

A Study to the Geometric Design of Road Project Using Civil 3D

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Abstract— India is a country whose population is growing rapidly, indicating that traffic is also increases. The development of rural areas also increases its means furthering of transportation facilities are also developed. The geometric design manages the dimensions and layout of visible features of the road such as alignment, sight distance, cross-section and intersections. When geometric design performed manually, it is time-consuming and highly susceptible to very costly errors. In the present time, various software are available in market such as Bentley MX Road, HEADS, AutoCAD Civil 3D, etc are used to design the geometry of road. Current patterns are adapted to the utilization of computer programs for roadway geometry design. This software provides clarity, save times and effort to a user. The purpose of this paper is on the complete study to the geometric design of road project using Civil 3D Software. Civil 3D is a software for engineering it is used for the design, plan and manage the civil engineering works. This software is generally used by experts and civil engineers. The objective of this project is to design the road alignment in a less time with high accuracy using Civil 3D. The survey data is must be necessary for road creation. By utilizing a total station study can be completed quickly and can shorten the time. Total station is utilized for import the points in Civil 3D which is as x, y, z coordinates that are easting, northing, and elevation. These coordinates of the ground data is very useful to generate the surface, design the alignment and other geometric features.

Keywords— Geometric Design, Total Station, Civil 3D, Design criteria, Horizontal and Vertical alignment.

INTRODUCTION

In our modern age, transportation is vital nearly for all the activities in our daily lives. There are several different modes, namely highway, rail, air and water transportation classified according to the vehicle and the movement type. Today, still the major part of the transportation worldwide is handled by highways. For efficient highway systems, land use planning and road network planning are critical concepts and they should be handled together. Different land uses generate distinct requirements and distinct network design strategies are to be established for distinct land uses in order to have sustainable transport by minimizing congestion and improving traffic safety. Therefore proper zoning plans and road network should be prepared to distribute the land use patterns, such as residential areas, shopping centers, trade areas, industrial facilities and others.

The most significant aspect of highway engineering is the geometric design of highways. It deals with the dimension and design of the road's visible characteristics. The significance of road geometric design is to set the driver and car prerequisites, such as effectiveness, safety, etc. The features usually regarded are the cross section, sight distance, intersection, vertical alignment and horizontal alignment. Proper geometric design will assist to reduce accidents and their severity. The goal of geometric design is therefore to provide optimum effectiveness in traffic operation and maximum safety at reasonable price.

Civil 3D software is developed by Autodesk. Civil 3D is a software for engineering it is used for the design, plan and manage the civil engineering works including roads, highways, water, land development and rail. This software is usually used by civil engineers and other experts. Civil 3D is generally used to minimize the time of design and also evaluate multiple situations. It is also helps you to complete task in quickly, brilliant and all the more definitely. It is used to produce 3D models for projects on transportation, water or land projects while maintain relationships to source data, for example, contours, corridors and grading. Civil 3D is well-established in the civil engineering society and commonly used in various big and small construction projects.

DESIGN METHODOLOGY

A. Data Collection

Existing ground surface data are needed to design the geometry of roads. The information is gathered from the survey company. Survey data includes easting, northing, and elevations.

B. Design Criteria

The following design criteria based on the Geometric design standards manual (IRC: SP: 20 – 2002) were assigned to the horizontal geometry of the center line and also to the profile and cross section of the roadway.

- I. Design speed = 65 km/h
- II. Superelevation rate = max 7%
- III. Coefficient of Friction = 0.15
- IV. Minimum K for sag curves = 33
- V. Minimum K for crest curves = 17
- VI. Roadway width = 7.5 m
- VII. Carriageway width = 3.75 m
- VIII. Shoulder width = 1.875 m

C. Design Procedure

- Create Surface.
- Import point files (comprising northing, elevation and easting and saved in Excel format) into the AutoCAD Civil 3D environment.
- Create alignment with the alignment creation tool.
- Calculate superelevation from the given alignment.
- Apply the IRC design criteria in this project.
- Create surface profile.
- Create grade line and vertical curves using the profile creation tools.
- Create the Assembly. The assembly is constructed by adding individual subassembly.
- Create a corridor, a 3D model representation that consists of a combination of vertical, horizontal and cross-sectional elements. Corridors also used to calculate earthwork quantity, perform sight distance analysis and find data for construction purposes.
- Generate volume table report.
- Generate perspective view.

D. Horizontal Alignment Design

The horizontal alignment of a road describes its orientation and location in plan view. It consists of three geometric components, including tangents (straight sections), circular curves and transition spirals between tangents and curves. Proper design of alignment increases the highway capacities and also improves the design speed performance.

In Excel format, survey data comprising easting, northing, and elevations was imported into the Civil 3D. This produced the existing surface of the ground automatically. The alignment creation tool was used to draw the road alignment after specifying the design requirements to be applied on the alignment. Using the 'Geometry Editor' tool, the spiral and circular curves were drawn and obtained alignment curve report.

The minimum curve radius was calculated in equation (1) based on the superelevation, design speed and coefficient of friction specified in the design criteria

$$R = \frac{v^2}{127(e+f)} \quad (1)$$

Where R = minimum radius of horizontal curve in meters.

v = minimum design speed, Km/h.

e = superelevation.

f = coefficient of friction.

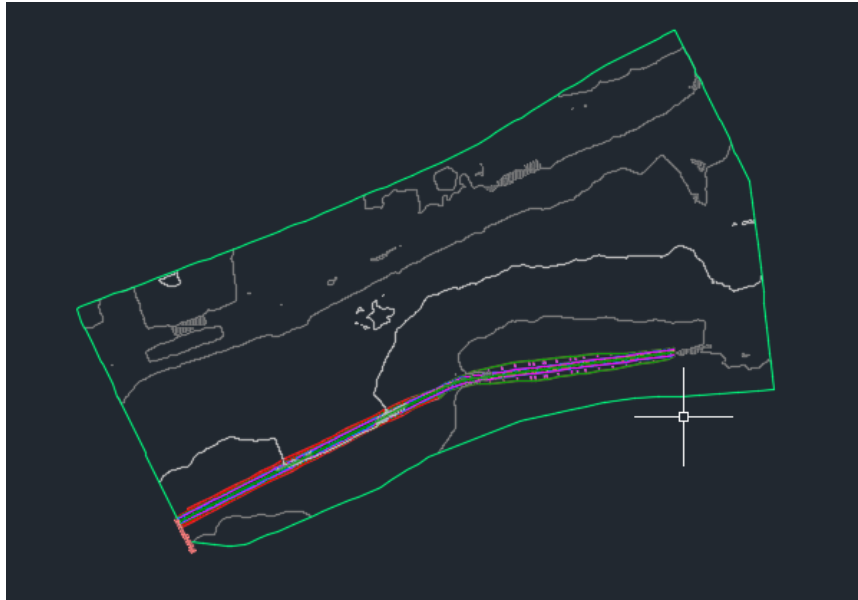


Fig.1: Horizontal Alignment generated by AutoCAD Civil 3D

E. Vertical Alignment Design

Vertical alignment is defined as the longitudinal section of the road. It consists of vertical curves and gradients, it also influence the comfort in vehicles movement at high speeds, sight distance and stopping distance. When the horizontal alignment is fixed, vertical alignment can then be created. To do this, first the horizontal alignment ground profile is developed and then the vertical alignment is produced on the perspective of the profile. Profile geometry was chosen by applying minimum K design standards for vertical curves of sag and crest that meet the basic prerequisites for stopping sight distance, accessibility and appearance criteria.

Vertical curve lengths were also calculated manually using the formula (2)

$$L=KA \quad (2)$$

Where K= length required for a 1% change of grade.

L = vertical curve length.

A = change of grade in %.

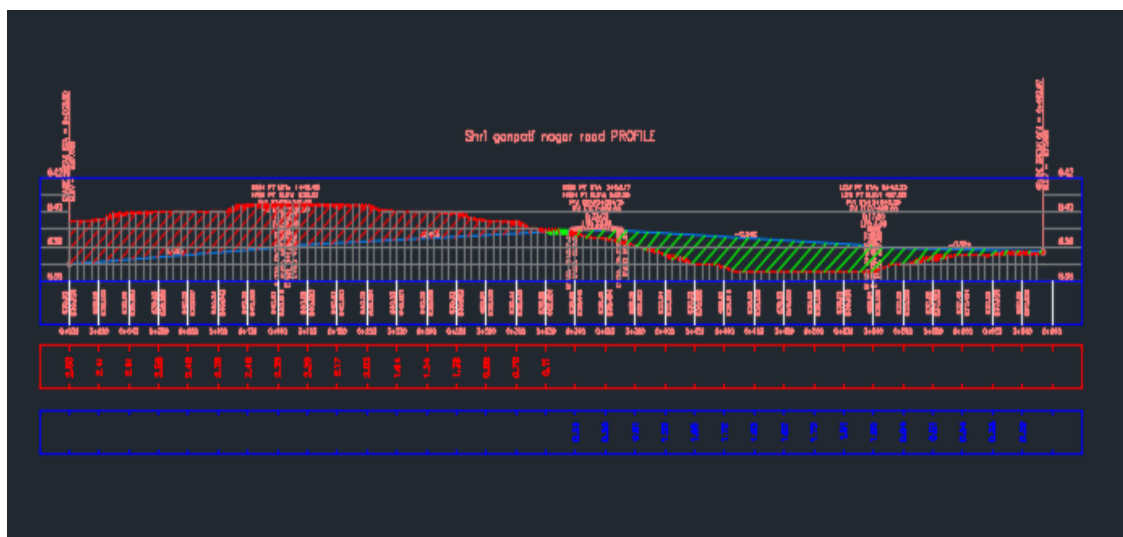


Fig. 2: Vertical alignment generated by AutoCAD Civil 3D

F. Decision of Superelevation

Superelevation is the transverse slope offered to counteract the centrifugal force effect and decrease the vehicle tendency to overturn and skid laterally outward by raising the pavement's outer edge toward the inner edge. Superelevation is described after the horizontal curve radius is determined. Superelevation is applied to the alignment segment via the command "Edit Superelevation."

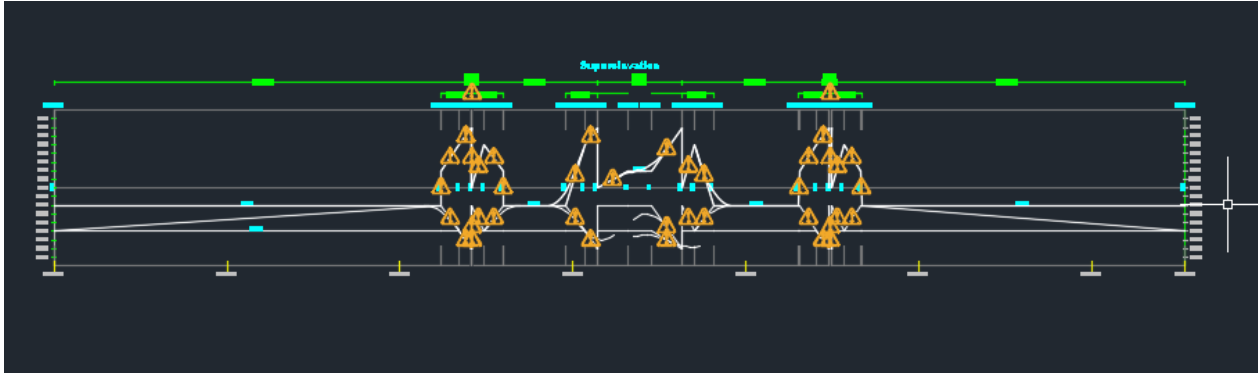


Fig.3: Superelevation View

G. Assemblies

Assembly is used for defining of platform in Civil 3D Software. 'Subassembly' command is a part of platform, Assembly that indicates such as shoulder, median, lane for creating typical cross section of road. Right and left parts are added center of platform with subassemblies. There are two probabilities for creating assembly as using existed subassemblies or creating subassemblies by oneself.

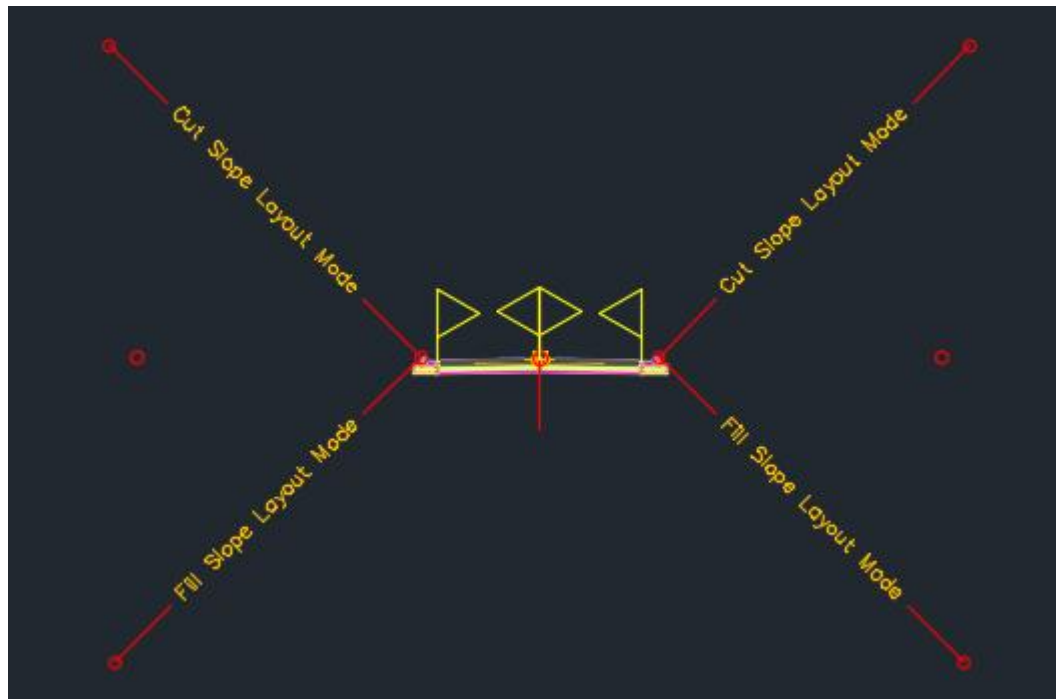


Fig. 4: Assembly

H. Cut and Fill Calculation

A feature within AutoCAD Civil 3D allows to calculate the earthwork required on a project within a few seconds. After generating the ground surface and the suggested completed grade surface, AutoCAD Civil 3D makes it simple to generate a comparison surface that highlights the difference in elevation and calculates the volume between the two surfaces. The earthwork calculation process begins by clicking 'Surfaces' on the Modify tab.

Table 1: Earthwork Volume Report

Station	Cut Area (Sq.m.)	Cut Volume (Cu.m.)	Reusable Volume (Cu.m.)	Fill Area (Sq.m.)	Fill Volume (Cu.m.)	Cum. Cut Vol. (Cu.m.)	Cum. Reusable Vol. (Cu.m.)	Cum. Fill Vol. (Cu.m.)	Cum. Net Vol. (Cu.m.)
0+000.000	47.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0+020.000	47.87	957.46	957.46	0.00	0.00	957.46	957.46	0.00	957.46
0+040.000	48.67	965.39	965.39	0.00	0.00	1922.85	1922.85	0.00	1922.85
0+060.000	50.28	989.54	989.54	0.00	0.00	2912.40	2912.40	0.00	2912.40
0+080.000	49.10	993.86	993.86	0.00	0.00	3906.26	3906.26	0.00	3906.26
0+100.000	46.49	955.93	955.93	0.00	0.00	4862.18	4862.18	0.00	4862.18
0+120.000	48.07	945.60	945.60	0.00	0.00	5807.78	5807.78	0.00	5807.78
0+140.000	45.32	933.87	933.87	0.00	0.00	6741.65	6741.65	0.00	6741.65
0+160.000	43.64	889.60	889.60	0.00	0.00	7631.25	7631.25	0.00	7631.25
0+180.000	40.42	840.62	840.62	0.00	0.00	8471.87	8471.87	0.00	8471.87
0+200.000	38.25	786.73	786.73	0.00	0.00	9258.60	9258.60	0.00	9258.60
0+220.000	32.88	711.35	711.35	0.00	0.00	9969.95	9969.95	0.00	9969.95
0+240.000	29.84	627.21	627.21	0.00	0.00	10597.17	10597.17	0.00	10597.17
0+260.000	24.39	542.28	542.28	0.00	0.00	11139.44	11139.44	0.00	11139.44
0+280.000	17.17	415.52	415.52	0.00	0.00	11554.96	11554.96	0.00	11554.96
0+300.000	12.65	298.16	298.16	0.00	0.00	11853.12	11853.12	0.00	11853.12
0+320.000	6.13	187.86	187.86	0.61	6.00	12040.99	12040.99	6.00	12034.99
0+340.000	2.17	83.26	83.26	0.46	10.21	12124.25	12124.25	16.21	12108.04
0+360.000	0.10	22.83	22.83	2.26	26.57	12147.08	12147.08	42.78	12104.30
0+380.000	0.00	0.99	0.99	6.55	87.94	12148.07	12148.07	130.72	12017.35
0+400.000	0.00	0.00	0.00	13.72	202.72	12148.08	12148.08	333.44	11814.64

I. Perspective view using Drive command

Select Drive command in Analyze menu and select your alignment, Feature line. Adjust the parameters and select play/pause button to drive through the corridor.

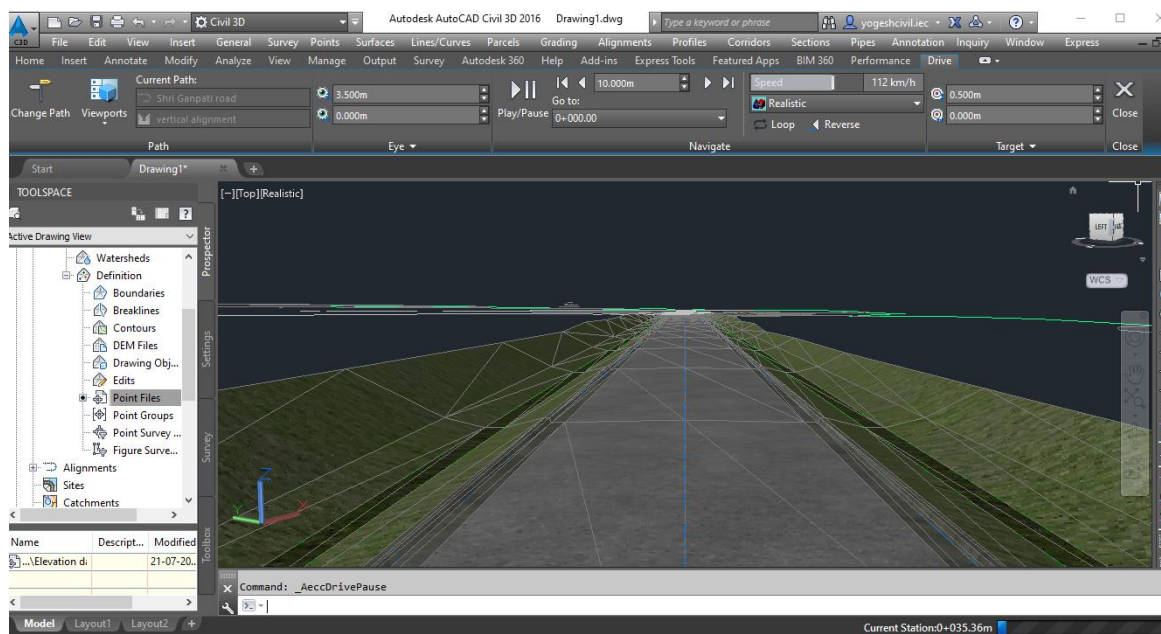


Fig.5: Perspective view

CONCLUSION

1. The geometry of the road was intended in accordance with the IRC and also regarded all safety measures.
2. Horizontal alignment was created. Vertical profile was drafted. Working cross section is being created.

3. AutoCAD Civil 3D enables to finish the design process in a relaxed and comfortable manner in time and also maintains a lot of time and effort.
4. Superelevation was calculated and implemented.
5. The capacities of AutoCAD Civil 3D eliminate the significant disadvantages of a manual design strategy that is cumbersome, time-consuming and extremely susceptible to expensive mistakes.
6. The entire geometric layout of the road using AutoCAD civil 3D is presented in this project.

REFERENCES

1. S.A. Raji, A. Zava, K. Jirgba, A.B. Osunkunle. "Geometric Design of a Highway Using AutoCAD Civil 3d", Journal of Multidisciplinary Engineering Science and Technology (JMEST), Volume 4, Issue 6, June 2017.
2. Autodesk Civil 3D Tutorials, Available from:
<https://knowledge.autodesk.com/support/civil-3d/getting-started/caas/CloudHelp/cloudhelp/2019/ENU/Civil3D-Tutorials/files/GUID-B6CF98F9-FF6F-4FF5-8022-60EB21A611A7-htm.html>.
3. IRC: SP: 20- 2002. "Rural Roads Manual", 2002.
4. IRC: 38-1988. "Guidelines for design of horizontal curve".
5. IRC-SP: 73-2015. "Manual for Specification and Standards for two laning of Highways with Paved Shoulder"
6. Nisarga, K., and Amate, V. (2018). "Geometric design of rural road using AutoCAD civil 3d", IJSDR, Vol.05, Issue 07.
7. Nazimuddim, M., and Faheem, M., Aquil. (2017). "Geometric Design of a Highway Using MXROAD." IJERIA, Vol.10, 25-34.
8. Manoj Mandal, Dr. Prashant Pawade, Prashant Sandel. "Geometric design of highway using Civil 3D", International Journal of Advance Research, Ideas and Innovations in Technology, Volume 5, Issue 3, April 2019.