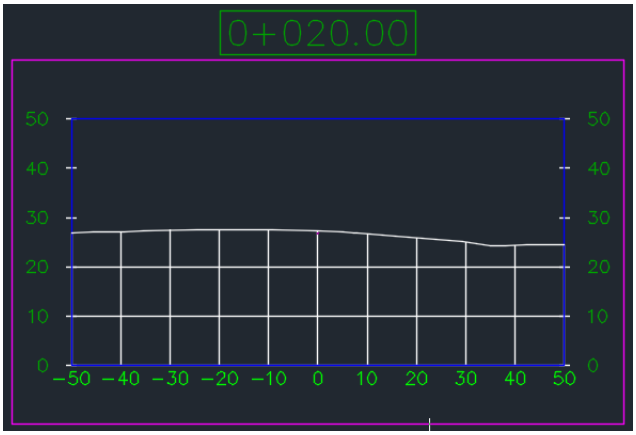

Figure 5: Cross Section at Chainage 20 m

The assembly is then created according to the U2 design standard (Figure 1). The assembly consists of the road carriageway, shoulder, landscape corridor, drain reserve, service reserve and daylight. Figure 6 depicts the assembly of the proposed road based on the U2 design standard.

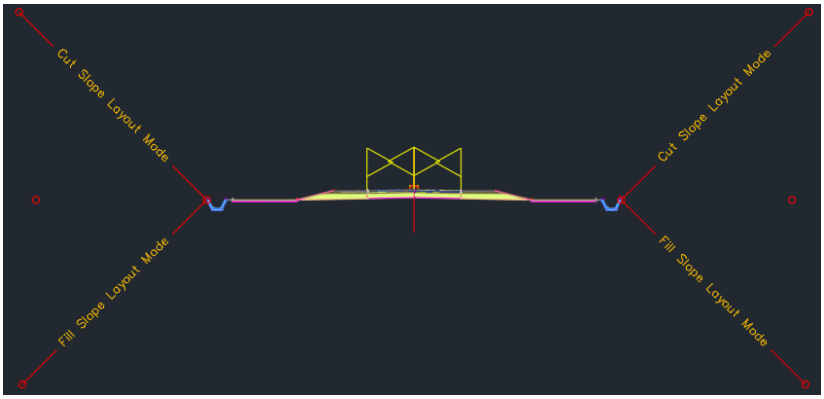

Figure 6: Assembly of the Road Design

The assembly is applied to the designed vertical alignment to create the corridor. The corridor can be converted to solid in order to view the proposed road in conceptual view. The created corridor of the proposed road is shown in Figure 7. The assembly will then be generated in all the cross sections. Figure 8 shows the generated assembly in the cross section at chainage 20 m.

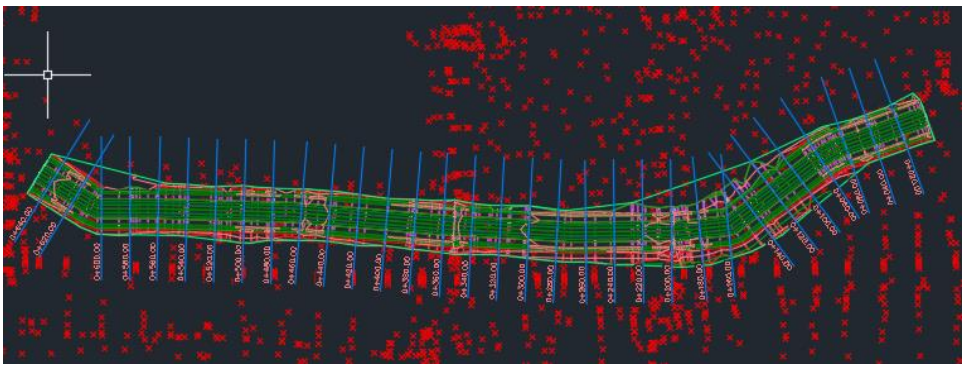

Figure 7: Corridor of the Proposed Road

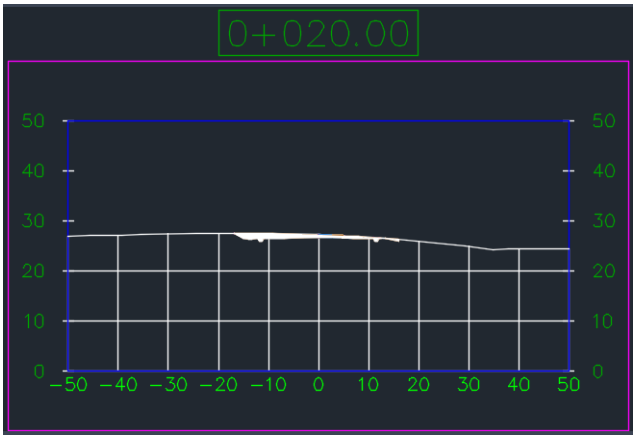

Figure 8: Generated Assembly in Cross Section at Chainage 20 m

The earthwork volume can now be estimated along the proposed road. The total volume table can be generated for the proposed road. The total volume table shows the area of fill, area of cut, volume of fill, volume of cut, cumulative fill volume and cumulative cut volume for every chainage interval of 20 m along the proposed road. The total cumulative fill volume and total cumulative cut volume for the proposed road are 2513.40 m^3 and 17152.25 m^3 respectively. There is an excess of cumulative cut volume of 14638.85 m^3. Table 1 shows the earthwork volume of the proposed road.

Table 1: Earthwork Volume of the Proposed Road.

Total Volume Table						
Station	Fill Area	Cut Area	Fill Volume	Cut Volume	Cumulative Fill Vol	Cumulative Cut Vol
0+020.00	0.02	18.61	0.00	0.00	0.00	0.00
0+040.00	1.03	13.78	10.38	325.75	10.38	325.75
0+060.00	2.15	15.49	31.80	292.64	42.17	618.39
0+080.00	9.75	25.29	88.89	387.26	131.07	1005.65
0+100.00	0.64	22.57	97.28	472.70	228.35	1478.35
0+120.00	4.55	40.66	51.93	632.28	280.27	2110.63
0+140.00	15.36	40.67	199.11	813.29	479.38	2923.92
0+160.00	26.77	41.60	268.88	1075.14	748.26	3999.07
0+180.00	13.11	39.18	398.85	807.85	1147.12	4806.92
0+200.00	35.77	11.45	493.31	515.42	1640.42	5322.34
0+220.00	3.87	13.00	396.38	244.47	2036.81	5566.80
0+240.00	0.43	20.88	42.97	338.79	2079.78	5905.59
0+260.00	0.34	38.62	7.72	595.04	2087.50	6500.64
0+280.00	0.69	38.46	9.90	794.93	2097.40	7295.57
0+300.00	5.13	22.66	58.14	611.19	2155.54	7906.76
0+320.00	0.21	18.75	53.38	414.06	2208.92	8320.82
0+340.00	0.58	25.58	7.95	443.30	2216.87	8764.12
0+360.00	0.22	28.23	8.07	538.16	2224.94	9302.28
0+380.00	0.00	25.81	2.30	543.02	2227.25	9845.30
0+400.00	0.01	21.47	0.06	472.80	2227.30	10318.10
0+420.00	0.00	24.49	0.06	459.66	2227.36	10777.76
0+440.00	0.02	30.03	0.16	545.19	2227.52	11322.95
0+460.00	0.56	23.49	5.75	535.12	2233.27	11858.07
0+480.00	0.09	34.52	6.17	573.35	2239.44	12431.41
0+500.00	0.00	61.24	0.89	957.56	2240.33	13388.97
0+520.00	0.28	23.51	2.82	847.47	2243.15	14236.44
0+540.00	0.09	32.34	3.70	558.43	2246.85	14794.86
0+560.00	0.89	20.72	9.73	530.59	2256.58	15325.46
0+580.00	11.02	23.78	121.73	442.19	2378.30	15767.65
0+600.00	1.17	22.40	121.84	461.76	2500.15	16229.41
0+620.00	0.21	24.09	4.42	492.42	2504.57	16721.83
0+640.00	0.67	18.95	8.83	430.41	2513.40	17152.25

The proposed road which has been converted into a solid can be viewed in 3D. The perspective view shows the assembly (Figure 6) according to the U2 design standard (Figure 1). Figure 9 depicts the perspective view of the proposed road using Autodesk Civil 3D.

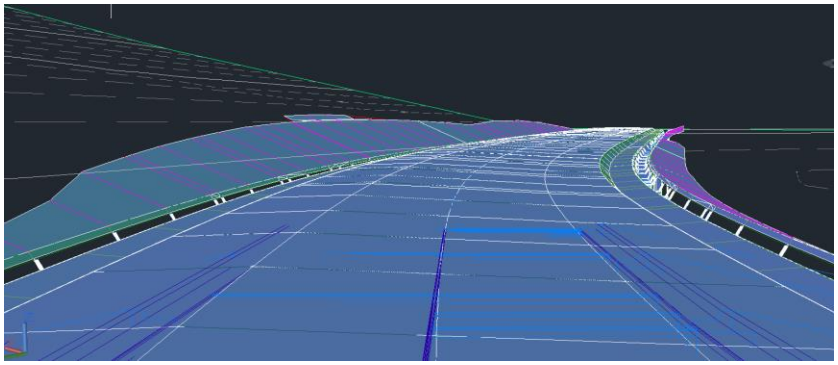

Figure 9: Perspective View of the Proposed Road.

CONCLUSION

The results obtained in this study show that Autodesk Civil 3D is applicable in geometrical design of road. The road is designed according to U2 design standard with a design speed of 50 km/h. The results generated by Autodesk Civil 3D are reliable and acceptable. Autodesk Civil 3D is able to generate the surface for the contour, design the horizontal alignment, generate the profile along the horizontal alignment, design the vertical alignment, generate the cross sections, creating assembly, creating corridors, generate the earthwork volume of the design and generating 3D views of the alignment.

It is recommended that future studies could incorporate traffic flow simulations and safety analysis into the geometric design of road. Software like VISSIM or SIDRA could be used alongside Autodesk Civil 3D to assess the design's performance under various traffic conditions. A comparative study of Autodesk Civil 3D with other design software like Bentley OpenRoads or Autodesk InfraWorks could provide insights into the software specific advantages and limitations in road design projects.

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