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Geometrical Road Design From NH163 to CJITS Boys Hostel Using AUTOCAD Civil 3D

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Abstract: *This project investigates the application of drone-based surveying for the design of a 743.43-meter-long roadway. The primary aim was to enhance the precision and efficiency of the roadway design process through the integration of Unmanned Aerial Vehicles (UAVs) and geospatial technologies. The road alignment was surveyed using a drone equipped with RTK GNSS, ensuring high positional accuracy. The UAV-collected data was processed using photogrammetry software like Agisoft Metashape, which generated Digital Elevation Models (DEM) and orthoimages. These outputs were crucial in visualizing the terrain and ensuring the accurate modeling of the project area.*

Following the data collection, geometric design principles were applied to develop the road's horizontal alignment, which included a circular curve, and the vertical profile was adjusted using the existing terrain data. The design ensured that the roadway conformed to standard highway design parameters, considering factors such as camber, slope, and design speed. Special attention was given to the cut and fill volume estimation, which is integral to the earthwork calculations and material requirements for the project.

The study incorporated AutoCAD Civil 3D for the design of the horizontal and vertical alignments, cross-sectional layers, and the preparation of construction drawings. Global Mapper was used to analyze cross-drainage structures at chainages 80m and 100m by generating flow networks and watersheds, which informed the optimal drainage design.

In addition to road alignment design, the project also addressed superelevation design by calculating the roadway's cross slope adjustments at different points along the curve to enhance road safety. Sight Distance Analysis (SSD and OSD) was conducted to ensure adequate visibility for drivers and prevent potential safety issues caused by obstructions.

The project concludes that the combination of drone-based surveying, photogrammetry, and advanced design software offers a significant improvement in the accuracy, cost-effectiveness, and speed of road design. The integrated approach also improves planning for earthworks, material management, and construction scheduling. This method presents a viable solution for future road projects, especially in challenging terrains where traditional surveying techniques may not be as effective.

Keywords: Unmanned Aerial Vehicles

I. INTRODUCTION

In recent years, advancements in Unmanned Aerial Vehicles (UAVs) and drone-based surveying have significantly transformed the landscape of civil engineering, particularly in the design and construction of infrastructure projects such as roads and highways. UAV technology, when integrated with Real-Time Kinematic (RTK) GNSS, offers a highly accurate and efficient method for data collection over large areas. This technology minimizes human error, reduces the time required for surveying, and provides high-resolution spatial data that is critical for engineering design. The project at hand focuses on the use of drone-based surveying for the design of a 743.43-meter-long roadway, incorporating the latest technologies and design methodologies to ensure both precision and efficiency.

The project aimed to survey and design a roadway alignment, starting with data collection through drone surveys that provided high-accuracy geospatial data. The drone was equipped with RTK GNSS to ensure the precision of location

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data, a crucial factor for determining the topography of the land and informing subsequent design decisions. This data was then processed using photogrammetry software such as Agisoft Metashape to generate Digital Elevation Models (DEM) and orthoimages, which were used to map the terrain accurately.

One of the key objectives of this project was to develop the horizontal alignment of the roadway, incorporating a circular curve to enhance the flow of traffic while adhering to design guidelines and standards. In parallel, a vertical profile was created based on the existing terrain data, with a focus on creating smooth transitions in gradient for user safety and comfort. Additionally, a comprehensive analysis of earthwork volumes was performed to estimate cut and fill volumes, a critical aspect of construction planning and resource allocation.

A significant portion of the project also focused on drainage planning, an essential aspect of any road design to prevent water accumulation, erosion, and flooding. For this purpose, Global Mapper was employed to generate flow networks and watersheds at key chainages, specifically at 80m and 100m. These analyses helped identify the most suitable locations for cross- drainage structures, ensuring that the road design effectively managed surface water and met environmental and safety standards.

The project also incorporated superelevation design, an essential aspect of road safety when dealing with curves. Superelevation is the transverse slope of a roadway in a curve, designed to counterbalance the centrifugal force experienced by vehicles, thus improving vehicle stability and reducing the risk of accidents. The roadway's cross slope adjustments were carefully calculated at various points along the curve to meet the design speed and curve radius requirements.

Moreover, Sight Distance Analysis (both SSD and OSD) was conducted to ensure the design meets the visibility requirements for safe driving. Any obstructions along the alignment were identified and rectified to avoid accidents caused by limited visibility.

Through the integration of drone-based surveying, advanced photogrammetry, and cutting-edge design software such as AutoCAD Civil 3D, this project demonstrates the power of technology in improving the accuracy, speed, and cost-effectiveness of road design processes. The successful implementation of UAV-based surveying combined with thorough geospatial analysis can provide engineers and planners with highly reliable data for decision-making, enabling the creation of roads that are safer, more efficient, and environmentally sustainable.

II. LITERATURE REVIEW

Drone-Based Surveying

Efficiency and Accuracy**:** UAVs equipped with RTK GNSS systems enable rapid and precise data collection, achieving sub- centimeter accuracy. This advancement significantly enhances topographic mapping, roadway design, and construction monitoring, especially for large-scale infrastructure projects.

Comparative Studies**:** Research comparing UAV-based surveys with traditional methods demonstrates that drones offer higher efficiency and comparable accuracy, even in challenging terrains, thereby reducing labor and minimizing manual measurement errors.

Photogrammetry and Digital Elevation Models (DEM)

Model Generation**:** Photogrammetry software like Agisoft Metashape processes UAV-captured imagery to create DEMs and orthophotos, providing 3D terrain models essential for road alignment and grading decisions. These models offer high spatial resolution, facilitating detailed terrain analysis.

Accuracy Considerations**:** Studies indicate that UAV-derived DEMs can achieve vertical accuracies within 68 mm, making them reliable for civil engineering applications.

Horizontal and Vertical Alignment Design

Design Principles**:** Incorporating DEMs into road design allows for precise planning of horizontal and vertical alignments. This integration ensures compliance with safety standards, such as those outlined in IRC 73-1980, and facilitates the design of superelevation and vertical curves to enhance road safety and driver comfort.

Drainage Design and Watershed Analysis

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Geospatial Analysis**:** Advanced GIS tools like Global Mapper assist in analyzing flow networks and watersheds, crucial for designing effective drainage systems. These analyses help identify optimal locations for cross-drainage structures, minimizing the risk of flooding and ensuring road longevity.

Geospatial Software in Road Design

Integration and Simulation**:** Software such as AutoCAD Civil 3D integrates survey data and topographic models to create accurate road layouts, profiles, and cross-sections. It also facilitates the simulation of design alternatives, aiding in decision-making and optimization of design parameters.

OBJECTIVES

The primary objectives of this project are as follows:

To Design Road Alignment:

Develop a comprehensive road alignment, including both horizontal and vertical alignment, using advanced surveying and geospatial technologies. The design will focus on optimizing the road geometry to ensure safety, efficiency, and environmental sustainability.

To Conduct High-Precision Surveying Using Drone Technology:

Utilize drone-based photogrammetry to capture accurate topographic data**,** facilitating the creation of Digital Elevation Models (DEMs) and orthophotos, which will be used for road design and analysis.

To Analyze Drainage and Hydrology:

Use Global Mapper software to generate flow networks and watershed models to identify potential drainage problems and optimize cross-drainage structures at critical chainages (80m and 100m) along the road alignment.

To Integrate Survey Data with Geospatial Software for Design Development:

Incorporate collected survey data into AutoCAD Civil 3D for developing detailed road design and ensuring that the design aligns with required geometric standards and safety regulations.

To Ensure Design Accuracy and Compliance with Standards:

Validate the alignment, drainage, and geometric design through cross- referencing with Indian Road Congress (IRC) design standards and guidelines to ensure compliance with local regulations**.**

To Provide Recommendations for Future Road Planning:

Based on the findings of the design, drainage analysis, and survey data, provide recommendations for further improvements and future road construction projects**.**

STUDY AREA

The study area for this project is a road alignment located near the cjits college starts from NH163and ends at cjits boys hostel . The specific area for analysis stretches from Station 0+000.00m to Station 0+743.43m**,** covering a variety of terrains that pose both challenges and opportunities for road design.

Key characteristics of the study area include:

Geographical Features:

The area includes sections of flat terrain interspersed with gentle slopes**,** making it suitable for incorporating horizontal and vertical road alignments**.**

Drainage challenges are identified at certain locations, requiring analysis and design for cross-drainage structures**.**

The study area also includes areas prone to waterlogging and requires a strategic approach to watershed management to mitigate potential flooding risks.

Land Use:

The surrounding land is a mix of agricultural and undeveloped terrain, with some urban developments at the western end.

The road is expected to facilitate increased traffic as the region develops, and thus, the design needs to accommodate future growth.

Hydrological Considerations:

A significant portion of the study area is part of a larger watershed, necessitating the implementation of drainage solutions.

Key chainages **(**80m and 100m**)** are especially critical for the design of cross-drainage structures to manage surface water flow.

The road will serve as a critical link for the local population and will improve transportation accessibility across the region. The area's hydrological data, slope profiles, and soil types have been factored into the design process to ensure a well-integrated infrastructure solution.

INSTRUMENTS AND SOFTWARE USED

To conduct this project, several advanced instruments and software applications were employed for data collection, analysis, and design development. These tools are vital for ensuring high accuracy and efficiency throughout the process.

Instruments:

Drone (UAV) with RTK GNSS:

The drone equipped with RTK GNSS technology was used for high-precision aerial surveying, capturing topographic data, and generating detailed Digital Elevation Models (DEMs). This tool was critical in obtaining rapid and accurate survey data over the entire study area, especially for difficult-to- reach locations.

Global Positioning System (GPS):

A high-precision GPS system was used to gather Ground Control Points (GCPs) for further georeferencing and calibration of drone imagery. This ensured the accuracy of photogrammetric processing in software like Agisoft Metashape.

Software:

Agisoft Metashape:

This photogrammetric software was used for image processing of the drone data. It converted the captured drone images into 3D models**,** orthophotos**,** and Digital Elevation Models (DEMs**)**. The models produced were then incorporated into the road design process.

AutoCAD Civil 3D:

AutoCAD Civil 3D was utilized for the geometric design of the road alignment, including horizontal and vertical alignment**,** cross- sections**,** and superelevation**.** The software also enabled the integration of surveyed data to develop a comprehensive road design plan, including earthworks**,** volume calculations**,** and alignment modifications**.**

Global Mapper:

Global Mapper was used to analyze hydrological data, specifically for generating flow networks and watershed models**.** It was essential for identifying the locations of cross-drainage structures at critical chainages (80m and 100m) along the road alignment.

Microsoft Excel:

Excel was employed for data management, including organizing survey data and conducting basic calculations related to alignment and drainage.

Google Earth (for Preliminary Surveying):

Google Earth was used during the **preliminary analysis** to assess the study area's general features and identify any preliminary obstacles or constraints in the road design.

II. METHODOLOGY

The methodology for this project involves several key steps, incorporating advanced surveying techniques, software applications, and civil engineering design practices. The process includes drone surveys for data collection, AutoCAD Civil 3D for road design, and hydrological analysis using Global mapper software.

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Drone Survey:

The drone survey was conducted using a high-precision RTK GPS- equipped drone, which allowed for rapid and accurate data collection over the entire study area. The drone was flown along the proposed road alignment, capturing high-resolution imagery and topographic data to generate Digital Elevation Models (DEMs) and orthophotos. The process of the drone survey included the following steps:

Pre-Survey Planning: A flight plan was established using the study area's coordinates, considering factors such as terrain type and accessibility.

Flight Execution: The drone followed the pre-planned flight path, collecting georeferenced images at specified intervals along the alignment.

Post-Processing: The collected data was processed using Agisoft Metashape software to generate 3D models, DEM, and orthophotos.

The primary purpose of the drone survey was to create accurate topographic models that would serve as the foundation for the subsequent design work in AutoCAD Civil 3D.

Drone Outputs – DEM, Orthoimages

Once the drone data was processed, the following outputs were generated:

Digital Elevation Model (DEM): A high-resolution DEM was created, representing the elevation of the terrain across the study area. This model was crucial for analyzing the topography, identifying slopes, and facilitating accurate design adjustments.

Orthophotos: The drone captured orthorectified images of the entire study area, which were used for visual inspection, feature identification, and verification of topographic data.

These outputs were imported into AutoCAD Civil 3D for detailed road alignment design, including the creation of horizontal and vertical alignments and drainage planning.

Traffic Data and Design

AADT (Annual Average Daily Traffic): Field survey and estimation conducted.

Vehicle Class Considered: Commercial vehicles (≥ 3 axles)

Average Daily Traffic (ADT) over 7 days: 1,500 vehicles/day

Growth Rate: 5% per annum

Commercial Vehicle Percentage: ~35%

Design Life: 15 years

Vehicle Damage Factor (VDF): 2.5 Calculated MSA = 1.5 million standard axles

CBR Value Calculation:

CBR @ 2.5 mm = (80 / 1370) × 100 = 5.84%

CBR @ 5.0 mm = (112 / 2055) × 100 = 5.45%

Final Design CBR Value (Average of Multiple Tests) = 7%

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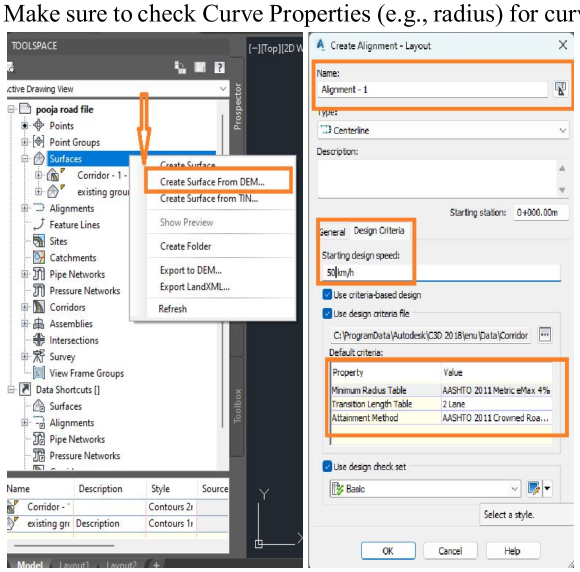
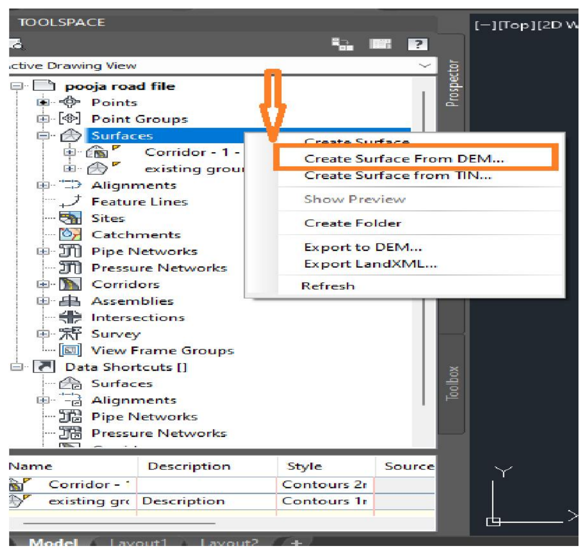
Alignment Creation
Start a New Drawing**:**
Open Civil 3D and create a new drawing or use an existing template suited for road design (e.g., Standard or Custom templates).
Create Alignment**:**
Go to Home → Create Design → Alignment → Alignment Creation Tools**.**
Set the Alignment Type to "Centerline" or as needed.
Draw the alignment by clicking along your design line or specifying tangent**,** curve**,** and spiral points. Use Stationing (start, increment, and direction) to define the alignment.
Make sure to check Curve Properties (e.g., radius) for curved segments





Alignment curve details

Tangent Data

300.243 Course: S 76° 26' 20.7387" E

1 Tangent

Start Station:	0+000.00
End Station:	0+293.94
Length:	293.945m
Design Speed:	50
Design Checks:	

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Subdivision Street		Cleared

2 Circular Curve

Start Station:	0+293.94	
End Station:	0+443.19	
Radius:	112.000m	
Design Speed:	50	
Design Criteria:		
Minimum Radius:	86.00	Cleared
Design Checks:		

3 Tangent

Start Station:	0+443.19	
End Station:	0+743.43	
Length:	300.243m	
Design Speed:	50	
Design Checks:		
Subdivision Street		Cleared

Create Existing Ground Profile
Create Existing Ground Surface (EG)**:**
Import your survey or topographic data to create a surface, if not already available.
Go **to** Home → Create Ground Data → Surfaces → Create Surface**.**
Select your surface type (e.g., TIN surface for triangulated data).
Create Existing Ground Profile**:**
Go to Home → Profile → Profile Creation Tools**.**
The existing ground profile will be generated along the alignment

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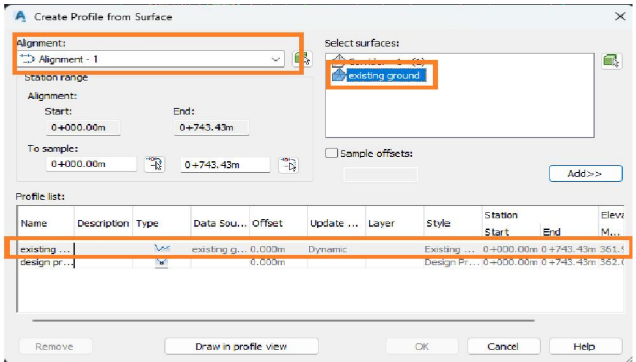
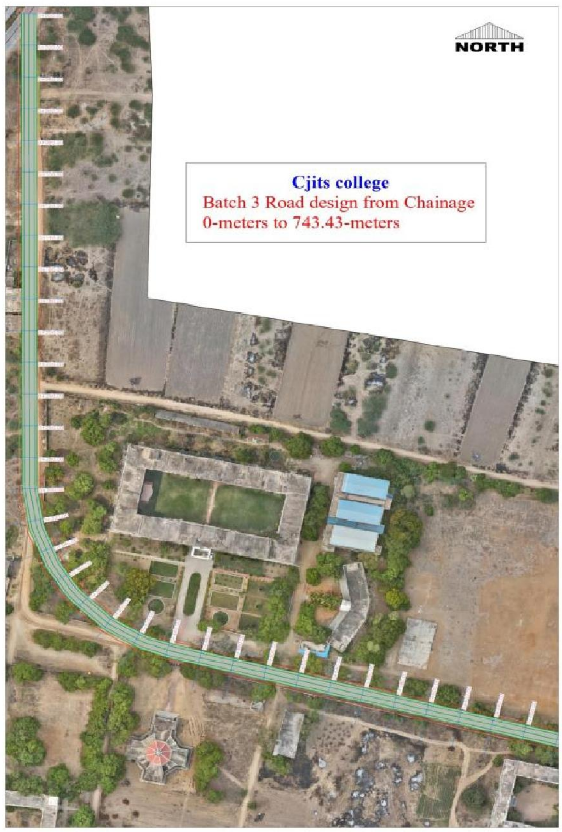




Create Design Profile

Design Profile Creation:

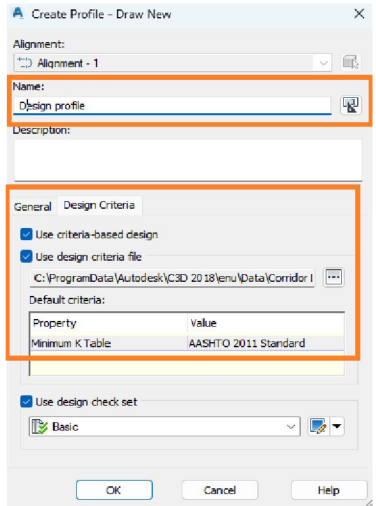
Once the existing ground profile is created, you can create a proposed profile for your road.

Go to Home → Create Design → Profile → Profile Creation Tools.

Select your alignment and click on Create Profile View to generate a new profile view.

Define vertical curves, grades, and elevations for the proposed design profile.

Adjust slopes and curves for smooth transitions, including vertical curves to meet design standards



Station Range: Start: 0+000.00, End: 0+743.43

PV I	Station	Easting	Northing	Elevation Existing	Elevation Design	Elevation Difference	Point Type
0	0+000.00	308963.2464	1960983.4066	365.160m	365.160m	-0.000m	Start
1	0+020.00	308963.2781	1960963.4066	364.312 m	365.076 m	-0.765m	Regular
2	0+040.00	308963.3098	1960943.4066	364.299 m	364.993 m	-0.694m	Regular
3	0+060.00	308963.3416	1960923.4066	364.352 m	364.910 m	-0.558m	Regular
4	0+080.00	308963.3733	1960903.4067	364.292 m	364.826 m	-0.534m	Regular
5	0+100.00	308963.405	1960883.4067	364.083 m	364.743 m	-0.660m	Regular
6	0+120.00	308963.4368	1960863.4067	364.048 m	364.660 m	-0.611m	Regular
7	0+140.00	308963.4685	1960843.4068	364.052 m	364.576 m	-0.524m	Regular
8	0+160.00	308963.5003	1960823.4068	364.058 m	364.493 m	-0.435m	Regular
9	0+180.00	308963.532	1960803.4068	364.272 m	364.410 m	-0.137m	Regular
10	0+200.00	308963.5637	1960783.4068	364.015 m	364.326 m	-0.311m	Regular
11	0+220.00	308963.5955	1960763.4069	363.666 m	364.243 m	-0.577m	Regular
12	0+240.00	308963.6272	1960743.4069	363.598 m	364.159 m	-0.561m	Regular

13	0+260.00	308963.659	1960723.4069	363.544m	364.076m	-0.532m	Regul ar
14	0+280.00	308963.6907	1960703.4069	363.413m	363.993m	-0.580m	Regul ar
15	0+300.00	308963.8861	1960683.4102	363.456m	363.909m	-0.454m	Regul ar
16	0+320.00	308966.7708	1960663.6461	363.515m	363.826m	-0.311m	Regul ar
17	0+340.00	308973.1203	1960644.7088	363.490m	363.743m	-0.253m	Regul ar
18	0+360.00	308982.7325	1960627.2004	363.462m	363.659m	-0.197m	Regul ar
19	0+380.	308995.30	1960611.67	363.522	363.576	-0.054m	Regul
	00	17	78	m	m		ar
20	0+400.00	309010.4283	1960598.6346	363.590m	363.493m	0.097m	Regul ar
21	0+420.00	309027.6311	1960588.4856	363.624m	363.409m	0.215m	Regul ar
22	0+440.00	309046.3631	1960581.5537	363.511m	363.326m	0.185m	Regul ar
23	0+460.00	309065.7944	1960576.8201	363.457m	363.242m	0.215m	Regul ar
24	0+480.00	309085.2369	1960572.1306	363.385m	363.159m	0.226m	Regul ar
25	0+500.00	309104.6793	1960567.441	363.280m	363.076m	0.205m	Regul ar
26	0+520.00	309124.1217	1960562.7514	363.253m	362.992m	0.261m	Regul ar
27	0+540.00	309143.5641	1960558.0618	362.959m	362.909m	0.050m	Regul ar
28	0+560.00	309163.0066	1960553.3723	362.678m	362.826m	-0.148m	Regul ar
29	0+580.00	309182.449	1960548.6827	362.406m	362.742m	-0.336m	Regul ar
30	0+600.00	309201.8914	1960543.9931	362.859m	362.659m	0.200m	Regul ar
31	0+620.00	309221.3338	1960539.3035	362.500m	362.576m	-0.075m	Regul ar
32	0+640.00	309240.7763	1960534.6139	362.344m	362.492m	-0.148m	Regul ar
33	0+660.00	309260.2187	1960529.9244	362.422m	362.409m	0.013m	Regul ar
34	0+680.	309279.66	1960525.23	362.377	362.325	0.052m	Regul ar

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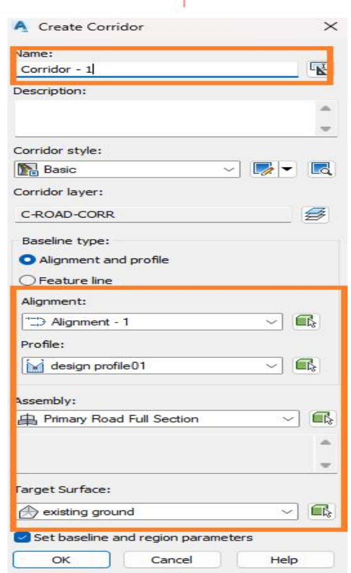
	00	11	48	m	m		
35	0+700.00	309299.1035	1960520.5452	362.457 m	362.242 m	0.215m	Regul ar
36	0+720.00	309318.546	1960515.8556	362.245 m	362.159 m	0.086m	Regul ar
37	0+740.00	309337.9884	1960511.1661	362.033 m	362.075 m	-0.042m	Regul ar
38	0+743.43	309341.3241	1960510.3615	362.061 m	362.061 m	0.000m	End

Basic Assembly Creation
Create Road Cross-Section Template (Assembly):
Go to Home → Create Design → Corridor → Assembly Creation Tools.
Design a basic cross-section template for your road. For a basic design, include:
Lane widths.
Shoulders.
Ditches or sidewalks.
Curbing (if applicable).
Use Subassemblies such as "Lane", "Shoulder", "Curb", and "Ditch" for typical road components.

- Modify the Assembly:

Customize the template to match your project's road geometry and expected cross-sections. For example, adjust lane widths, shoulder slopes, and ditch depths



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Corridor Creation

Create the Corridor**:**

Go to Home → Create Design → Corridor → Corridor Creation Tools**.**

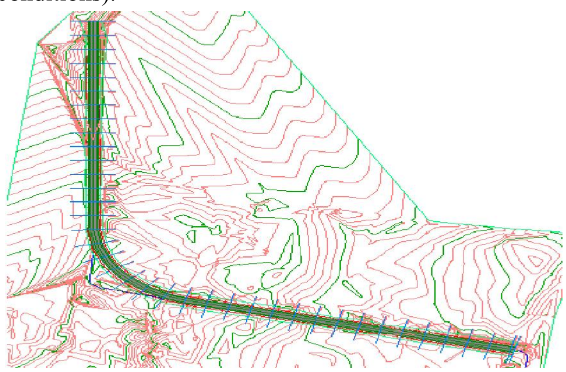
Select the alignment, profile (proposed), and the assembly (cross-section template).

Specify the corridor limits by choosing a range of stations.

Choose the appropriate target surfaces for the corridor (e.g., existing ground surface, proposed design surface).

Corridor Modifications**:**

Adjust the corridor to ensure it fits within design requirements (e.g., modify the super elevation for curves or adjust the cross-section based on existing conditions).



Corridor Surface Creation

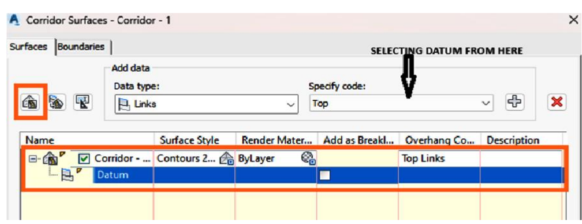
Create Corridor Surface**:**

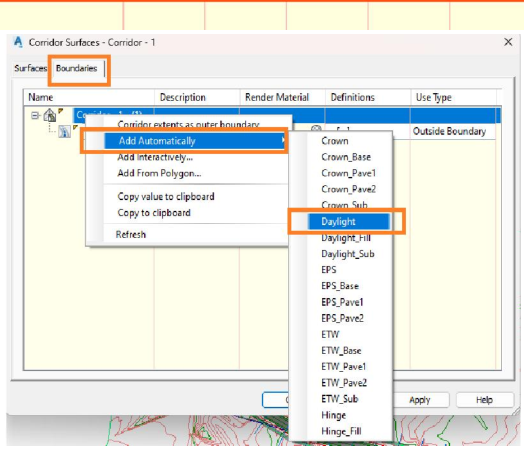
Go to Home → Create Design → Surfaces → Create Corridor Surface**.**

Select the corridor you just created.

Choose the type of surface (e.g., Top**,** Bottom, or Existing depending on what you want to calculate).

This will generate a surface based on the corridor geometry, which can then be used for further calculations (earthwork, volume, etc.).



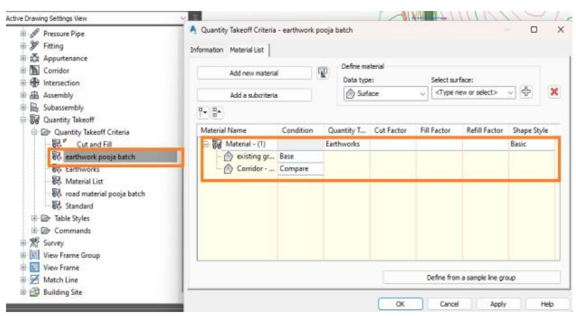


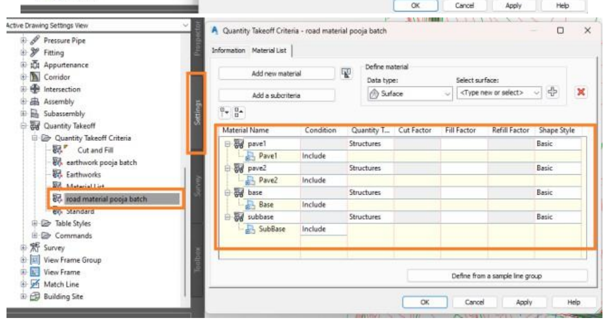
Sample Line Creation

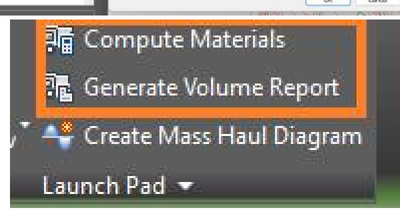
• Create Sample Lines:
o Go to Home → Create Design → Section Views → Sample Line Creation Tools.
o Select your alignment.
o Choose the range of stations where you want to create sample lines (you can create sample lines at every station or at specific intervals).
o Set the Sample Line Style (e.g., typical, detailed).
o Civil 3D will generate sample lines across the alignment at the selected intervals.
• Create Section Views:
o After creating the sample lines, go to Home → Create Design → Section Views → Create Section Views.
o Choose the sample lines you want to display and the station range.
o These will give you the cross-sectional profile of the road at different points along the alignment.

Quantity Takeoff and Material Computation

Create a New Quantity Takeoff**:**
Go to Analyze → Volumes → Create Volume Surface**.**
Define your surfaces (e.g., Existing Ground Surface and Corridor Surface).
This will create a volume surface used for earthwork calculations.
Calculate Material Quantities**:**
Go to Analyze → Quantities → Create Quantities**.**
Select the Volume Surface for cut/fill calculations.
The software will automatically calculate quantities based on the difference between the proposed corridor surface and the existing ground surface







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Generate Material Report

Generate Material Report:

Go to Output → Reports → Create Report.

Choose the Volume Report to generate a material takeoff, showing cut and fill quantities.

Include additional materials if needed (e.g., road base, asphalt, concrete for curbs, etc.).

Customize the report for your project's needs, including unit measurements (e.g., cubic yards, cubic meters).

Generate Cross Section Drawing

Generate Cross-Section Sheets:

Go to Output → Create Section Sheets.

Select the cross-section views you created earlier.

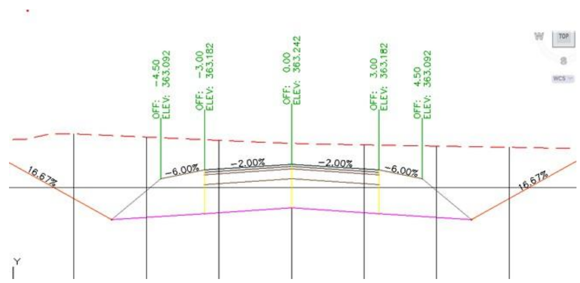
Set the sheet layout and number of sheets.

Civil 3D will generate the drawing sheets with cross- sectional information.

Annotate Cross Sections:

Annotate the cross-sections with dimensions, elevations, and any additional notes.

Customize the section view styles to show key information such as ditch depths, road width, and lane markings.



PLACEMENT OF 1VENT PIPE CULVERT AS PER IRC:SP:13-2022

During the analysis of the drainage pattern using Global Mapper, a flow network was generated to understand the interaction between natural watercourses and the proposed road alignment. It was observed that a stream intersects the road between chainages 80 m and 100 m. To ensure proper drainage and avoid waterlogging or road damage, a vent pipe culvert was proposed at this location.

As per the guidelines provided in IRC:SP:13-2022 – Guidelines for the Design of Small Bridges and Culverts, vent pipe culverts are suitable for low discharge conditions and where the stream width is relatively narrow. These culverts are economical, easy to install, and effectively allow the passage of water beneath the roadway without interrupting the flow.

Based on the observed topography and anticipated discharge at the location, a single vent pipe culvert was deemed sufficient. The culvert will be designed with appropriate dimensions, bedding, and inlet/outlet treatments to ensure durability and performance during peak flow conditions. This provision not only maintains the natural flow regime but also protects the structural integrity of the road.

The design adheres to relevant hydrological, hydraulic, and structural considerations as prescribed by IRC:SP:13-2022, ensuring both functionality and compliance with national standards.

Specifications of the Vent Pipe Culvert

The proposed vent pipe culvert at chainage 90 m (between 80 m and 100 m) is designed in accordance with IRC:SP:13-2022, which outlines the criteria for small bridges and culverts. The key specifications are as follows:

Vent Pipe Culvert – Circular cross-section, typically made from RCC (Reinforced Cement Concrete) or NP (Non-Pressure) class concrete pipes.

Single Vent – Adequate for the low discharge observed at the location.

900 mm (commonly used for small water crossings with moderate flow).

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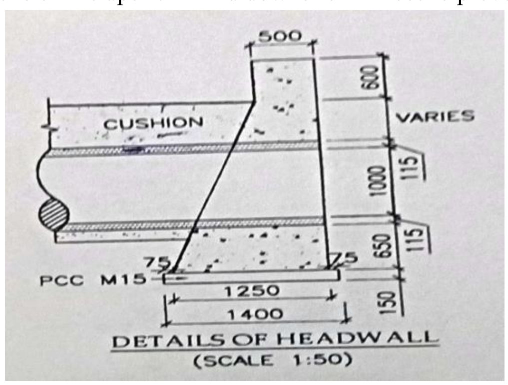
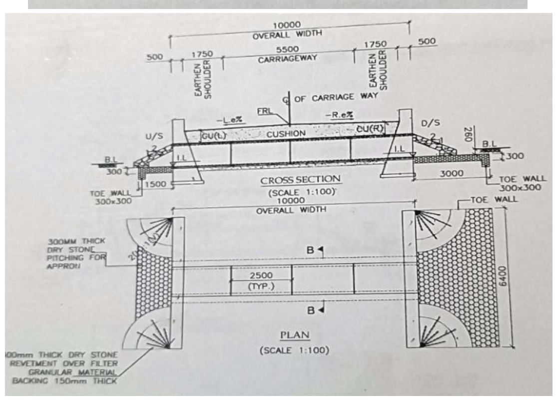
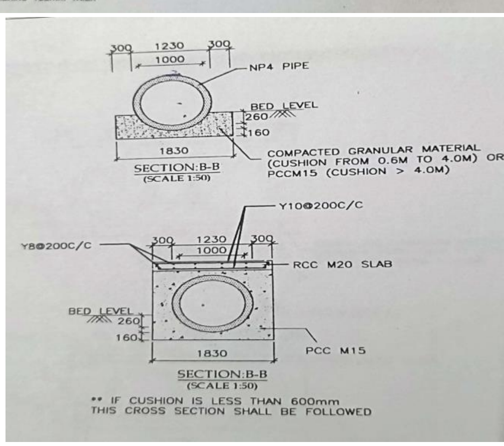
Final size to be confirmed based on site-specific hydraulic calculations.
NP3 Class RCC Pipe – Suitable for moderate loading conditions and buried installations.
Depends on road width and embankment slopes.
Typically ranges between 6m to 12m, including headwall extensions.
Pipe laid with a minimum slope of 1 in 100 to maintain self- cleansing velocity and prevent silting.
RCC or Masonry Construction on both inlet and outlet sides.
Headwalls to extend at least 500 mm above the road surface to prevent overtopping
Wing walls flared to guide water efficiently into and out of the pipe.
Minimum 150 mm thick bedding of sand or granular material beneath the pipe.
Pipe covered with at least 600 mm earth cushion over the crown to resist traffic loads.
Pitching with stone or concrete blocks on the upstream and downstream faces to prevent erosion







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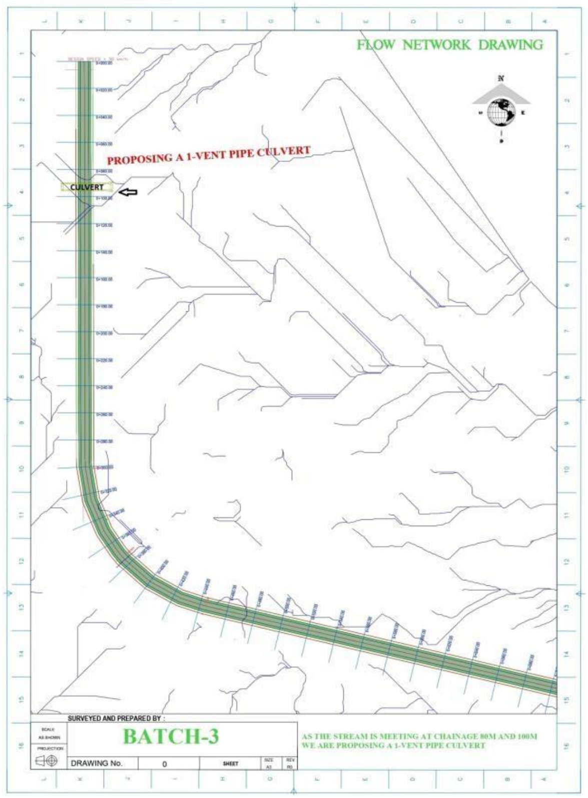

III. RESULTS

The primary aim of this project was to design a 743.43-meter-long roadway using drone-based surveying, resulting in the generation of precise Digital Elevation Models (DEM) and orthoimages. These products provided the necessary topographic data to develop both the horizontal and vertical road alignments, along with other essential road design elements

Horizontal Alignment Design

The horizontal alignment was divided into three distinct segments:

Segment 1 (Tangent): This section runs from Station 0+000.00 to 0+293.94, covering a distance of 293.945 meters with a course direction of S 00° 05' 27.32" E.

Segment 2 (Circular Curve): This curve runs from Station 0+293.94 to 0+443.19, covering a length of 149.243 meters. The curve has a radius of 112 meters, with a delta angle of 76° 20' 53.41". The design speed is 50 km/h, and the minimum radius required was 86 meters, confirming that the curve was within the acceptable design limits. Key parameters for the curve include: Tangent Length: 88.053 meters

Mid-ordinate: 23.953 meters Chord Length: 138.444 meters

Segment 3 (Tangent): This final tangent section spans from Station 0+443.19 to 0+743.43, covering 300.243 meters, with a course direction of S 76° 26'
20.74" E.

Vertical Profile Design

The vertical alignment has been designed with an initial gradient of -0.417%, ensuring a smooth and safe transition in elevation. The road's design elevation varies from 365.160 meters at the start (Station 0+000.00) to
362.061 meters at the end (Station 0+743.43). This ensures that the road complies with basic topographical and design standards. No vertical curves were incorporated in this design.

Pavement Structure Design
The pavement structure thickness was selected from IRC based on CBR and AADT traffic test values
Sub-base: 0.30 meters of granular material Base: 0.10 meters of aggregate material
Pavement Layers (2 Bituminous layers): Each layer is 0.025 meters thick
Camber: A 2% crowned cross slope was included for drainage purposes.
Road Cross Section & Slopes
The road's cross-section was designed with the following parameters:
Carriageway Width: 6.0 meters (3.0 meters each lane) Shoulder Width: 1.5 meters on each side
Total Road Width: 9.0 meters
Cut Slope: 6:1 (Horizontal:Vertical ratio) Fill Slope: 9:1 (Horizontal:Vertical ratio)
These dimensions ensure sufficient space for traffic and safety features, as well as proper drainage and slope considerations.
Earthwork and Volume Calculations
A crucial part of the project was estimating the cut and fill volumes needed for road construction. The following calculations were made: Total Cut Volume: ≈ 266 m^3
Total Fill Volume: ≈ 4,166 m^3
Net Volume (Fill – Reusable Cut): ≈ 3,900 m^3
These calculations allow for better planning and material management, ensuring the right amount of material is available for construction while minimizing wastage.
Pavement Volume Calculations
The volume of each pavement layer was calculated every 20 meters to ensure proper material
Distribution along the road. The volumes are as follows: Sub-base: ~2,766.53 m^3
Base: ~446.06 m^3
Pavement Layers 1 & 2 (each): ~111.51 m^3
Summary of osd ssd Findings:
Throughout the entire alignment, the Actual Sight Distance is consistently greater than or equal to the Minimum Sight Distance of 45 meters.
No obstructions were reported at any station, and no violations were observed in the sight distance requirements. The sight distance along the road alignment meets the design criteria and no obstructions or violations were identified. The alignment is clear, ensuring safe visibility for drivers along the proposed road.
In overtaking sight distance some points are violated so we ensure to place of regulatory and warning signs.

IV. CONCLUSION

The application of drone-based surveying, using UAVs with RTK GNSS, significantly improved the efficiency and accuracy of the road design process for the 743.43-meter-long roadway. The collected data allowed for the precise generation of DEMs and including the circular curve, pavement structure, and earthwork estimations, IRC met required standards and provided accurate information for future construction.

By integrating cutting-edge tools like AutoCAD Civil 3D and GIS software, this approach offers a faster, more cost-effective method for road design that can be applied to similar projects. The results highlight the effectiveness of drone-based surveying in overcoming challenges related to terrain, data accuracy, and road construction, and provide a solid foundation for future infrastructure projects.

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