International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 07 | July 2021 www.irjet.net p-ISSN: 2395-0072

GEOMETRIC DESIGN OF RURAL ROAD

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Abstract - *Roadways are expected to guarantee users" comfort and safety, to permit efficient traffic operation, and at the same time attract the least possible cost in construction and maintenance. Geometric design is the means through which these demands are met. Roadway geometry design involves such tasks as creating the road alignment and plotting the alignment profile using bearings or coordinates, stations and elevations of points along the proposed route; calculation of sight distances, radii of horizontal curves, and lengths of vertical curves; computation of earthwork quantities, and numerous other analyses and calculations aimed at finding the optimum alignment while satisfying design standards and constraints. When performed manually, geometric design is very cumbersome, time-consuming and highly susceptible to very costly errors. The programs offer amazing precision and save lots of time and effort. This paper presents a complete geometric design of a typical rural road using AutoCAD Civil 3D software. The aim of the project was to demonstrate how roadway geometric design can be performed in a very short time with much ease and precision.*

Key Words: Geometric design, AutoCAD Civil 3D, Design criteria, Horizontal and Vertical Alignment, Cross section, Earthwork quantity, Corridor.

1. INTRODUCTION

The importance of transportation in the development of a country is multidimensional. Transportation is a vital for the economic growth of any region .The basic modes of transportation are roadways, waterways and airways. Road transport is one of the most common mode of transport. The construction of high-quality road network accelerates economic growth. The transportation by road is the only mode which could give maximum service to one and all. This mode also has the maximum flexibility for travel with reference to route, direction and speed of travel reduced the travail time and cost. Current trends are geared towards the use of very sophisticated computer programs for roadway geometry design that offer amazing precision and save lots of time and effort. Geometric design is vital in road design. The geometric design deals with the dimensions and layout of visible features of the highway. The emphasis of the geometric design is to address the requirement of driver and the vehicle such as safety, comfort, efficiency, etc. The features considered are cross sectional element, sight distance consideration, horizontal alignment and vertical alignment, intersections elements and it is depends on the important factors such as design speed, traffic factor, topography or terrain, design hourly volume and capacity, environmental and another factor.

AutoCAD Civil 3D is a software application used by civil engineers and professionals to plan and design the projects for building constructions, road engineering projects, water include construction of dams, ports, canals, embankments, etc. AutoCAD Civil 3D associate design and production drafting, greatly reducing the time it takes to implement design changes and evaluate multiple situations. 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.

2. LITERATURE REVIEW

Researchers discussed about the geometric design using AutoCAD Civil 3D which include both highways and rural roads. And the data collections are done by surveying and traffic volume count to get proper and scrupulous picture of the area and also the data are collected from LIDAR or similar technology.

Nisarga K, Vinoda Amate (2018): They chose a study area in Mysore district, which is 5.3 km length of rural area. This project introduces a complete geometric design of the village road using AutoCAD Civil 3D. Their data collection was done by surveying & traffic volume count.

S A Raji, A Zava, K Jirgba, A B Osunkunle (2017): This journal deals with the geometric design of a highway using AutoCAD Civil 3D. They have clearly explained the procedure to do the design of highway using Civil3D.
Yogesh Bajpai et al (2019): Design the road alignment in a less time with high accuracy using Civil 3D. Total station is utilized for import the points in civil 3D.

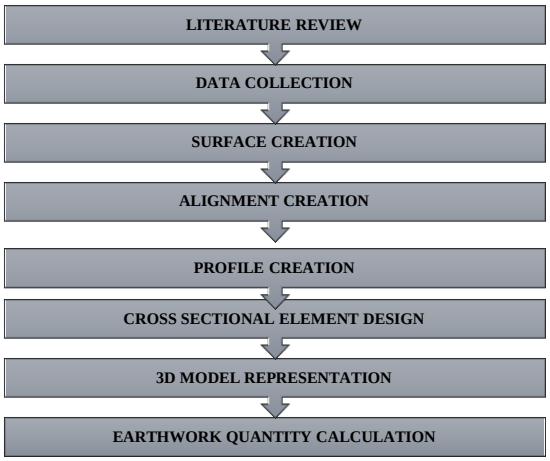
Neeraj and S S Kazal (2015): They were presented formulas in pavement widening on horizontal curves. To prevent off tracking, extra widening of pavement is provided at horizontal curves which is called Mechanical Widening.

Shivam Pandey, Er. Atul, Yogesh Bajpai (2019): Deals with planning, designing & proposing a flyover road using AutoCAD Civil 3D software. The designing process of flyover is a complex task when done by manual methods whereas by using AutoCAD Civil3D helps in saving time &

energy which results in the completion of a project on time. They chose the study area in Prayagraj (Allahabad) district in Uttar Pradesh. They have clearly mentioned the procedure to do the work by suitable design criteria, design procedure & design output.

A defined idea about the geometric design of road using AutoCAD Civil 3D got from the referred journals. It was realized that best and feasible software which is generally used to minimize the time of design and also evaluate multiple situations. It is also helping you to complete the task quickly, brilliant and all the more definitely.

3. DESIGN METHODOLOGY



3.1 DATA COLLECTION

Existing ground surface data are needed to design the geometry of road. The survey information included Easting, Northing and elevations of points along the proposed area.

3.2 SURFACE CREATION

A surface is a three-dimensional geometric representation of an area of land, or, in the case of volume surfaces, is a difference or composite between two surfaces.

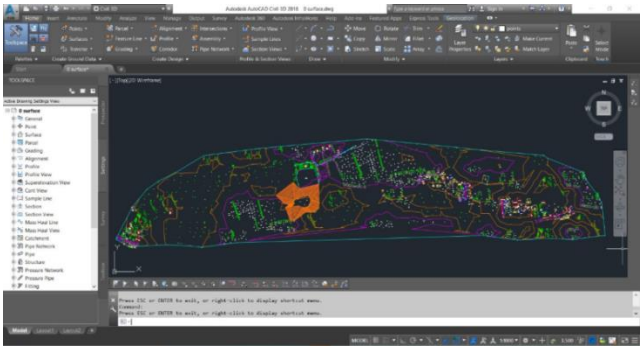


Fig 3.2.1 Surface

3.3 SLOPE ANALYSIS

The terrain is an important parameter governing the geometric design of road. The slope distribution of our area is given in the fig 3.3.1 and the slopes and its corresponding area of the terrain is given in the table 3.3.1. From that, we can conclude that our terrain is plain and rolling.

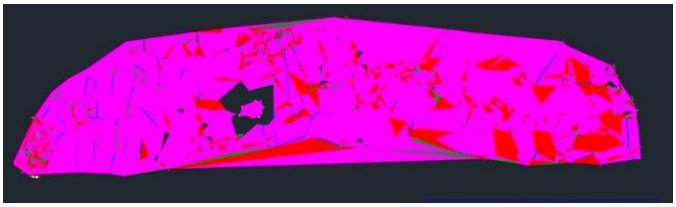


Fig 3.3.1 Slope Analysis

Sl. No	Slope	Area (m^2)
1	0.00% - 10.00%	418241.78
2	10.00% - 25.00%	70275.27
3	25.00% – 60.00%	8702.19
4	60.00% -100.00%	1517.16

Table 3.3.1 Slope Analysis Table

3.4 DESIGN CRITERIA

Designing a rural road as per the specifications of IRC. Design Standards are adopted from IRC: SP: 20 - 2002 “Rural Roads Manual” are;

- Single lane carriageway
- Terrain – Plain and rolling
- Design Speed – 40km/hr.
- Road Land Width – 15m
- Road Way Width – 7.5m
- Carriageway Width – 3.75m
- Shoulder width - 1.875m (one half the difference between the roadway width and carriageway width)
- Camber – 3.5%
- Maximum Super elevation – 7% (as per IRC for plain and rolling terrain)
- Minimum Radius of Curve – 90m (Corresponding to ruling design speed as per IRC)

Vertical curves are designed as per IRC: SP: 23

- Ruling Gradient of Plain and Rolling terrain - 3.3%
- Maximum grade change which not requiring a vertical curve – 1.2%
- Minimum length of vertical curve – 20m

- Minimum K - value for summit curve - 4.6
- Minimum K - value for valley curve – 6.6

3.5 ALIGNMENT AND PROFILE

The position or the layout of the centre line of the road on the ground is called alignment. Alignment comprises of horizontal and vertical alignment

Profiles define the road surface elevation along an alignment. The profile consists of grade lines, the line joining different gradients and also the changes in the gradient should be smoothened out by vertical curves.

3.5.1 HORIZONTAL ALIGNMENT

Horizontal alignment consists of three geometric components, including tangents (straight sections), circular curves and transition spirals between tangents and curves. Alignment design was done as per IRC: SP: 20 - 2002 "Rural Roads Manual**".**

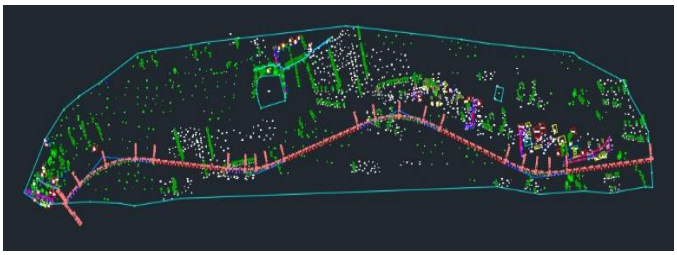


Fig 3.5.1.1 Alignment

Curve	Spiral in length (m)	Length of circular curve (m)	Spiral out length (m)	Radius of circular curve (m)
Curve 1	50.00	164.02	50.00	250
Curve 2	50.00	62.50	50.00	270
Curve 3	50.00	130.80	50.00	260
Curve 4	50.00	77.64	50.00	270

Table3.5.1.1 Horizontal Curves

3.5.1.1Superelevation

The radii of horizontal curve beyond which normal cambered section may be maintained and no superelevation is required at horizontal curves is recommended by IRC. Superelevation is not needed to be given in the designed road, since the radius of curve is beyond which superelevation is not required, as per IRC: SP:20-2002, Table 2.14.

3.5.2 VERTICAL ALIGNMENT

The vertical alignment is the elevation or profile of the centre line of the road Vertical alignment is fixed by considering minimum elevation difference between existing ground profile and road profile so that the cut and fill cost will be minimum.

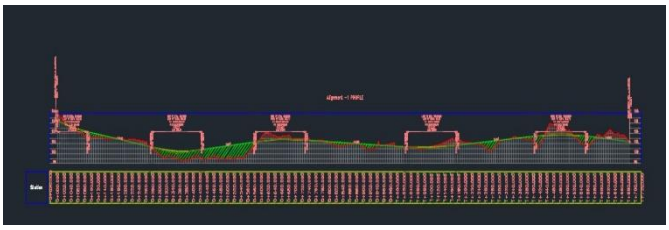


Fig 3.5.2.1 Vertical Road Profile

Curve	Grade in	Grade out	Grade change	Curve Type	K Value
Curve 1	-3.21%	-1.61%	1.6%	Sag	57.07
Curve 2	-1.61%	0.98%	2.6%	Sag	57.77
Curve 3	0.98%	-0.45%	1.43%	Crest	104.67
Curve 4	-0.45%	0.79%	1.24%	Sag	121.07
Curve 5	0.79%	-0.83%	1.62%	Crest	92.59

Table 3.5.2.1 Vertical Curve Properties

3.6 ASSEMBLY

Assembly is a basic block which shows the cross-section of the road design. This is used to build up the corridor.We provided the lane, shoulder and daylight as assembly parameters and it is shown in the figure 3.6.1. Daylight slope is the slope of embankment or cutting.

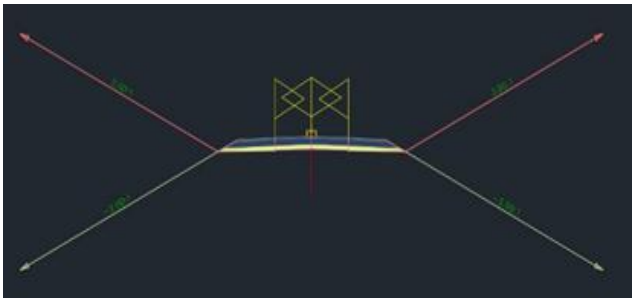


Fig: 3.6.1 Assembly

Lane width	3.75%
Lane camber	3.5m
Shoulder width	1.875m
Shoulder slope	4.5%
Daylight slope	2:1

Table 3.6.1 Subassembly Parameter

3.7 CORRIDOR

Corridors combine surface, alignment, profile, and assembly information to create dynamic three-dimensional representations of route-type features, such as roads, railroads, channels, and bridges.

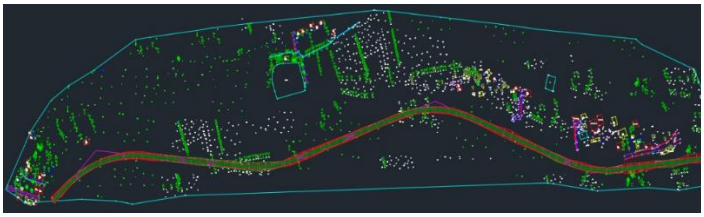


Fig 3.7.1 Corridor

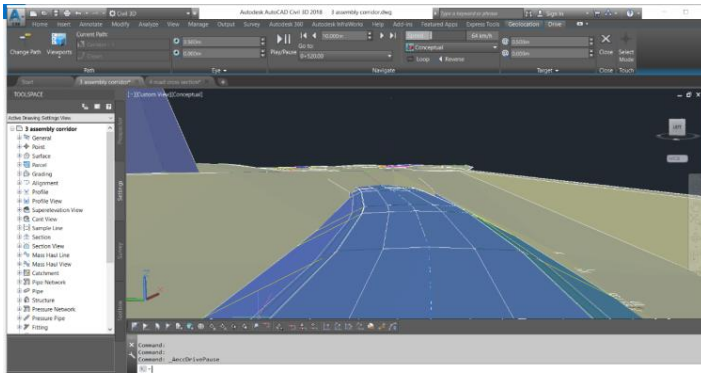


Fig 3.7.2 Perspective view

3.8 CROSS SECTION

The cross-sectional view of designed road at each station can be obtained very easily using AutoCAD Civil 3D. In our design, the cross section at particular intervals shows lanes, shoulders, daylight slope and pavement layers.We have provided a lane slope of 3.5% as per IRC. Shoulder slope is given as 4.5% and the daylight slope is 50%.

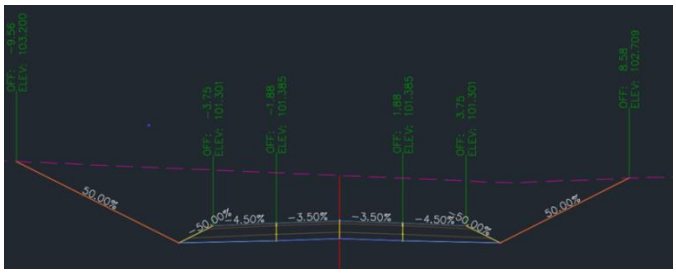
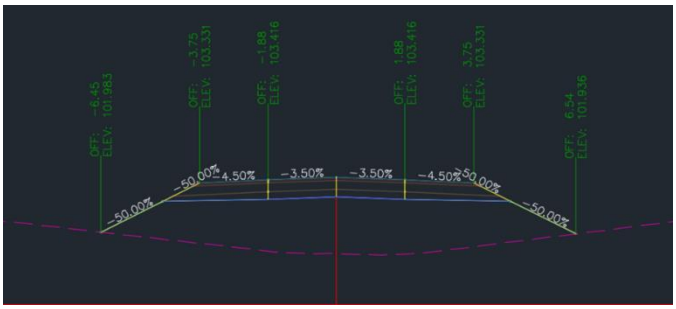


Fig 3.8.1 Cross section at station 1+160.00m



3.8.2 Cross section at station 1+420.00m

3.9 EARTHWORK QUANTITY

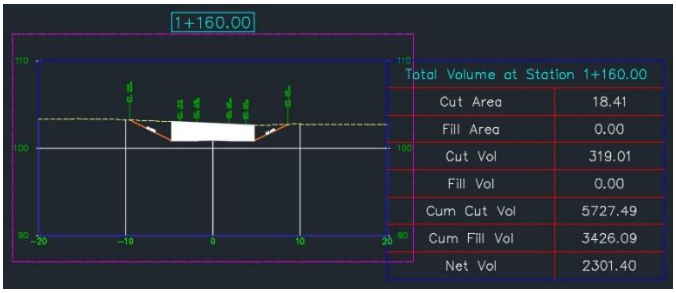


Fig 3.9.1 Cross section with earth work quantity at station 1+160.00m

Cut Area	18.41
Fill Area	0.00
Cut Volume	319.01
Fill Volume	0.00
Cumulative cut volume	5727.49
Cumulative fill volume	3426.09
Net volume	2301.40

Table 3.9.1 Earthwork Quantity at station 1+160.00m

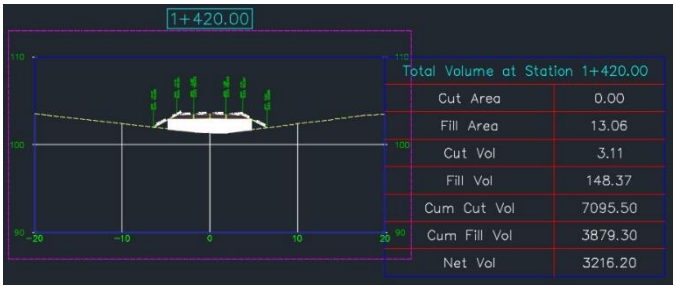


Fig 3.9.2 Cross section with earth work quantity at station 1+420.00m

Table 3.9.2 Earthwork Quantity at station 1+420.00m

Cut Area	0.00
Fill Area	13.06
Cut Volume	3.11
Fill Volume	148.37
Cumulative cut volume	7095.50
Cumulative fill volume	3879.30
Net volume	3216.20

3.10 EARTHWORK VOLUME RESULT

Cumulative Fill Volume	4334.44 m^3
Cumulative cut Volume	9945.2 m^3
Cumulative net Volume	5610.8 m^3

Table 3.10.1 Total Volume of Earthwork

4. CONCLUSIONS

Geometric design of a road deals with the dimensions and layout of visible features of the road such as alignment, sight distance and intersection. The geometrics of road should be designed to provide efficiency in traffic operations with maximum safety at reasonable cost. The design should be in such a way that it will maximize the comfort, safety, and economy of facilities and also minimize the environmental impacts. Through this project, we dealt with the geometric design of a single lane rural road by considering the elements such as horizontal alignment, vertical alignment, sight distance considerations, cross section elements and volume of earthwork with the help of AutoCAD Civil 3D software. The geometry of the road was strictly done in accordance with the IRC and also regarded all safety measures.

The solutions for road design in AutoCAD Civil 3D software make defining, annotating, and analyzing the road design more efficient and help our design comply with sound engineering standards. Drawings are obtained for the proposed road and simultaneously tabular column are generated automatically with details. We will get the formation level, cross sections, curve details along with the information of depth of cut and fill (Earthwork quantity) for the entire project stretch within a short time period. The capacity of the Auto CAD Civil 3D eliminated the significant disadvantages of manual design strategy that is time consuming and extremely susceptible to expensive mistakes.

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