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A Case Study of Geometric Design of Pune Ring Road Western Part Using Autodesk Civil 3D 2022

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ABSTRACT: India is a rapidly growing country, suggesting that traffic is also increasing. As transportation options expand, so does the development of rural areas. The geometric design controls the dimensions and layout of the visible features of the road Placement, viewing distance, cross section and intersection. The basic goal is to optimize efficient traffic and safety on the highway while minimizing cost and environmental damage. Road design knows the basics of road shape. The next step in increasing their value is to learn the software for using important information. For road geometric design, create road alignment, draw alignment or coordinates (easting and northing), station and elevation of points along the proposed route, length of vertical curve.

KEYWORDS: Civil 3D, Alignment, Profile, Corridor, Geometric design.

I. INTRODUCTION

In the present trend, geometric design is an important component and has a great effect while aligning a new road. Geometric design is a backbone of any alignment of road. It deals with cross sectional elements, sight distance considerations, horizontal alignment and vertical alignment details, intersection elements and it is relying on the important factors such as design speed, topography or terrain, traffic factors, design hourly volume and capacity, environmental and other factors. While aligning a new road, it should be short, easy, safe, and economic and it is expected to be comfort and safe for the movement.

Today in extremely competitive and sensitive business environment a timely preparation of road construction and reconstruction projects depends on modern computer-based facilities. Autodesk Civil 3D design software that is widely used in the world over in the road projects.

Autodesk 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. Autodesk Civil 3D associate design and production drafting, greatly reducing the time it takes to implement design changes and evaluate multiple situations. A change made in one place immediately updates an entire project, helping your complete projects faster, smarter and more accurately. Civil 3D provides to create 3D models of the project and helps to adopt for both small- and large-scale projects. It helps to imagine the things in 3D visualization, reduces the time and budget. It also inherits many benefits of using civil 3D.

• Objective of Geometric Design

The basic objectives in geometric design are to optimize efficiency and safety while minimizing cost and environmental damage. Geometric design also affects community goals, including providing access to employment, schools, businesses, and residences, accommodate a range of travel modes such as walking, bicycling, transit, and automobiles, and minimizing fuel use, emissions, and environmental damage.



II. LITERATURE REVIEW

Aram Ali (2010) studied the safety factor of the horizontal curve of a Two-Lane Highway and added that the horizontal curve has a higher accident rate than the straight part of the same length and traffic composition. This difference becomes apparent when the radius is less than 1000m. The increase in collision rate below a radius of 200 m is especially noticeable.[1]

Aswad Mohammed Hameed (2013) The shoulder widths above 2.25 m were stated to provide additional security. The average single-vehicle accident rate on the freeway curve is about four times the average single-vehicle accident rate on highway tangents. Horizontal curves are more dangerous when combined with slopes and surfaces with a low coefficient of friction. There is only a slight decrease in speed expected by the driver approaching the turn with a radius significantly smaller than the minimum radius specified for the design speed. Horizontal rotation is more dangerous when combined with sloped or low friction surfaces. Horizontal curves have a higher accident rate than straight sections of similar length and traffic composition. Differences become apparent with radii less than 1000m. The increase in fall rate is especially noticeable at radiuses of less than 200 m. [2]

Fitzpatrick Kay et. al. (2008) developed AMEs for median characteristics on urban and rural freeways and on rural multilane highways. A series of negative binomial regression models was used to determine the effects of independent variables on crashes. [3]

Hadi Mohammad A. et al. (1995) Negative binomial regression analysis was used to estimate the impact of cross-sectional design factors on overall accident mortality and injury rates on different types of rural and urban highways at different traffic volumes. The results show that increasing lane width, average width, and inner road shoulder width can help reduce accidents, depending on the type of expressway investigated.[4]

Hong Sung-Joon et. al. (2005) It was discussed to properly evaluate the actual geometric design of the highway and to propose a balanced design policy, especially considering the driver's perception and behavior. In this task, after classifying all the design elements, we will introduce and consider a new concept of backward calculation speed as a road layout evaluator. Analysis of the actual linear backward calculation speed on Japanese highways reveals the driver's perception of the physical limits imposed by the road alignment. The vehicle detector database is then used to estimate and analyze the actual operating speed of the vehicle. Using the 5-minute average speed of observing only one vehicle with the central lane detector of Japan's highway network of 7,000 km or more, the speed during self-sustaining driving is reasonably "driving speed" (free speed). You can guess. Finally, speed values are evaluated using highway design factors such as horizontal radius of curvature and vertical slope. Road shapes should be designed with vehicle traffic safety and efficiency in mind, especially on highways and highways where traffic functionality is paramount. The horizontal radius of each point is approximately proportional to the square of the calculated inverse velocity of in the future, the back-calculated speed will be changed to reflect not only the shape of the road but also the factor of safety.[5]

Jha Manoj k. and Schonfeld Paul (2004) It turns out that optimizing highway alignment based on cost minimization requires comprehensive formulation of routing-sensitive costs and the development of efficient solution algorithms. To solve real-world problems, optimization algorithms need to work directly with GIS to store relevant geographic information such as land boundaries, environment-sensitive areas, and terrain data. Highway route optimization models that integrate GIS with genetic algorithms also consider optimization in confined spaces that realistically reflect the various costs of route selection and the limitations of road improvement projects. [6]

Karlaftis Matthew G. and GoliasIoannis (2001) Using a rigorous nonparametric statistical technique known as hierarchical tree-based regression, we focused on the relationships between local road geometry, accident rates, and their predictions. You have two goals. First, we developed a methodology to quantitatively evaluate the effects of various geometrical properties of highways on accident rates, and then we developed simple yet basic and mathematical methods for predicting accident rates on local roads. Provides a healthy way to. The results show that the importance of isolated variables differs between two-lane and multi-lane roads, but the "geometric design" and "road conditions" variables are the two most important factors influencing accident rates. [7]

Kumar Ashok et al. (2015) used MXROAD Software for the geometric design of the existing state highway (SH 131) in Maharashtra to improve its, geometric features and upgrading it from two lanes to four lanes. The Software uses 3D string modelling technology and gives the desired values of different components of geometric design such as Horizontal and Vertical Curves, Superelevation, Shoulder, etc. [8]

Reddy Marri Srinivasa et al. (2019) Demonstrates the complete geometric design of a typical highway using Autodesk Civil3D software. The purpose of this project was to show how to carry out the geometric design of roads easily and accurately in the shortest possible time. A road design process using Autodesk Civil 3D was presented. The same manual geometric design was also performed, and the results were comparable to the results of Autodesk Civil 3D. [9]

III. RESEARCH METHODOLOGY

- **Steps to be perform in design office:**
 - Clean up the Survey data.
 - Import the Data to Civil 3D.
 - Setup data Shortcuts for Project.
 - Preparation of Surface.
 - Horizontal Alignment Design.
 - Vertical Alignment Design.
 - Generation of Drawings.
 - Assemblies and Corridor.
 - Generation of Quantities.

IV. INTRODUCTION TO CIVIL 3D

Civil 3D is a civil engineering design and documentation tool developed by Autodesk. Civil 3D is an engineering software application used by civil engineers and other professionals to plan, design, and manage civil engineering projects. Civil 3D allows is used to create three dimensional (3D) models of land, water, or transportation features while maintaining dynamic relationships to source data such as grading objects, breaklines, contours, and corridors.

Individuals who are currently using AutoCAD or plan on learning AutoCAD will inherit many benefits of using Civil 3D. Civil 3D was originally created to be an add-on for AutoCAD but as its popularity and demand grew, it was further evolved and developed into a stand-alone product built on the AutoCAD platform. Civil 3D offers a familiar design environment and many AutoCAD-compatible shortcuts and with true DWG (drawing) file support, Civil 3D allows you to store and share design data with existing AutoCAD users.

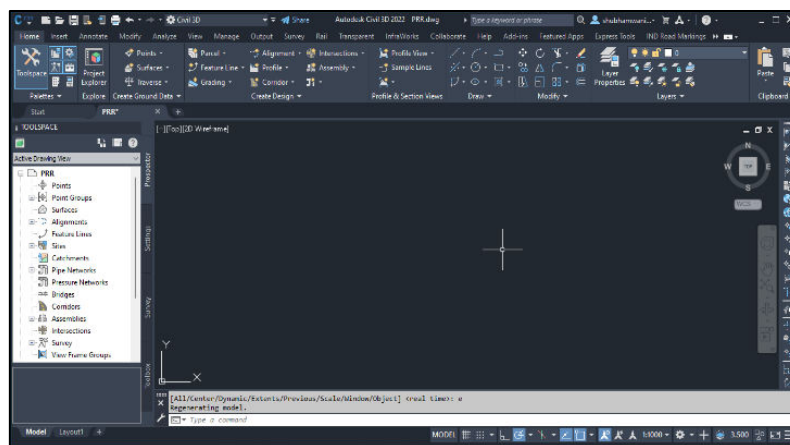


Fig. 1 Civil 3D Interface



Fig. 2 Google Earth Preview

A. DATA SHORTCUTS

Data shortcuts is use to create a new file with use of previous data. Fig. 10, we create an alignment and profile in one file (file A), then next we create a data shortcut of alignment and profile from original file (File A), Now we create a new C3D file and import the data shortcuts in new drawing (File B). after this if you make any changes in File A then it automatically shown in File B.

File A	File B	File C	File D	File E
Surface DEM	Alingment and Profile	Assmebly and Corridor	Plan Profile Sheets	Cross Sections Sheets

Fig. 3 Data Shortcut Working Methodology

B. DATA PROCESSING BEFORE INITIATE DESIGN

• **Geometric design of highway deals with following elements:**

- Cross sectional elements
- Sight distance considerations
- Horizontal alignment details
- Vertical alignment details
- Intersection elements

Under cross sectional elements, the considerations for width of pavement, the surface characteristics and cross slope of pavement are included. The sight distance or clear distance visible ahead of the driver at horizontal and vertical curves and at intersections govern the safe movements of vehicles.

• **DesignControls andCriteria:**

Thegeometricdesignofhighwaysdependsonseveraldesignfactors.Theimportantofthesefactorswhich controlthegeometricelementsare:

- 1)Designspeed.
- 2)Topography.
- 3)Trafficfactors.
- 4)Designhourlyvolumeand capacity.
- 5)Environmentalandotherfactors.
- 6) CrossSectionElements.

C. SURFACE

As we discussed earlier, Surface is nothing but the terrain model, basically there have two types of models, first one

- **Existing Ground Surface model:** - The Existing Surface model help us to get the existing geometry of roadway, like road width, existing superelevation etc.
- **Proposed Road Surface model:** - after finishing our horizontal and vertical design we can go to the model developing of our proposed roadway
Surface is not required when we go for horizontal design but when are start working on Vertical profile, existing surface is must be required to start the design in vertical design.

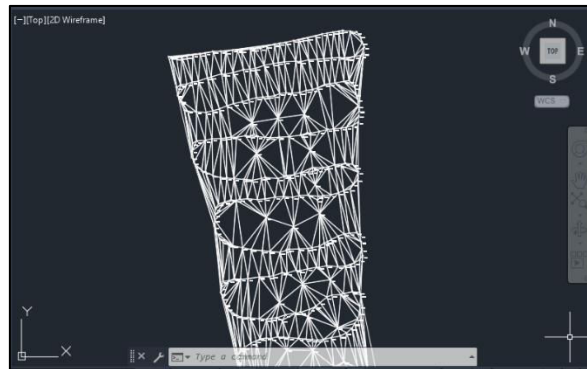


Fig. 4 Existing Ground Surface

D. HIGHWAY GEOMETRIC DESIGN

- **Horizontal Alignment**

Alignment is a Center line of the roadway, we have two center line existing CL and proposed CL, Existing alignment means, Center line of existing roadway, this line helps us a lot while we design our proposed alignment.



Fig. 5 Horizontal Alignment

- **Vertical Alignment**

The second important thing in design engineering is design of Profiles. This is the elevation of the central line of the horizontal alignment. The vertical alignment of a road consists of gradients (straight lines in a vertical plane) and vertical curves. The vertical alignment is usually drawn as a profile, which is a graph with elevation as vertical axis and the horizontal distance along the center line of the road as the horizontal axis.

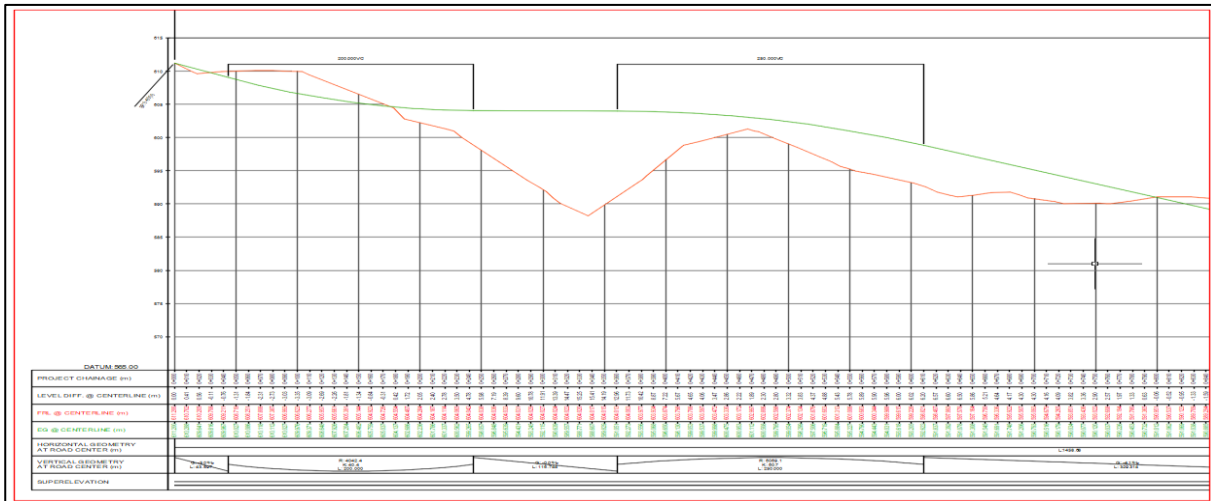


Fig. 6 Vertical Alignment

- **Superelevation**

Superelevation is the transverse slope provided to counteract the effect of centrifugal force and reduce the tendency of the vehicle to overturn and to skid laterally outwards by raising the pavement outer edge with respect to the inner edge. Superelevation is represented by “e”

- **For with Transition Curves**

- End Normal Crown
- Level Crown
- Reverse Crown
- Begin Full Super
- End Full Super
- Reverse Crown
- Level Crown
- Begin Normal Crown

- **For without Transition Curve**

- End Normal Crown
- Reverse Crown
- Begin Full Super
- End Full Super
- Reverse Crown
- Begin Normal Crown

	A	B	C	D	E	F	G	H	I	J	K	L
1	Superelevation Region	Station	Description	Smoothing Curve Length	Left Outside Shoulder	Left Outside Lane	Left Inside Lane	Left Inside Shoulder	Right Outside Shoulder	Right Outside Lane	Right Inside Lane	Right Inside Shoulder
2		00.000m	Begin Alignment	0	-2.50%	-2.50%	-2.50%	0.00%	-2.50%	-2.50%	-2.50%	0.00%
3	1	1375.340m	End Normal Shoulder	0	-2.50%	-2.50%	-2.50%	0.00%	-2.50%	-2.50%	-2.50%	0.00%
4	1	1375.340m	End Normal Crown	0	-2.50%	-2.50%	-2.50%	0.00%	-2.50%	-2.50%	-2.50%	0.00%
5	1	1437.840m	Level Crown	0	0.00%	0.00%	-2.50%	0.00%	-2.50%	-2.50%	0.00%	0.00%
6	1	1500.340m	Begin Full Super	0	2.50%	5.00%	-5.00%	0.00%	-5.00%	-5.00%	5.00%	0.00%
7	1	1854.106m	End Full Super	0	5.00%	5.00%	-5.00%	0.00%	-5.00%	-5.00%	5.00%	0.00%
8	1	1916.606m	Level Crown	0	0.00%	0.00%	-2.50%	0.00%	-2.50%	-2.50%	0.00%	0.00%
9	1	1979.106m	Begin Normal Crown	0	-2.50%	-2.50%	-2.50%	0.00%	-2.50%	-2.50%	-2.50%	0.00%
10	1	1979.106m	Begin Normal Shoulder	0	-2.50%	-2.50%	-2.50%	0.00%	-2.50%	-2.50%	-2.50%	0.00%
11		2849.079m	End Alignment	0	-2.50%	-2.50%	-2.50%	0.00%	-2.50%	-2.50%	-2.50%	0.00%

Table 1 Exported data of Superelevation to .CSV file

• Assemblies

An assembly is an Autodesk Civil 3D drawing object that manages a collection of subassembly objects. Together, assemblies and subassemblies function as the basic building blocks of a roadway or other alignment-based design.



Fig. 7 Expressway Assembly of PRR Cross section

• Corridors

A corridor model builds on and uses various Autodesk Civil 3D objects and data, including subassemblies, assemblies, alignments, surfaces, and profiles. The corridor manages the data, tying various assemblies (applied for different ranges of stations) to the baselines and their finished grade profiles.

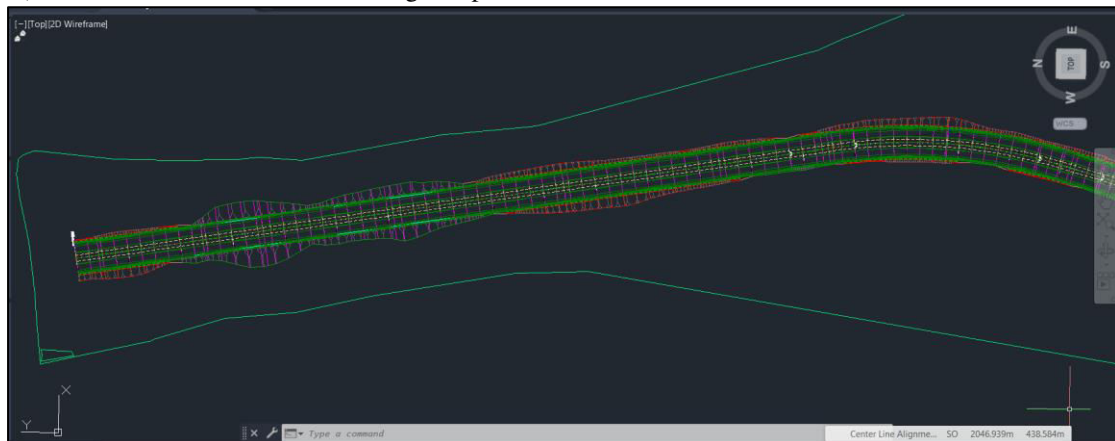


Fig. 8 Updated Corridor Section is Seems like above



- **Generation of Quantities**
 - Average End Area Method
 - Volume Dashboard Method

❖ **ComparisonBetweenEarthworkQuantities**

Table 2 Quantity Comparison

Method of Calculation	Cut Volume (Cu.m)	Fill Volume (Cu.m)
1. Average End Area Method @ 10 m interval	368583.33	358974.45
2. Volume Dashboard	359935.59	368514.83

V. CONCLUSION

- The use of Autodesk Civil 3D for roadway geometric design makes the design process to be complete within a very short time and with much ease and amazing precision. These capabilities of Autodesk Civil 3D eliminate the major disadvantages of the manual design approach that is cumbersome, time consuming and highly prone to costly errors.
 - The solutions for road design in Autodesk Civil 3D software make defining, annotating, and analyzing your road design more efficient and help your design comply with sound engineering standards.
 - Using criteria-based design, road modelling with real-time analysis and designer feedback helps expedite the design process and minimizes problematic issues.
 - Additionally, a good understanding of subassemblies and their functions enables the efficient construction of more accurate, construction-ready corridor models. Utilizing points, links, shapes, codes, target parameters, and road models, which can be tailored to your design’s needs, will automate many repetitive and/or difficult road design tasks, such as labeling and updating cross section sheets.
- **Scope for Future Study**
- Only one format of survey data is analyzed in the study i.e., topo Survey. Other formats like total station, auto level and GPS data may be considered for the future study.
 - More complex problems like interchange design, and rotary intersection etc. may be studied to check the capabilities of software in handling complex situations.
 - Other software like Bentley OpenRoads Designer, Bentley MX Road and other road designing software available in the market may also be incorporated in future studies to recommend the most suitable software in the market.

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- 1. Indian Roads Congress (IRC:73:1980), “Geometric Design Standards for Rural Highways” , New Delhi.
- 2. Indian Roads Congress (IRC:38:1988),“Design of Horizontal Curves for Highway and Design Tables” ,New Delhi.
- 3. Indian Roads Congress (IRC:SP:023:1993), “Vertical Curves for Highways” , New Delhi.
- 4. Indian Roads Congress (IRC:SP:099:2013), “Manual of Specification and Standards for Expressways” , New Delhi.

International Codes and Guidelines

- 1. CD 109 Revision 1 Highway link design- DMRB.
- 2. CD 127 Cross-sections and headroom's- DMRB.

Others Links

- 1. Autodesk Help <https://help.autodesk.com/view/CIV3D/2022/ENU/>
- 2. Autodesk, "Civil Engineering Design/Autodesk Civil 3D", Available from: <https://www.autodesk.com/products/civil-3d/features>
- 3. For Survey data <https://environment.data.gov.uk/DefraDataDownload/?Mode=survey>



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