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An Analysis of Roadway Geometric Design through 3D Software

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Abstract: India is experiencing rapid population growth, which directly contributes to an increase in traffic volume. The development of rural regions further accelerates the demand for improved transportation infrastructure. Geometric design plays a vital role in road planning by defining the dimensions and layout of visible road features such as alignment, sight distance, cross-section, and intersections. The primary objective of geometric design is to ensure traffic efficiency and road safety while minimizing construction costs and environmental impact.

To effectively design roads, it is essential to understand the fundamentals of geometric road design and enhance this knowledge through the use of advanced design software. The geometric design process includes tasks such as creating road alignments, plotting alignment profiles using bearings or coordinate data (easting, northing), defining stations and elevations, determining vertical curve lengths, computing earthwork quantities, and performing various analyses to identify the optimal alignment within design standards and constraints.

Manual design methods are not only time-consuming but also prone to costly errors. In modern practice, software tools such as Bentley MX Road, HEADS, and AutoCAD Civil 3D are widely used for efficient geometric design. This dissertation focuses on the complete geometric design of a road project using AutoCAD Civil 3D. The primary aim is to demonstrate how geometric design can be achieved with high precision and in significantly less time using this software.

AutoCAD Civil 3D is a powerful tool used by civil engineering professionals for designing, planning, and managing infrastructure projects. Survey data is essential for road design, and Differential GPS (DGPS) technology is utilized to collect accurate ground data. DGPS provides x, y, and z coordinates (easting, northing, and elevation), which are imported into Civil 3D for generating surfaces, designing alignments, and developing other geometric components of the road.

Keywords: AutoCAD Civil 3D, DGPS, Geometric Design, Road Alignment.

I. INTRODUCTION

A. General

The development of a constructive road transport system is the primary purpose of any country. The improvement of existing road network system is also essential as the traffic on urban and rural highways touches to saturation level over a given period of time.

The road development projects being highly capitals intensive involve very high degree of recognition by the project authorities as well as by the consultants, engineers and contractors. Any type of mistake may result in wastage of millions, which could have been avoided. Normally the alignment and the pavement construction decide the cost of a highway project and for this job the best experienced manpower and the best available tools must be deployed.

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

B. AutoCAD Civil 3D 2016

AutoCAD 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, break lines, 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**.**

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Civil 3D is used by civil engineers and other professionals to create digital models of infrastructure projects early in the design process. Ultimately, Civil 3D is used to explore, design, analyze and optimize civil engineering projects. This, in turn, helps to improve infrastructure designs and build projects safely, on time and on budget.

C. Road Geometric Design

The Geometric Design of a highway deals with the dimensions and layout of visible features of the highway such as alignment, sight distances and intersections.The geometries of highway should be designed to provide optimum efficiency in traffic operations with maximum safety at reasonable cost.

Geometric design of highway deals with following elements:

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

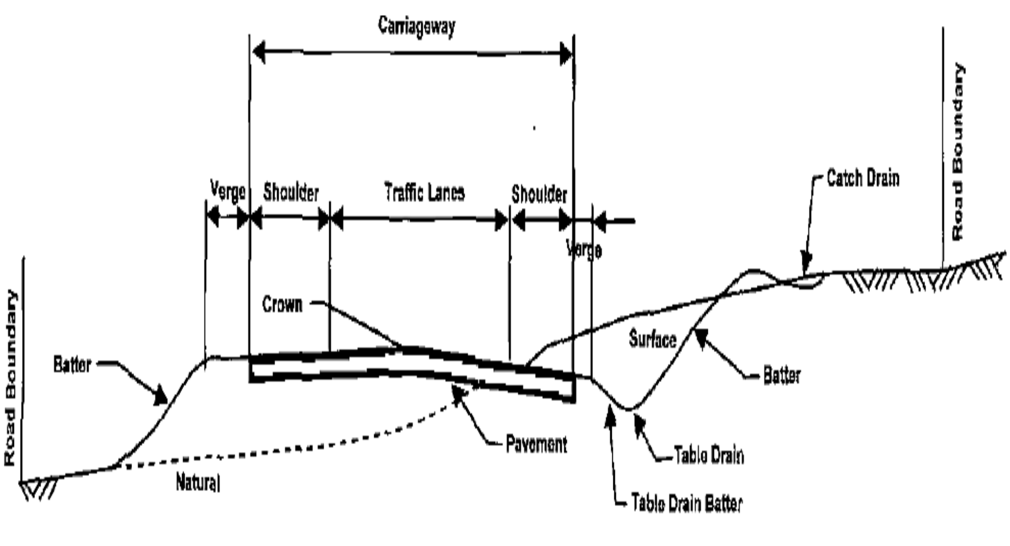
Table1.1 Design Speed on Rural Highways as per IRC 73:1980

Road Classification	Design Speed in kmph for Various Terrains							
	Plain		Rolling		Mountainous		Steep	
	Ruling	Min.	Ruling	Min.	Ruling	Min.	Ruling	Min.
National & StateHighways	100	80	80	65	50	40	40	30
Major District Roads	80	65	65	50	40	30	30	20
Other District Roads	65	50	50	40	30	25	25	20
Village Road	50	40	40	35	25	20	25	20

D. Cross SectionElements

The features of the cross-section of the pavement influence the life of the pavement as well as the riding comfort and safety. Camber, kerbs, and geometry of various cross-sectional elements are important aspects to be considered in this regard.

A typical cross section for a normal two lane two-way rural road and divided rural road is shown in Figure 1.1.



TWO LANE TWO WAY RURAL ROADS

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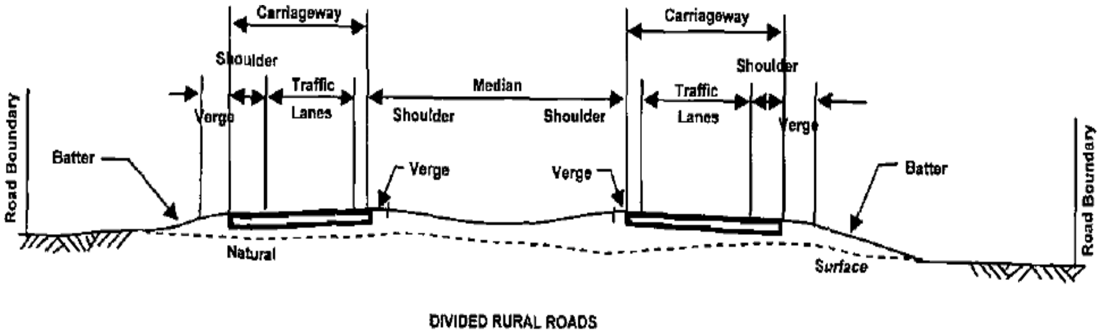

Figure 1.1:-Elements of Cross Sections

E. Objectives

The study analyzes the functions and the abilities of AutoCAD Civil 3D software designated for a computer aided road design. The analysis of the software will help to answer the questions raised by the designers regarding the selection of the software. It will thus be helpful in saving user's time and money and will be of interest to agencies involved in the business of road designing.

AutoCAD Civil 3D software has been used to evolve various design features of a road project.

The study will be undertaken with the following main objectives:-

- To research different software applications.
- To determine the alignment of a road project using ground data.
- To develop the alignment's geometric features.
- To use the software to provide a cross section.
- To perform earthwork calculations using the program.

F. Scope of theStudy

The software AutoCAD Civil 3D has been used to analyse how different geometric design elements of a road project evolve.

In the investigation, AutoCAD Civil 3D 2016 was utilised. A single-lane road project situated in a plain area is the subject of the design aspects that have been developed. The study's contents are fairly general in nature and can be readily applied to other software versions and to different types of roads and terrain conditions, even though it was conducted using the software version mentioned above and for the specific road category situated in plain terrain.

II. LITERATURE REVIEW

Neeraj *et al.* (2015) carried out a study on the geometric design of highway. Each factor describes to his function of geometry design and planning factor. To initial alignment is proposed then lock about the traffic in the road and there topographic. Always traffic factor is the main part of the design the alignment, the traffic growth consideration the future growth of traffic flow and possibility of the road being upgraded to a higher category or to a higher design speed standard at a later stage as it is very expensive and rather difficult to improve the geometric elements of a highway in stages at a later date. Their study was mainly emphases on the importance of planning and design of geometric feature of the highway during the initial alignment itself taking into consideration the future growth of traffic flow and possible of the road upgrading to higher categories.

Ananya Augustine *et al.* (2016) research intends to build a 3D object based intelligent design model of the roadway in which elements of the design are related to each other dynamically. In order to test the feasibility of the proposed approach, a prototype object based 3D model was developed and tested on a highway project in Vadakkencherry.

Shah *et al.* (2016) carried out planning and design of purposed bypass road used civil 3D and carries out capacity analysis by projection traffic volume data for 15 years and concluded that high design precision and saving in time were achieved by using Autodesk Civil 3D.

Vayalamkuzhi*et al.* (2016) studied influence of geometric design characteristics on safety under heterogeneous traffic flow. They found that operating speed, access point, median opening and horizontal curvatures (inverse radius) are identified as the significant factors influencing road crashes in a divided highway under heterogeneous traffic using the same carriageway.

Nazimuddin *et al.* (2017) carried out a study on geometric design of highway using MX ROAD and achieved high design precision and accuracy for given set of data.

Raghu veer *et al.* (2018) explained the geometric design of highway and emphasises planning and designing of geometric features. Although there are number of factors influences on design of highway, but suitable geometric design having objective of giving optimum efficiency in traffic operation with contentment safety measures at reasonable cost.

Nisarga *et al.* (2018) studied geometric design of rural road using AutoCAD civil 3D. They explained that Geometric design plays a major role in every road and it is weighty in the road alignment. AutoCAD Civil 3D is a software application used by civil engineers and professionals to plan and design the projects & one Place change firstly or immediately all project should be updated, project compilation fastly helping for us, more accurate and smarter.

Marri Srinivasa Reddy *et al.* (2019) presents a complete geometric design of a typical highway 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. The road design procedure using AutoCAD Civil 3D has been presented. Manual geometric design of the same road was also performed, the results of which was compared favourably with that of AutoCAD Civil 3D.

Manoj Mandal *et al.* (2019) studied total geometric design of road using AutoCAD Civil 3D software. AutoCAD Civil 3D associate design and production drafting, greatly reducing the time it takes to implement design changes and assess multiple sets of circumstances. Although there are a number of factors influences the design of the highway, the suitable geometric design having the objective of giving optimum efficiency in traffic operation with contentment safety measures at a reasonable cost.

III. RESEARCH METHODOLOGY

A. General

The survey data chosen for the research work was taken from Raipur, Chhattisgarh, India. Survey was done using DGPS for the existing ground features in the area under study. The information is gathered from the survey company. Survey data text file contain data as space separated (tab delimited text) values. In case of Survey by DGPS the points must be in proper sequence, so that when joined will describe the shape of the feature in the drawing.

DGPS: Differential global positioning system is an enhancement to global positioning system that provides improved location accuracy from the 15- metre nominal GPS accuracy to about 10cm in case of the best implementations.

B. Procedure for Survey

1) DGPSSurvey

a) The Survey shall be carried along the boundaries which are invariably shown by the concerned local staff and conforming to the notifications or other documents relating to location and extent of the land.

b) DGPS readings at each station along the periphery shall be taken by a Rover with a minimum observation period of 15 minutes. Differentially correct the DGPS Rover data with base station / control point data, if real-time DGPS is not used. In addition to DGPS readings, at each location simultaneously Handheld GPS readings must also be taken for comparison, with the same observation period of 15 minutes.

c) Establishment of Base stations (Control Points):

- Base Stations to be fixed by Multi/Dual frequency DGPS receivers with SOI Control Point as reference.
- The minimum observation time for base station shall be 12 hours from nearest SOI control point.
- Required number of Control Points shall be established in such a way that the distance between the DGPS base station & rover shall be less than 10km (for single frequency DGPS Rovers) and less than 50 km (for dual frequency DGPS Rovers).
- The panoramic view surrounding the Base Station as well as antenna location showing the terrain in near proximity should be digitally photographed (should be taken in three or four different directions) and documented.
- Rovers shall be of Dual/Multiple frequency DGPS receivers within a radius of50 km from the base. In case Single frequency DGPS receivers are used they should be used within 10 km radius only. To differentially correct the DGPS Rover data with base station / control point data.
- The height above MSL shall also be recorded for location and must be linked to HAE.
- DGPS instruments are used for survey they must be set-in to Geographic.

2) Corridor

A corridor model builds on and uses various AutoCAD Civil 3D objects and data, including assemblies, alignments, surfaces, and profiles. A corridor object is created from a baseline (alignment) by placing 2D sections (assemblies) at incremental locations, and by creating matching slopes that reach a surface model at each incremental location (User's Guide, AutoCAD Civil 3D 2018).

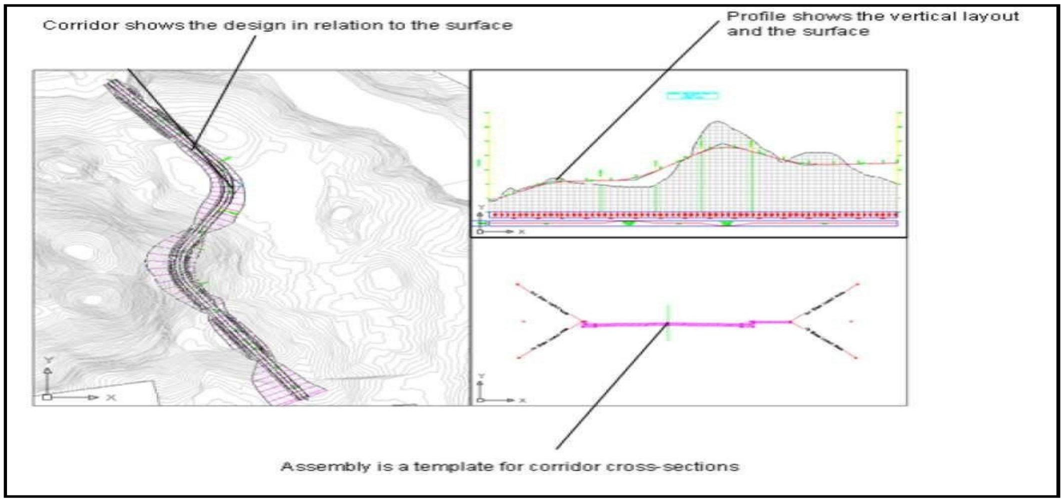

Figure 3.33:-Elements of a Corridor Design

In this study, creating a simple corridor is sufficient. To create a simple corridor; Click Home tab ➤Create Design panel ➤Corridor drop-down ➤Create Simple Corridor. The command is demonstrated in Figure 3.34.

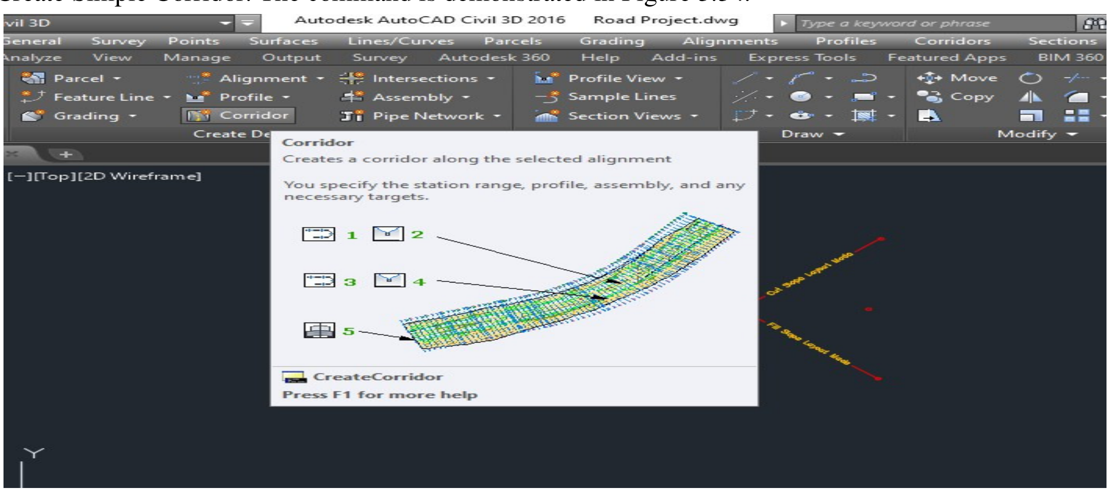

Figure 3.34:-Corridor Command

In the Create Corridor dialog box that opens up, as per Figure 3.35, the name of the corridor, display style can be changed, but it is not necessary in this selection, the default settings can be accepted, the software asks the user to identify the alignment, profile and assembly, one after another. Since one of each item is created, there would be only one item on each list, except the profile. Care should be taken when identifying the layout profile. As mentioned in previous sections, the different name chosen for the layout profile will help the user to refer to the desired profile easily.

IV. RESULTS AND DISCUSSION

A. General

Using made-up data for road project various reports are generated. Output data as generated by software i.e. AutoCAD Civil 3D in respect of Horizontal Alignment, Vertical Alignment, Cross-sectional Elements and Earthwork Calculation have been given in the following sections. Total length of the road to be considered for the study is 793.26 m.

B. Horizontal Alignment Using AutoCAD Civil 3D

The output data as generated by the software is shown as:

1) Alignment Curve Report

Prepared by:
Uttam Kumar Verma
Date:14-02-2025 19:10:51
Alignment: Unnamed Road
Station Range: Start: 0+000.00, End: 0+793.26

Table 4.1 Horizontal Alignment Curve Report

Tangent Data			
Length:	302.638	Course:	N 63° 08' 42.7019" E
Tangent Data			
Length:	125.974	Course:	N 63° 25' 13.2160" E
Circular Curve Data			
Delta:	19° 06' 55.0519"	Type: RIGHT	
Radius:	155.000		
Length:	51.712	Tangent:	26.098
Mid-Ord:	2.152	External:	2.182
Chord:	51.472	Course:	N 72° 58' 40.7419" E
Tangent Data			
Length:	134.839	Course:	N 82° 32' 08.2679" E
Tangent Data			
Length:	178.094	Course:	N 82° 59' 09.6735" E

2) Alignment Design Criteria VerificationReport

Prepared by:
Uttam Kumar Verma
Date: 14-02-2025 19:10:51
Alignment: Unnamed Road
Station Range: Start: 0+000.00, End: 0+793.26

Table 4.2 Horizontal Alignment Design Criteria Verification Report

1 Tangent	
Start Station:	0+000.00
End Station:	0+302.64
Length:	302.638m
Design Speed:	65
Design Checks:	
Subdivision Street	Cleared
2 Tangent	
Start Station:	0+302.64
End Station:	0+428.61
Length:	125.974m
Design Speed:	65
Design Checks:	
Subdivision Street	Cleared
3 Circular Curve	

Start Station:	0+428.61	
End Station:	0+480.32	
Radius:	155.000m	
Design Speed:	65	
Design Criteria:		
Minimum Radius:	155.00	Cleared
4 Tangent		
Start Station:	0+480.32	
End Station:	0+615.16	
Length:	134.839m	
Design Speed:	65	
Design Checks:		
Subdivision Street	Cleared	
5 Tangent		
Start Station:	0+615.16	
End Station:	0+793.26	
Length:	178.094m	
Design Speed:	65	
Design Checks:		
Subdivision Street	Cleared	

3) Alignment Incremental Station Report

Prepared by:
Uttam Kumar Verma
Date: 14-02-2025 19:14:44
Alignment Name: Unnamed Road
Station Range: Start: 0+000.00, End: 0+793.26
Station Increment: 20.00

Table 4.3 Horizontal Alignment Incremental Station Report

Station	Northing	Easting	Tangential Direction
0+000.00	2,033,603.9120m	657,620.8350m	N63° 08' 43"E
0+020.00	2,033,612.9466m	657,638.6781m	N63° 08' 43"E
0+040.00	2,033,621.9812m	657,656.5212m	N63° 08' 43"E
0+060.00	2,033,631.0159m	657,674.3642m	N63° 08' 43"E
0+080.00	2,033,640.0505m	657,692.2073m	N63° 08' 43"E
0+100.00	2,033,649.0851m	657,710.0504m	N63° 08' 43"E
0+120.00	2,033,658.1197m	657,727.8935m	N63° 08' 43"E
0+140.00	2,033,667.1544m	657,745.7366m	N63° 08' 43"E
0+160.00	2,033,676.1890m	657,763.5797m	N63° 08' 43"E
0+180.00	2,033,685.2236m	657,781.4227m	N63° 08' 43"E
0+200.00	2,033,694.2582m	657,799.2658m	N63° 08' 43"E
0+220.00	2,033,703.2928m	657,817.1089m	N63° 08' 43"E
0+240.00	2,033,712.3275m	657,834.9520m	N63° 08' 43"E
0+260.00	2,033,721.3621m	657,852.7951m	N63° 08' 43"E
0+280.00	2,033,730.3967m	657,870.6382m	N63° 08' 43"E
0+300.00	2,033,739.4313m	657,888.4812m	N63° 08' 43"E
0+320.00	2,033,748.3915m	657,906.3618m	N63° 25' 13"E

0+340.00	2,033,757.3403m	657,924.2481m	N63° 25' 13"E
0+360.00	2,033,766.2892m	657,942.1343m	N63° 25' 13"E
0+380.00	2,033,775.2380m	657,960.0206m	N63° 25' 13"E
0+400.00	2,033,784.1868m	657,977.9069m	N63° 25' 13"E
0+420.00	2,033,793.1357m	657,995.7931m	N63° 25' 13"E
0+440.00	2,033,801.7059m	658,013.8573m	N67° 37' 48"E
0+460.00	2,033,808.1050m	658,032.7913m	N75° 01' 23"E
0+480.00	2,033,812.0145m	658,052.3914m	N82° 24' 58"E
0+500.00	2,033,814.6131m	658,072.2218m	N82° 32' 08"E
0+520.00	2,033,817.2113m	658,092.0524m	N82° 32' 08"E
0+540.00	2,033,819.8095m	658,111.8829m	N82° 32' 08"E
0+560.00	2,033,822.4076m	658,131.7134m	N82° 32' 08"E
0+580.00	2,033,825.0058m	658,151.5439m	N82° 32' 08"E
0+600.00	2,033,827.6040m	658,171.3744m	N82° 32' 08"E
0+620.00	2,033,830.1645m	658,191.2097m	N82° 59' 10"E
0+640.00	2,033,832.6067m	658,211.0601m	N82° 59' 10"E
0+660.00	2,033,835.0490m	658,230.9104m	N82° 59' 10"E
0+680.00	2,033,837.4912m	658,250.7607m	N82° 59' 10"E
0+700.00	2,033,839.9334m	658,270.6110m	N82° 59' 10"E
0+720.00	2,033,842.3757m	658,290.4614m	N82° 59' 10"E
0+740.00	2,033,844.8179m	658,310.3117m	N82° 59' 10"E
0+760.00	2,033,847.2601m	658,330.1620m	N82° 59' 10"E
0+780.00	2,033,849.7023m	658,350.0124m	N82° 59' 10"E
0+793.00	2,033,851.3212m	658,363.1702m	N82° 59' 10"E

C. Vertical Alignment Using AutoCAD Civil 3D

The output data as generated by the software is shown as:

1) Profile Vertical Curve Report

Prepared by:
Uttam Kumar Verma
Date: 14-02-2025 19:14:44
Vertical Alignment: Proposed Road

Station Range: Start: 0+005.00, End: 0+793.26

Table 4.4:-Profile Vertical Curve Report

Vertical Curve Information :(Crest Curve)			
PVC Station:	0+130.11	Elevation:	637.787m
PVI Station:	0+145.00	Elevation:	638.000m
PVT Station:	0+159.89	Elevation:	638.078m
High Point:	0+159.89	Elevation:	638.078m
Grade in:	1.43%	Grade out:	0.53%
Change:	0.90%	Elevation:	33.000m
Curve Length:	29.774m	Curve Radius	3,300.000m
Passing Distance:	1,728.772m	Stopping Distance:	751.458m
Vertical Curve Information :(Crest Curve)			
PVC Station:	0+319.85	Elevation:	638.920m
PVI Station:	0+335.00	Elevation:	639.000m
PVT Station:	0+350.15	Elevation:	638.941m
High Point:	0+337.21	Elevation:	638.966m
Grade in:	0.53%	Grade out:	-0.39%
Change:	0.92%	Elevation:	33.000m
Curve Length:	30.310m	Curve Radius	3,300.000m
Passing Distance:	1,698.779m	Stopping Distance:	738.720m
Vertical Curve Information :(Sag Curve)			
PVC Station:	0+582.48	Elevation:	638.029m
PVI Station:	0+590.00	Elevation:	638.000m
PVT Station:	0+597.52	Elevation:	638.037m
Low Point:	0+589.15	Elevation:	638.016m
Grade in:	-0.39%	Grade out:	0.49%
Change:	0.88%	Elevation:	17.000m
Curve Length:	15.030m	Curve Radius	1,700.000m

(Note: K= Length required for a 1% change of grade)

2) PVI Station Increment Report

Prepared by:
Uttam Kumar Verma
Date: 14-02-2025 19:14:44
Vertical Alignment: Proposed Road
Station Range: Start: 0+005.00, End: 0+793.26
Station Increment: 20.00

Table 4.5 PVI Station Increment Report

Station	Elevation	Grade Percent (%)	Location
0+005.00	636.000m	PVI	636.000m
0+025.00	636.286m	1.43%	
0+045.00	636.571m	1.43%	
0+065.00	636.857m	1.43%	
0+085.00	637.143m	1.43%	
0+105.00	637.429m	1.43%	
0+125.00	637.714m	1.43%	

0+130.11	637.787m	1.43%	PVC
0+145.00	637.966m	1.20%	Crest
0+159.89	638.078m	0.75%	PVT
0+165.00	638.105m	0.53%	
0+185.00	638.211m	0.53%	
0+205.00	638.316m	0.53%	
0+225.00	638.421m	0.53%	
0+245.00	638.526m	0.53%	
0+265.00	638.632m	0.53%	
0+285.00	638.737m	0.53%	
0+305.00	638.842m	0.53%	
0+319.85	638.920m	0.53%	PVC
0+325.00	638.943m	0.45%	
0+335.00	638.965m	0.22%	Crest
0+345.00	638.957m	-0.08%	
0+350.15	638.941m	-0.31%	PVT
0+365.00	638.882m	-0.39%	
0+385.00	638.804m	-0.39%	
0+405.00	638.725m	-0.39%	
0+425.00	638.647m	-0.39%	
0+445.00	638.569m	-0.39%	
0+465.00	638.490m	-0.39%	
0+485.00	638.412m	-0.39%	
0+505.00	638.333m	-0.39%	
0+525.00	638.255m	-0.39%	
0+545.00	638.176m	-0.39%	
0+565.00	638.098m	-0.39%	
0+582.48	638.029m	-0.39%	PVC
0+585.00	638.021m	-0.32%	
0+590.00	638.017m	-0.10%	Sag
0+597.52	638.037m	0.27%	PVT
0+605.00	638.074m	0.49%	
0+625.00	638.172m	0.49%	
0+645.00	638.271m	0.49%	
0+665.00	638.369m	0.49%	
0+685.00	638.467m	0.49%	
0+705.00	638.566m	0.49%	
0+725.00	638.664m	0.49%	
0+745.00	638.763m	0.49%	
0+765.00	638.861m	0.49%	
0+785.00	638.959m	0.49%	
0+793.26	639.000m	0.49%	PVI

D. Cross Sectional Analysis Using AutoCAD Civil 3D

The output data as generated by the software is shown as:

1) Corridor Slope Stake Report

Prepared by:
Uttam Kumar Verma

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Date: 14-02-2025 19:14:44
Corridor Name: Unnamed Road corridor
Base Alignment Name: Unnamed Road
Sample Line Group Name: SLCollection-1
Link Code Name: Datum
Station Range: Start: 0+020.00, End: 0+100.00
Unnamed Road

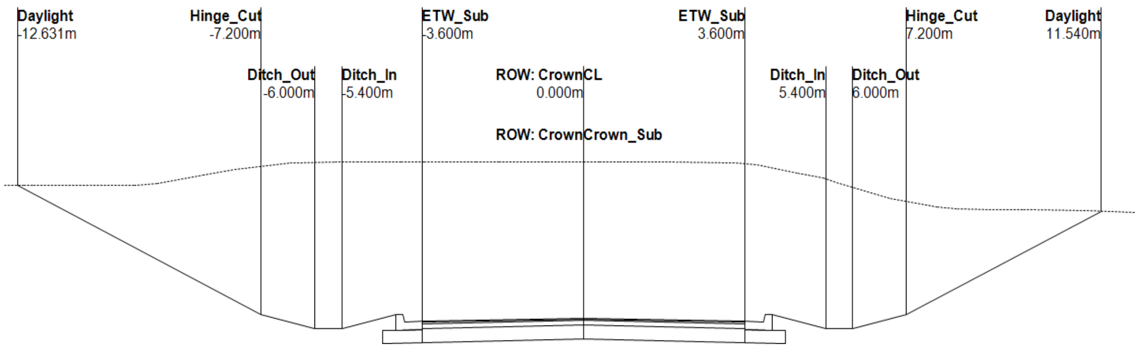
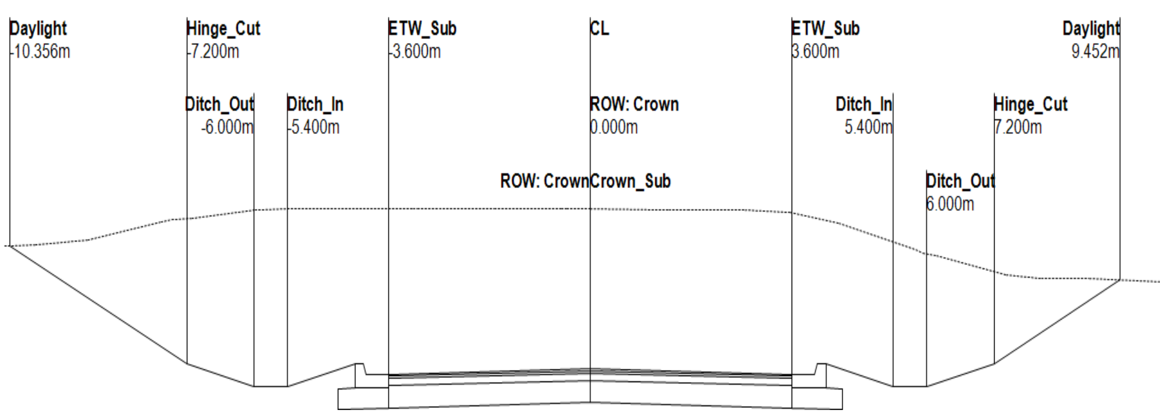


Figure 4.1:- Cross Section Drawn by AutoCAD Civil3D Software at Station: 0+020

Table 4.6 Corridor Slope Stake Report at Station 0+020

C2.72	Ditch_Out	Ditch_In			ETW_Sub	CL	Crown_Sub	ETW_Sub			Ditch_In	C2.17
@5.43	-6.000m	-5.400m	-4.500m	-4.200m	-3.600m	0.000m	0.000m	3.600m	4.200m	4.500m	5.400m	@4.34
1:0.50	635.984m	635.984m	635.674m	636.284m	635.692m	636.214m	635.764m	635.692m	636.284m	635.674m	635.984m	1:0.50
	25.00 %	0.00 %	34.44 %	1:-2.03	1:0.99		-2.00 %	1:0.99	1:-2.03	34.44 %	0.00 %	
				Daylight	Hinge_Cut		Ditch_Out	Hinge_Cut	Daylight			
				-12.631m	-7.200m		6.000m	7.200m	11.540m			
				639.000m	636.284m		635.984m	636.284m	638.454m			
					1:0.50		25.00 %	1:0.50				



Unnamed Road
Figure 4.2:-Cross Section Drawn by AutoCAD Civil 3D Software at Station: 0+100

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Table 4.7 Corridor Slope Stake Report at Station 0+100

C1.58	Ditch_Out	Ditch_In			ETW_Sub	CL	Crown_Sub	ETW_Sub			Ditch_In	C1.13
@3.16	-6.000m	-5.400m	-4.500m	-4.200m	-3.600m	0.000m	0.000m	3.600m	4.200m	4.500m	5.400m	@2.25
1:0.50	637.127m	637.127m	636.817m	637.427m	636.835m	637.357m	636.907m	636.835m	637.427m	636.817m	637.127m	1:0.50
	25.00 %	0.00 %	34.44 %	1:-2.03	1:0.99		-2.00 %	1:0.99	1:-2.03	34.44 %	0.00 %	
				Daylight	Hinge_Cut		Ditch_Out	Hinge_Cut	Daylight			
				-10.356m	-7.200m		6.000m	7.200m	9.452m			
				639.005m	637.427m		637.127m	637.427m	638.553m			
					1:0.50		25.00 %	1:0.50				

2) Lane Slope Report

Prepared by:
Uttam Kumar Verma
Date: 14-02-2025 19:14:44
Corridor Name: Unnamed Road corridor
Base Alignment Name: Unnamed Road
Sample Line Group Name: SL Collection - 1
Station Range: Start: 0+000.00, End: 0+793.26

Table 4.11 Corridor Lane Slope Report

SL Name	Station	Existing Ground Elevation	Layout Profile Elevation	X	Y	Slope Left	Slope Right
0+020.00	0+020.00	639.491	636.214	6,57,638.678	20,33,612.947	2.0%	2.0%
0+040.00	0+040.00	639.499	636.500	6,57,656.521	20,33,621.981	2.0%	2.0%
0+060.00	0+060.00	639.491	636.786	6,57,674.364	20,33,631.016	2.0%	2.0%
0+080.00	0+080.00	639.498	637.071	6,57,692.207	20,33,640.050	2.0%	2.0%
0+100.00	0+100.00	639.497	637.357	6,57,710.050	20,33,649.085	2.0%	2.0%
0+120.00	0+120.00	639.500	637.643	6,57,727.893	20,33,658.120	2.0%	2.0%
0+140.00	0+140.00	639.849	637.914	6,57,745.737	20,33,667.154	2.0%	2.0%
0+160.00	0+160.00	639.936	638.079	6,57,763.580	20,33,676.189	2.0%	2.0%
0+180.00	0+180.00	639.998	638.184	6,57,781.423	20,33,685.224	2.0%	2.0%
0+200.00	0+200.00	640.000	638.289	6,57,799.266	20,33,694.258	2.0%	2.0%
0+220.00	0+220.00	640.090	638.395	6,57,817.109	20,33,703.293	2.0%	2.0%
0+240.00	0+240.00	640.330	638.500	6,57,834.952	20,33,712.327	2.0%	2.0%
0+260.00	0+260.00	640.300	638.605	6,57,852.795	20,33,721.362	2.0%	2.0%
0+280.00	0+280.00	640.351	638.711	6,57,870.638	20,33,730.397	2.0%	2.0%
0+300.00	0+300.00	640.377	638.816	6,57,888.481	20,33,739.431	2.0%	2.0%
0+320.00	0+320.00	640.168	638.921	6,57,906.362	20,33,748.391	2.0%	2.0%
0+340.00	0+340.00	640.000	638.965	6,57,924.248	20,33,757.340	2.0%	2.0%
0+360.00	0+360.00	639.998	638.902	6,57,942.134	20,33,766.289	2.0%	2.0%
0+380.00	0+380.00	639.809	638.824	6,57,960.021	20,33,775.238	2.0%	2.0%
0+400.00	0+400.00	639.499	638.745	6,57,977.907	20,33,784.187	2.0%	2.0%
0+420.00	0+420.00	639.175	638.667	6,57,995.793	20,33,793.136	2.0%	2.0%
0+440.00	0+440.00	638.989	638.588	6,58,013.857	20,33,801.706	2.0%	2.0%
0+460.00	0+460.00	638.654	638.510	6,58,032.791	20,33,808.105	2.0%	2.0%
0+480.00	0+480.00	638.378	638.431	6,58,052.391	20,33,812.015	2.0%	2.0%

0+500.00	0+500.00	637.904	638.353	6,58,072.222	20,33,814.613	2.0%	2.0%
0+520.00	0+520.00	637.456	638.275	6,58,092.052	20,33,817.211	2.0%	2.0%
0+540.00	0+540.00	636.999	638.196	6,58,111.883	20,33,819.809	2.0%	2.0%
0+560.00	0+560.00	636.568	638.118	6,58,131.713	20,33,822.408	2.0%	2.0%
0+580.00	0+580.00	636.500	638.039	6,58,151.544	20,33,825.006	2.0%	2.0%
0+600.00	0+600.00	636.500	638.049	6,58,171.374	20,33,827.604	2.0%	2.0%
0+620.00	0+620.00	636.500	638.148	6,58,191.210	20,33,830.165	2.0%	2.0%
0+640.00	0+640.00	636.500	638.246	6,58,211.060	20,33,832.607	2.0%	2.0%
0+660.00	0+660.00	636.761	638.344	6,58,230.910	20,33,835.049	2.0%	2.0%
0+680.00	0+680.00	637.001	638.443	6,58,250.761	20,33,837.491	2.0%	2.0%
0+700.00	0+700.00	637.299	638.541	6,58,270.611	20,33,839.933	2.0%	2.0%
0+720.00	0+720.00	637.484	638.640	6,58,290.461	20,33,842.376	2.0%	2.0%
0+740.00	0+740.00	637.502	638.738	6,58,310.312	20,33,844.818	2.0%	2.0%
0+760.00	0+760.00	637.598	638.836	6,58,330.162	20,33,847.260	2.0%	2.0%
0+780.00	0+780.00	637.977	638.935	6,58,350.012	20,33,849.702	2.0%	2.0%

E. Earthwork Calculations Using AutoCAD Civil 3D

The output data as generated by the software is shown in Volume Report.

1) VolumeReport

Prepared by:
Uttam Kumar Verma
Date: 14-02-2025 19:14:44
Alignment: Unnamed Road
Sample Line Group: SL Collection-1
Start Station: 0+000.00
End Station: 0+793.26
Mass Haul Diagram: Unnamed road mass haul

Table 4.12 Volume Report

Station	Cut Area (Sq.M.)	Cut Volume (Cu.M.)	Fill Area (Sq.M.)	Fill Volume (Cu.M.)	Cum. Cut Vol. (Cu.M.)	Cum. Reusable Vol. (Cu.M.)
0+020.00	63.71	0.00	0.00	0.00	0.00	0.00
0+040.00	56.40	1,201.04	0.00	0.00	1,201.04	0.00
0+060.00	49.30	1,056.98	0.00	0.00	2,258.02	0.00
0+080.00	43.68	929.82	0.00	0.00	3,187.83	0.00
0+100.00	38.52	821.95	0.00	0.00	4,009.78	0.00
0+120.00	34.60	731.18	0.00	0.00	4,740.96	0.00
0+140.00	33.46	680.65	0.00	0.00	5,421.62	0.00
0+160.00	33.10	665.67	0.00	0.00	6,087.29	0.00
0+180.00	34.75	678.53	0.00	0.00	6,765.82	0.00
0+200.00	33.21	679.56	0.00	0.00	7,445.37	0.00
0+220.00	32.27	654.75	0.00	0.00	8,100.12	0.00
0+240.00	34.58	668.44	0.00	0.00	8,768.56	0.00
0+260.00	32.37	669.46	0.00	0.00	9,438.02	0.00
0+280.00	31.42	637.85	0.00	0.00	10,075.88	0.00
0+300.00	27.77	591.84	0.00	0.00	10,667.71	0.00
0+320.00	23.61	513.81	0.00	0.00	11,181.52	0.00

0+340.00	21.25	448.62	0.00	0.00	11,630.14	0.00
0+360.00	21.18	424.27	0.00	0.00	12,054.40	0.00
0+380.00	17.88	390.55	0.00	0.00	12,444.96	0.00
0+400.00	14.87	327.51	0.00	0.00	12,772.46	0.00
0+420.00	11.21	260.83	0.00	0.00	13,033.29	0.00
0+440.00	8.98	202.04	0.00	0.05	13,235.33	0.05
0+460.00	5.39	144.22	0.30	3.14	13,379.55	3.19
0+480.00	3.38	88.04	0.12	4.23	13,467.59	7.42
0+500.00	0.78	41.59	0.42	5.40	13,509.19	12.82
0+520.00	0.00	7.80	7.36	77.87	13,516.99	90.69
0+540.00	0.00	0.00	10.33	176.95	13,516.99	267.64
0+560.00	0.00	0.00	16.58	269.08	13,516.99	536.72
0+580.00	0.00	0.00	16.07	326.50	13,516.99	863.21
0+600.00	0.00	0.00	16.27	323.39	13,516.99	1,186.60
0+620.00	0.00	0.00	18.19	344.59	13,516.99	1,531.19
0+640.00	0.00	0.00	20.15	383.46	13,516.99	1,914.66
0+660.00	0.00	0.00	18.55	386.97	13,516.99	2,301.63
0+680.00	0.00	0.00	14.17	327.17	13,516.99	2,628.80
0+700.00	0.00	0.00	9.89	240.64	13,516.99	2,869.43
0+720.00	0.00	0.00	10.54	204.34	13,516.99	3,073.77
0+740.00	0.00	0.00	12.25	227.89	13,516.99	3,301.66
0+760.00	0.00	0.00	13.42	256.67	13,516.99	3,558.33
0+780.00	0.00	0.00	8.10	215.20	13,516.99	3,773.53

V. CONCLUSIONS

1) The use of AutoCAD Civil 3D for roadway geometric design makes the design process to be completed within a very short time and with much ease and amazing precision. These capabilities of AutoCAD Civil 3D eliminate the major disadvantages of the manual design approach that is cumbersome, time consuming and highly prone to costly errors.
2) The solutions for road design in AutoCAD Civil 3D software make defining, annotating, and analyzing your road design more efficient and help your design comply with sound engineering standards.
3) Using criteria-based design, road modeling with real-time analysis and designer feedback helps expedite the design process and minimizes problematic issues.
4) 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 designs needs, will automate many repetitive and/or difficult road design tasks, such as labeling and updating cross section sheets.
5) Autodesk offers an abundance of manuals and training courses for AutoCAD Civil 3D. Autodesk also offers technical support and an extensive online knowledge base for AutoCAD Civil 3D.
6) Accessing and displaying Survey Data with the Civil 3D software is found to be straightforward. Survey data can be saved in any Windows directory and accessed directly from that location. AutoCAD Civil 3D offers different data import and export options in most widely used formats in the market.
7) The key element of a road model in the software is road geometry which is the basis of the structure of all design models. The more simple and accurate is the design of geometry in CAD system the better is the computerization of the design process, saving in user time and money.
8) Civil 3D software lack dynamic relationship of the project data, i.e. a change in one object does not cause an automatic renewal and representation of the other related project data. If a change or modification is to be incorporated in the design model at any stage then the model reports need to be generated again to incorporate the desired change in the design.

9) In Civil 3D the survey data of the area under study is analyzed and the horizontal alignment are created by alignment tool and vertical alignment are created by profile tool and the alignment tool all the design parameters like speed, criteria file can be incorporated in the input data. We can change the location of alignment in the drawing itself and the changes are incorporated automatically in the results once the module is run again.
10) By using DGPS method makes survey easier and possible to truncate the time for the field survey. It eradicates manual errors like reading and recording co- ordinates.
11) Output of horizontal design and vertical design using AutoCAD Civil 3D are shown in section 4.2 and 4.3 respectively.
12) Few cross sections drawn by the software are displayed in Fig. 4.1 to Fig.4.5.
13) The reports of Earthwork calculation are shown in section 4.5.

VI. SCOPE FOR FUTURE STUDY

1) Only one formats of survey data are analyzed in the study i.e. DGPS. Other formats like total station, auto level and GPS data may be considered for the future study.
2) More complex problems like interchange design, and rotary intersection etc. may be studied to check the capabilities of software in handling complex situations.
3) Other software like Inroads, Bentley MX Road and other road designing software available in the market may also be incorporated in future study to recommend the most suitable software in the market.
4) Fictitious data used can be tested on the actual data.

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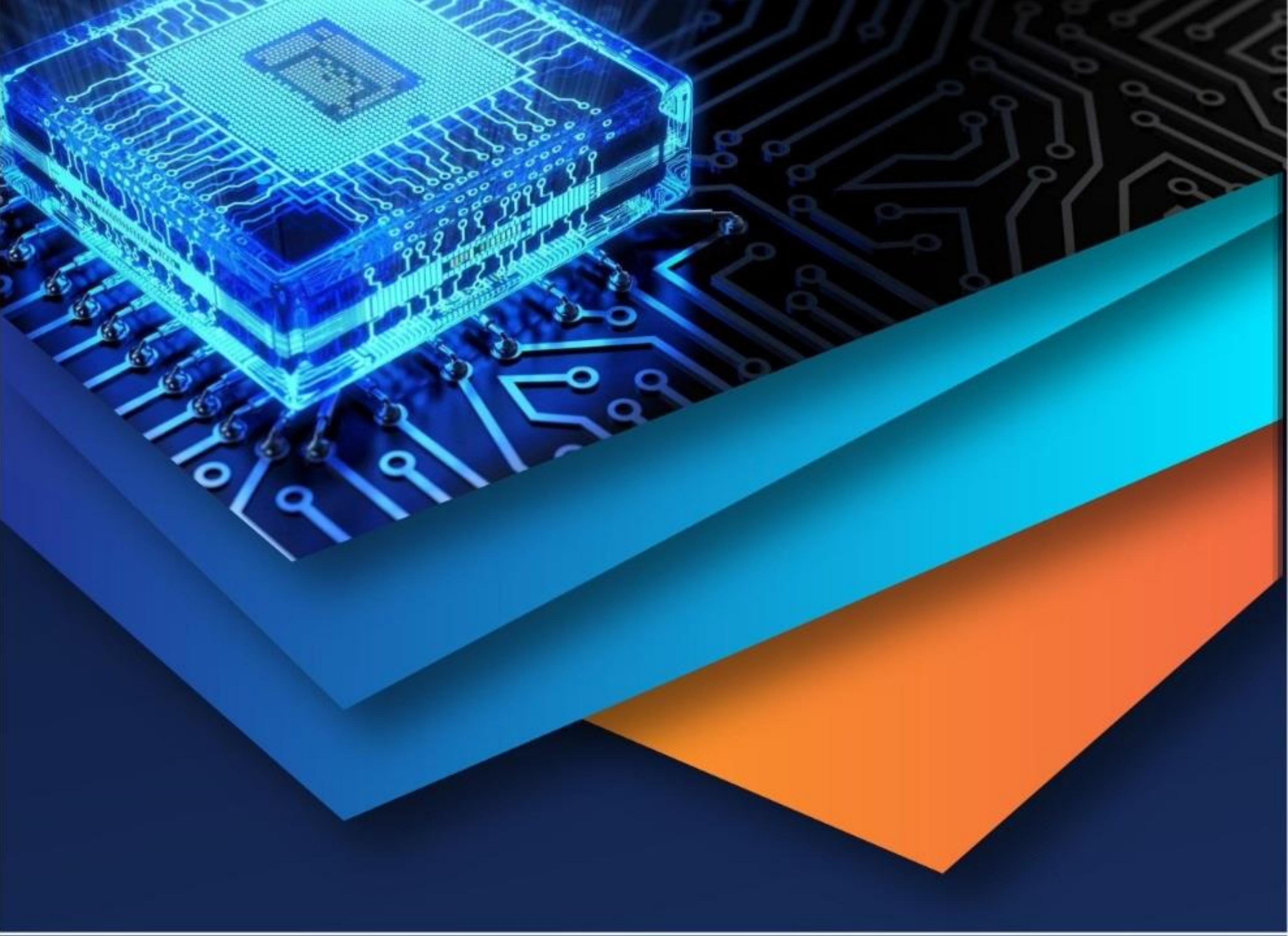

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