Design of Highway using Open Road Software

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Abstract: *Roads offer a dynamic involvement to sustainability and economic growth, contribution major social benefits. Roads are important for growth and development. Roads to open more regions and encourage socio-economic development. The location of design for the centerline of highway on the surface is named alignment. The primary prerequisite for alignment is to be short, easy, safe, and economical. The mail component of geometric design are Horizontal alignment, vertical alignment, and cross-section and quantity takeoff. This paper demonstrates the usual design of the roadway with the assistance of AutoCAD Open Road. It is modelling software helps to accomplish modelling during a convenient and relaxed way. Open Road modelling is quick and easy to understand to construct alignment, AutoCAD Open Road uses topography and survey data obtained from LIDAR or related technologies. Once alignment has been demarcated, geometry can be tested and evaluated using the IRC model and specifications of the Open Road built-in program. Vertical geometry is often enhanced once horizontal geometry has been achieved. Open Road avails integrated checks for transition length & sight distance to analyze horizontal geometry and vertical geometry, thus avoiding tiresome calculations. Open Road also helps to make use of catchment and contours in drainage design. Thus, AutoCAD Open Road is therefore very useful and even user-friendly.*

Index Terms -Global Mapper, Open Road Software, Horizontal and Vertical geometry.

I. INTRODUCTION

Roads are required to make sure comfort and protection for users, to enable efficient movement of traffic. The geometric structure of the roads has three important parts, which are horizontal, vertical, cross section. Which, when combined, give a 3-dimensional road layout. Horizontal alignment consists of three geometric components, including curves, tangents, and transitions. Vertical alignment may be a longitudinal section, alongside geometric additives like crest curves, sag curves, and gradients. Highway geometry formulations depend on selection, estimated and thus act by certain design standards as sight distance, vehicle stability, driver consolation, drainage, economy, and aesthetics. Numerous Computations and Measurements pursue design process. The activities shall integrate the alignment and tracing the profile of the roads consisting of coordinates and elevations, horizontal radii curves, vertical curve length, sight distance calculation, and earth quantity calculation, with various calculations and analyzes planned for ideal alignment while conforming with design standards and limitations. The Open Road upgrade has modified this paradigm so that both design and development are carried out concurrently. When performed manually, geometrical design are often very cumbersome, time-consuming, and quite helpless to costly blunders, the normal technique is additionally based, especially, on a two-dimensional analysis that does not ensure a pleasant layout. The goal of this study is to point out how geometrical design is completed quickly and perfectly during a short period to enable professionals from those within the developing world to use road design. This paper shows a typical design of the highway with the support of Open Road that saves time and energy. Highway design faces tremendous challenges without 3D modeling. It consumes a lot of effort to cut and fill that amounts. The volume computing approach can be used

II. SOFTWARE DESCRIPTION

The software system for highway engineering projects and design development by Bentley organisation. Open Road software is a complicated, string-based modelling tool that permits rapid and accurate design of all highway types and facilities.Normally the alignment and therefore the pavement composition decide the value of a highway project and best available tool must be deployed. Today is extremely competitive and sensitive business environment a timely preparation of construction and reconstruction depends on modern computer-based facilities.

Bentley Open Road software is the new developed software by Bentley which is most widely used the world over in the road projects. Looking at the functionality of the software it is observed that if we want to gain more accuracy in Highway Design the Bentley Open Road software help to get the benefits over it. Following are few importance functions which help to achieve the highway design in minimum time with more accuracy.

- Survey Data Extraction and Modification
- Understanding of Contour of Surface
- Highway alignment modification based on Topography of area
- Vertical Profile management based on calculation
- Design codes implementations to cross check the design criteria
- 3D Modelling of highway with embedded of other structural component like Retaining wall, plumbing system and more
- Easy way for Quantity Take off
- Material cost finalisation22
- Plan and profile preparation with Cross section detailing
- Tracking alignment with respect to google earth function

III. Literature Review

Raghuveer et al (2018) explained the geometric design of highway considering various geometric elements such as alignment, profile, cross section and determined that horizontal curve at grade separation is more dangerous and causes 25% of more accidents.

Ali Aram (2010) studied its particularly important at radius below 200m, two-lane highway safe factor on a horizontal curve, that section is the high crash rate in a horizontal curve that section is the similar length and traffic composition.

Golakati (2015) carried out study between 2 villages where consider the geometric feature of the road such as horizontal radius, superelevation, K-value, visibility etc and carries out regression analysis for study be to conclude that geometric feature has to be given more important while designing a road.

Shinkar (2016) carried out planning and design of purposed bypass road used civil 3D and carries out capacity analysis by forecast traffic volume data for 15 years and concluded that high design precision and saving in time were attained by using Civil 3D.

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

Neeraj and Kazal (2015) perform the study on geometric design of highway. The study was mainly weighting on the importanc of planning and design of geometric feature of the highway.

Neeraj and Kazal (2015) highlighted on the importance of planning and designing of geometric features of the highway during the initial alignment itself taking into consideration the future growth of traffic flow and likelihood of the road being 20 upgraded to design speed standard at a advanced stage as it is very expensive and rather difficult to improve the geometric elements of a highway in stages at a later date.

Anitha and Dhanya (2013) carried out to study in this paper is based on the safety of the geometry of the highway. Were curves being state and end, their curves are inadequate length and radius is caused an accident. In multiple horizontal curves are provided in alignment which should be safe and speed properly maintained for proper movement of traffic vehicle.

Nisarga and AmateH (2018) deliberate 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. Civil 3D is a software application used by civil engineers and professionals to plan and design the projects & one Place change firstly or directly all project should be updated, project compilation helping for us, more accurate and smarter.

IV. Study Area

I have considered the location of project to be performed at Kalmeshwar (SH 248) to Khaperkheda (SH 48) Project Corridor in Nagpur Maharashtra.

Figure 1 :. Location of stretch from Kalmeshwar to Khaperkheda

V. Objective of Study

1. To study about the Open Roads Designer (ORD) software
2. To create terrain for pavement section by using ORD.
3. To draw horizontal and vertical alignments in the road section by using ORD.

VI. DESIGN METHODOLOGY

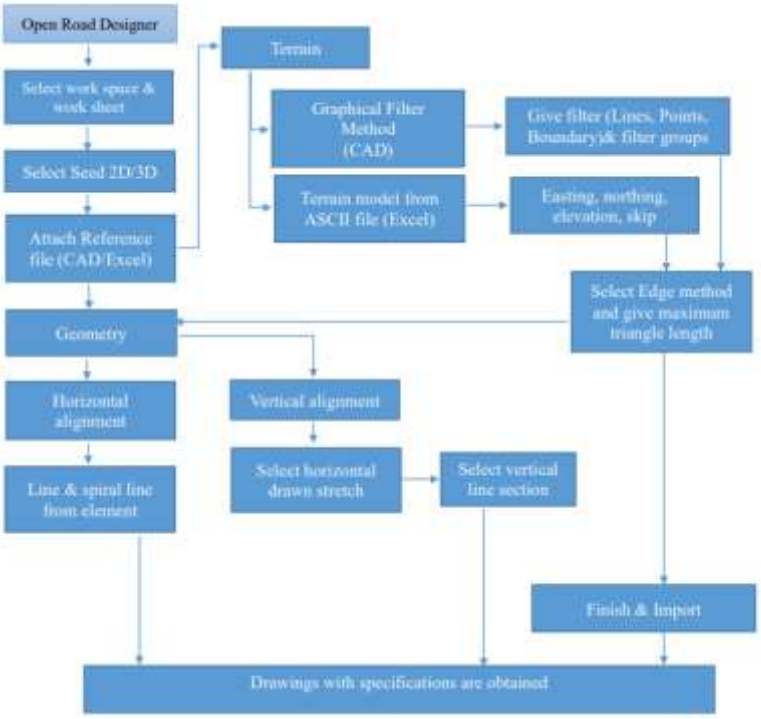

Figure 2 : Methodology

- **Data collection**

Survey Data Collection, the existing surface data is needed for the highway design. The survey data on the current route is received from the Google earth and converted into Global Mapper which performed the road development. The survey data covered Easting, Northing and elevations.

- **Surveying**

The survey was conducted before the standard design of project road started e.g. Location study, Reconnaissance, Preliminary, Final location survey. Location study is about getting a general idea of the field. The Reconnaissance survey is out there for viewing and points at the most features of the sector but does not clarify them. The reconnaissance data are generally used for planning and scheduling detailed studies and inquiries and a couple of suitable alignments also can be selected for any modifications or changes within the preliminary survey, Preliminary surveys use the field surveying duties to classify the survey data and collect all required data such as Easting, Northing, Elevations, etc. and alternative alignment of the data.

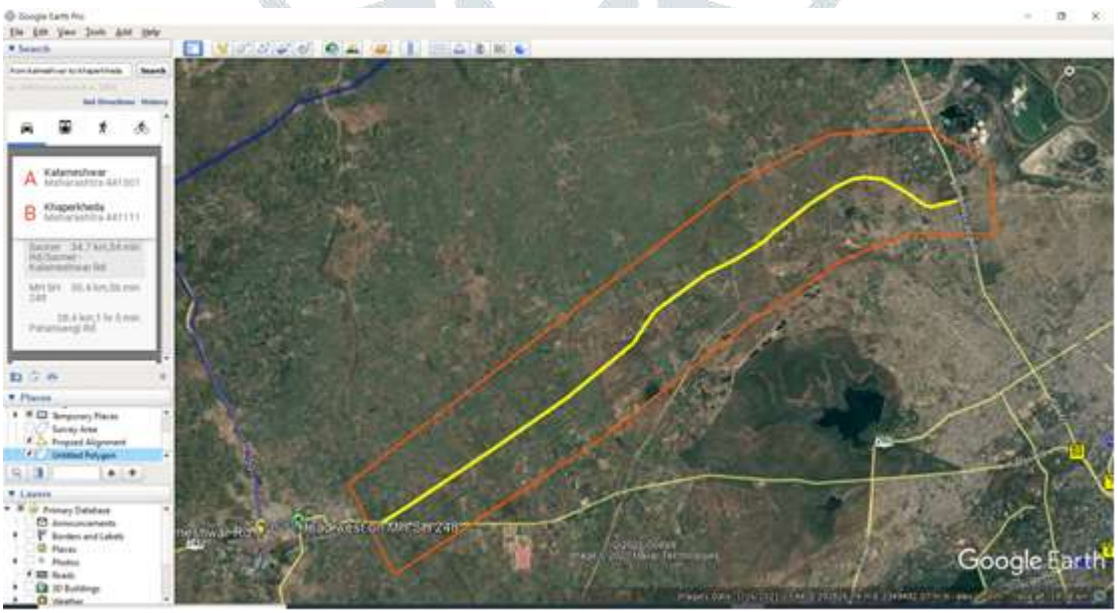

Figure 3: Survey data collecting from Google Earth software

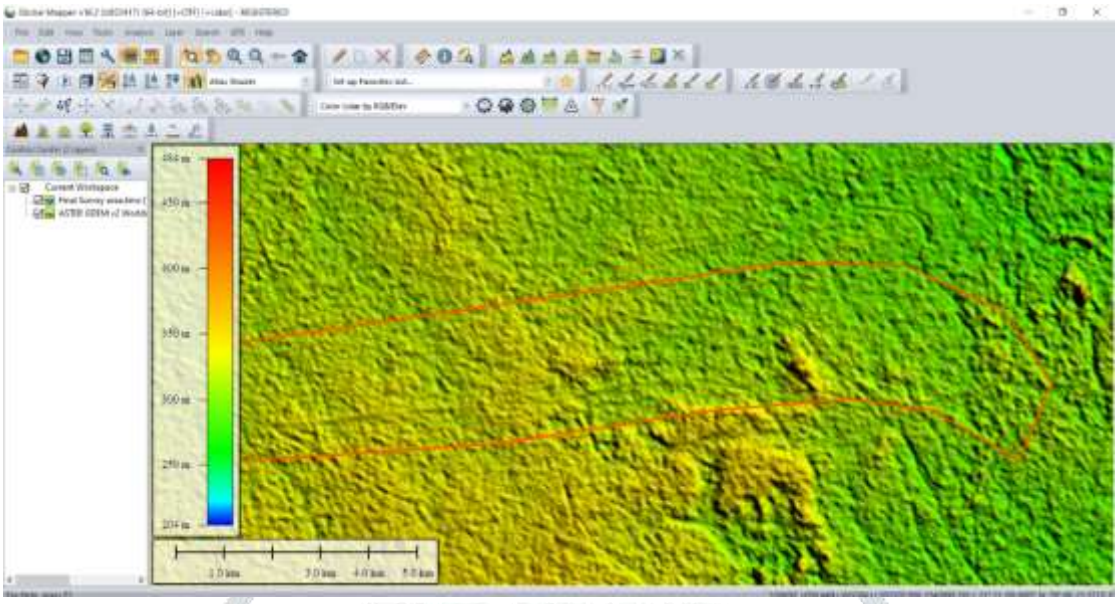

Figure 4: Survey data converting to ASCII File by Global Mapper Software

Easting	Northing	Elevation
284829.2	2349763	314.457
284713.7	2347327	327.454
290675.4	2347742	336.79
295026.4	2348418	336.82
297876.6	2348659	317.243
299597.7	2348417	312.074
301386.1	2347403	304.62
302066.2	2348970	303.499
301133.8	2350439	309.18
299018	2351436	287.214
296524.1	2351472	296.509
284829.2	2349763	314.457

Figure 5 : Survey data in Easting, Northing & Elevation Format (Terrain & Alignment)

Easting	Northing	Elevation
285078.1	2348561	319.902
285892	2348603	324.591
288408.7	2348808	339.946
290423.1	2349002	330.977
292461.2	2349367	343.847
292861.1	2349578	328.483
293271.5	2349784	319.52
294522.5	2349932	308.224
294797.6	2349967	309.221
295491	2349929	314.006
295745.7	2349930	310.901
296338.6	2349959	306.739
296805.5	2350054	314.659
297806.9	2350215	308.055
298558.8	2350260	301.144
298981.5	2350235	298.786
299273.5	2350126	298.897
299620.2	2349887	304.965
299882.3	2349486	301.891
300064.2	2349144	307.015
300177.9	2348904	299.41
300241.8	2348808	304.707
300300	2348754	304.201
300357.2	2348727	305.791
300645.9	2348648	304.505
300876	2348580	299.832
301031	2348536	311.419

VII. Highway Design carried out using Open Road Software

Step No 1: Importing of Terrain Data

Identified terrain data from global mapper using excel function by converting into CSV format which need to import in open road software using navigation tool.

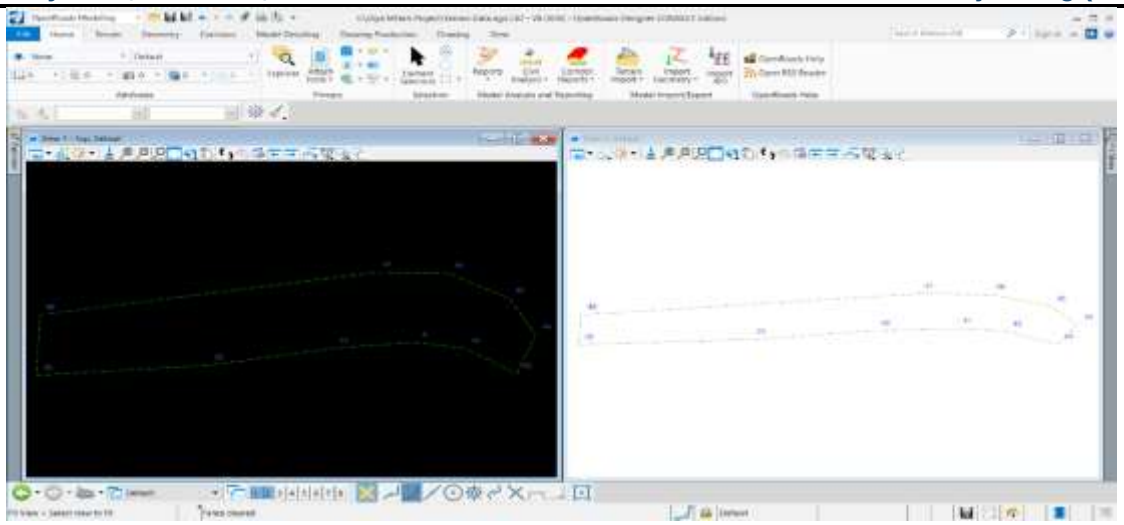

Figure 6 : Terrain Data importing to ORD software

Step No. 2: Importing of Terrain data with alignment points

Open road software allows to manage the data in different way. It is essential to manage the highly captured data in easy way i.e. X-Ref which means terrain data imported in software as reference for an alignment.

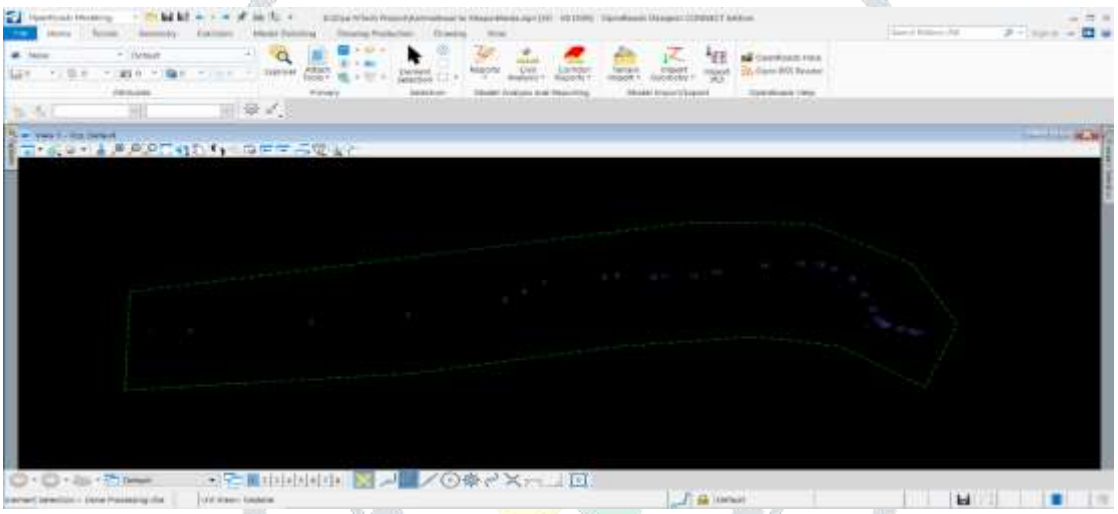

Figure 7 :Terrain obtained using ASCII File with Alignment points

Step No. 3: Finalization of Horizontal Alignment by using survey points

Alignment needs to draw using the survey point imported in open road software. This is important process of geometric design which help to understand the requirement of curves to smoothing the flow.

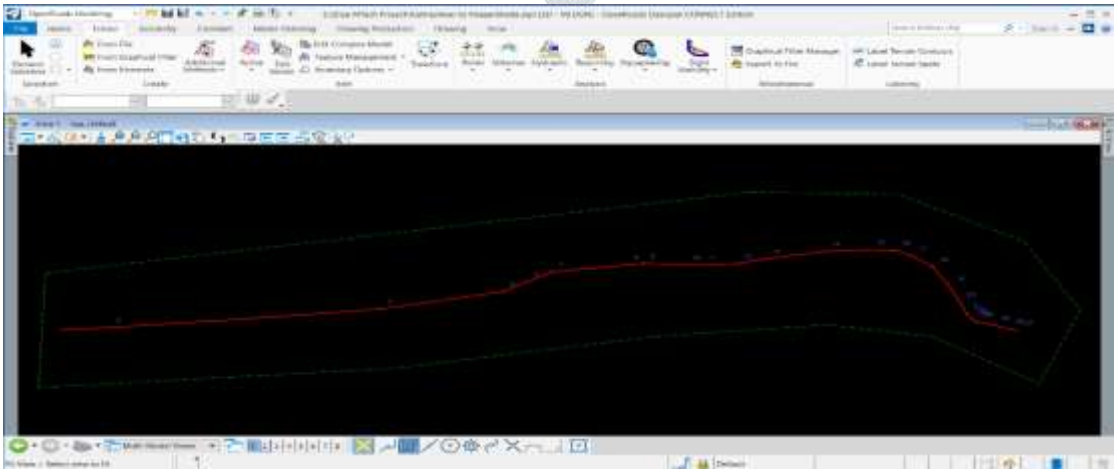

Figure 8 : Horizontal Alignment by using Survey points

Alignment needs to modify based upon the calculations for curves. Provided image references reflect the procedure procure to create the alignment using tentative points based on methodology.

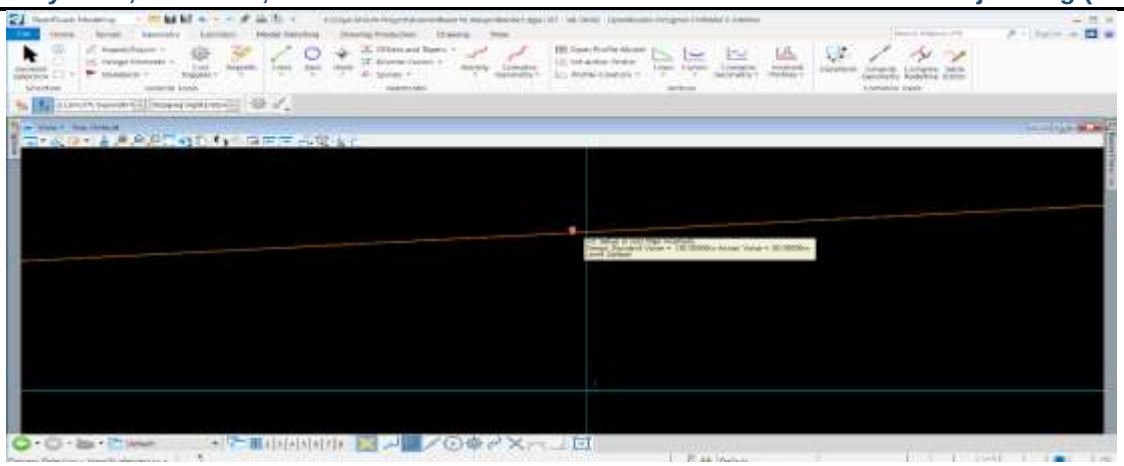

Figure 9: Error Identification According to standards

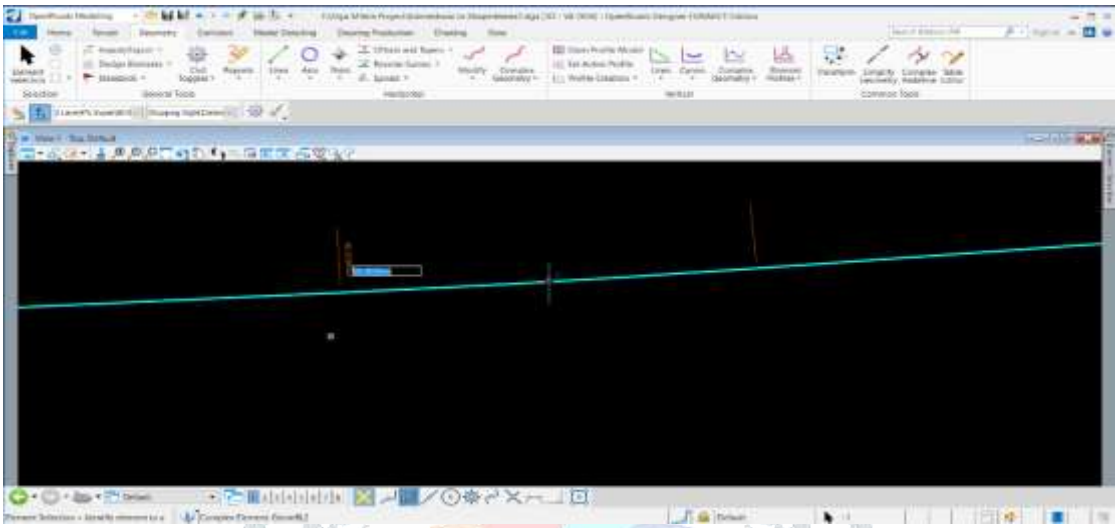

Figure 10: Error Identification and resolved According to standards

Open Road software all to implement the IRC standard table for horizontal and vertical alignment. Based on IRC-73-1980 open road applied the standard to perform the analysis for 60km/hr speed on proposed alignment and accordingly provided the warnings for the curves.

Provided images reflect the error elimination using open road software where the minimum radius for plain & rolling terrain as per IRC 38 is 135m and the same is updated in alignment to eliminate the errors. Due to this functionality, it is observed that open road software help to eliminate the error according to IRC Standards.

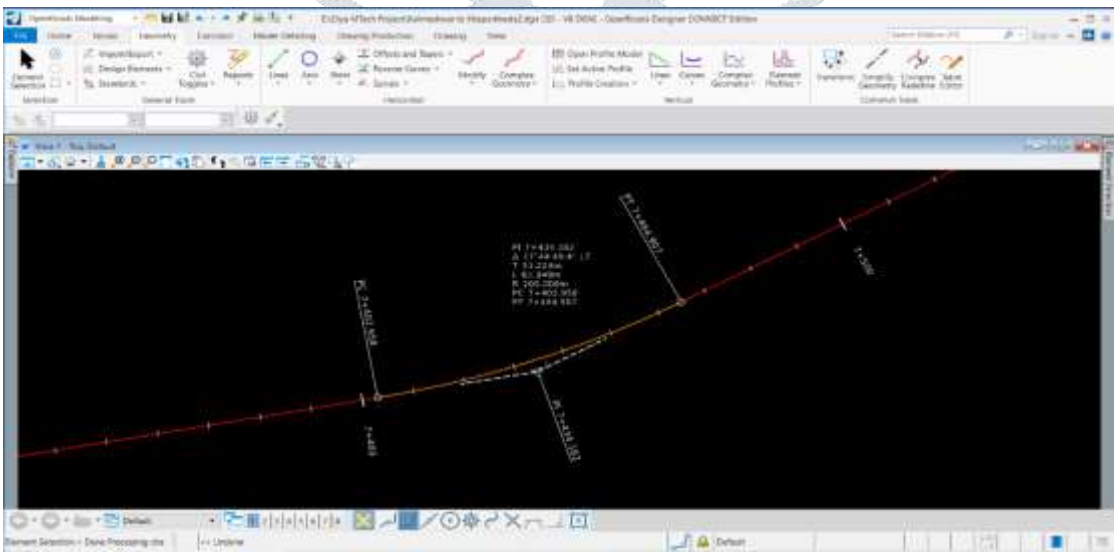

Figure 11 :Annotation of Horizontal Alignment

Annotation of an alignment play important role while design. As per the above image it is observed that based on provided data the all-relevant details can be provided to alignment using the annotation tool.

The final report of horizontal alignment as shown in below image.

Figure 12 : Horizontal Alignment review report

Step No. 4: Finalization of Vertical Alignment (Profile View)

Vertical profile provides an information about terrain elevation. During highway design it is important to validate the cut and fill of earthwork. This data can be used for quantity takeoff of earthwork which can be justify using the vertical profile. In this project I have created vertical profile based on the existing terrain and topography of an area.

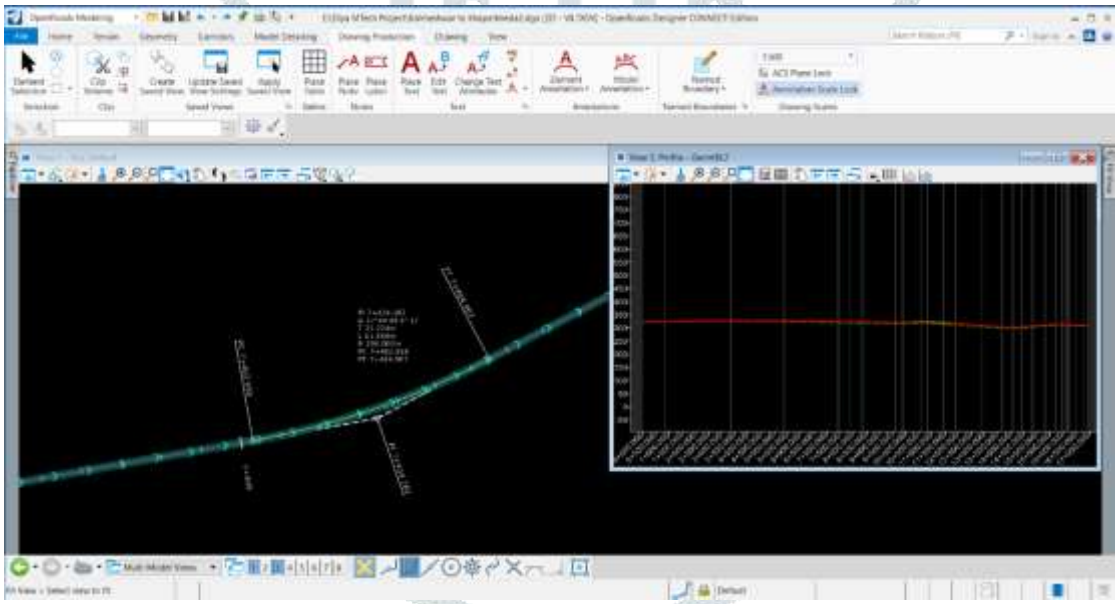

Figure 13 :Profile view of Vertical Alignment

Step No. 5: Template Creation

It consists of all layers of Highway like soil subgrade, subbase, basecourse & wearing course according to type of pavement. As per IRC 37-2012 the pavement thickness identification were done using the appropriate values for the period of 10 years. Consideration was made in term of number of commercial vehicles per day i.e., CV/day which we considered as 5000 CV./day. The number of years between the last count and year of completion is 3 year. As we don't have axile load spectrum so we identified the vehicle damage factor using the provided spreadsheet as per IRC 37-2012.

The vehicle damage factor was identified based on the terrain area for number of commercial vehicles as per the last count is 5000 CV/day where the VDF is 4.5.

As per the details required the single wheel load identified in P is 8160 KN & input tire pressure is 0.56 MPa. According to this the spreadsheet provide details required for the IIT pave software such as no of layers, elastic modulus, poisons rations, layers of thicknesses, wheel load, analysis point and radius.

Based on the above identified details IIT pave application provided the thickness of each layer given below and same provided in the figures.

- Layer 1: 50mm (Bituminous Layer)
- Layer 2: 135mm (Granular Base)
- Layer 3: 250mm (Granular Sub Base)
- Layer 4: 200mm (Subgrade)

Select the type of carriage way=		Two-lane single carriageway roads	
Number of commercial vehicles as per last count in both direction =		5000	CV/day
	P=	5000	CV/day
Number of years between the last count and the year of completion of	x=	3	Years
Annual growth rate of commercial vehicles in decimal=	r=	7	%
Lane distribution factor=	D=	0.5	
If you have axle load spectrum then click on **YES** or click on **NO**		YES	NO
Vehicle Damage Factor (VDF)=	F=	12.42	
Design life in years=	n=	10	
Initial traffic in the year of completion of construction in terms of the number of Commercial Vehicles Per Day (CVPD)=	A=	6125.22	
Cumulative number of standard axles to be catered for in the design in terms of msa=	N=	191.84	msa

Click on the type of pavement

- Granular Base and Granular Subbase
- Cemented Base and Cemented Subbase with Crack Relief Interlayer of Aggregate
- Cemented Base and Cemented Subbase with SAMI at the Interface of Cemented Base and the
- Foamed Bitumen/Bitumen Emulsion Treated RAP/Aggregates Over Cemented Sub-base
- Cemented Base and Granular Sub-base with Crack Relief Layer of Aggregate interlayer Above the Cemented Base

Figure 14: Input for IIT pave software 1

Select the type of terrain =		Rolling/Plain	
Number of commercial vehicles as per last count =	P=	5000	CV/day
Vehicle damage factor (VDF)=	4.5		
Sprectrum is recommended do you still want to continue with this value	NO		

Figure 15 :Input for IIT pave software 2

Temperature=	40 °C			
Select the type of bitumen=	BC and DBM for VG30 bitumen			
$M_{R\_bituminous\ layer}$=	1250 MPa			
CBR of Compacted Borrow Material 500 mm Thick=	10 %			
CBR of soil below 500mm of compacted subgrade=	4 %			
Effective CBR of the subgrade=	7.8 %	≈	8 %	(effective CBR value upto 15%)
Modulus of elasticity of subgrade $E_{subgrade}$=	65.53 Mpa			
Thickness of individual layers (in mm)		N=		
from **plate 6**				
GSB= ### Granular Base= 250	DBM= 135	BC= 50		
Resilient modulus of granular layer $M_{R\_granular}$=	204.85 Mpa			
Choose Reliability factor =	90 %			
Allowable Horizontal Tensile Strain in Bituminous layer (for 4.5% air void and bitumen content 4.5% by weight of mix) =	133.19 ×10^-6			
Allowable Vertical Tensile Strain in Bituminous layer (for 4.5% air void and bitumen content 4.5% by weight of mix) =	276.30 ×10^-6			
Input center to centre distance between tyres(mm)	300			
Load on single wheel **P**(kN)	8160			
Input tyre pressure **p**(Mpa)	0.56			
Input radius of tyre imprint	68.09			
Clear distance between tyres	163.82			

Figure 16 :Input for IIT pave software 3

No of Layers	5				
Layer: 1 Elastic Modulus(Mpa)	1250	Poison Ratio	0.5	Thickness(mm)	50
Layer: 2 Elastic Modulus(Mpa)	1250	Poison Ratio	0.5	Thickness(mm)	135
Layer: 3 Elastic Modulus(Mpa)	204.85	Poison Ratio	0.35	Thickness(mm)	250
Layer: 4 Elastic Modulus(Mpa)	204.85	Poison Ratio	0.25	Thickness(mm)	200
Layer: 5 Elastic Modulus(Mpa)	65.53	Poison Ratio	0.5		
Wheel Load(Newton)	8160000	Tyre Pressure(Mpa)		0.56	
Analysis Points	3				
Point: 1 Depth(mm):	50.0	Radius(mm):		0.0	
Point: 2 Depth(mm):	50.0	Radius(mm):		150.0	
Point: 3 Depth(mm):	635.0	Radius(mm):		150.0	
Wheel Set	2				

BACK TO START PAGE

Run IITPAVE_EX

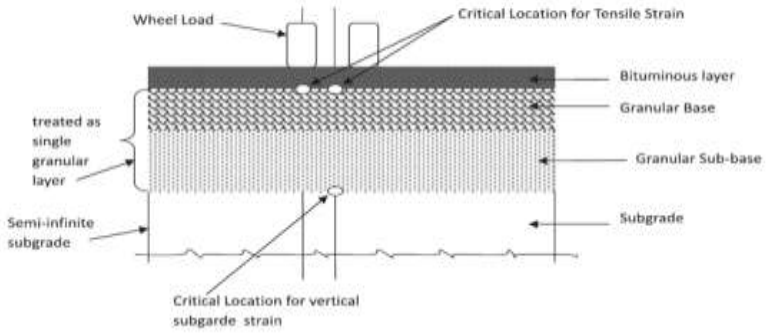

Figure 17: Input for IIT pave software 4

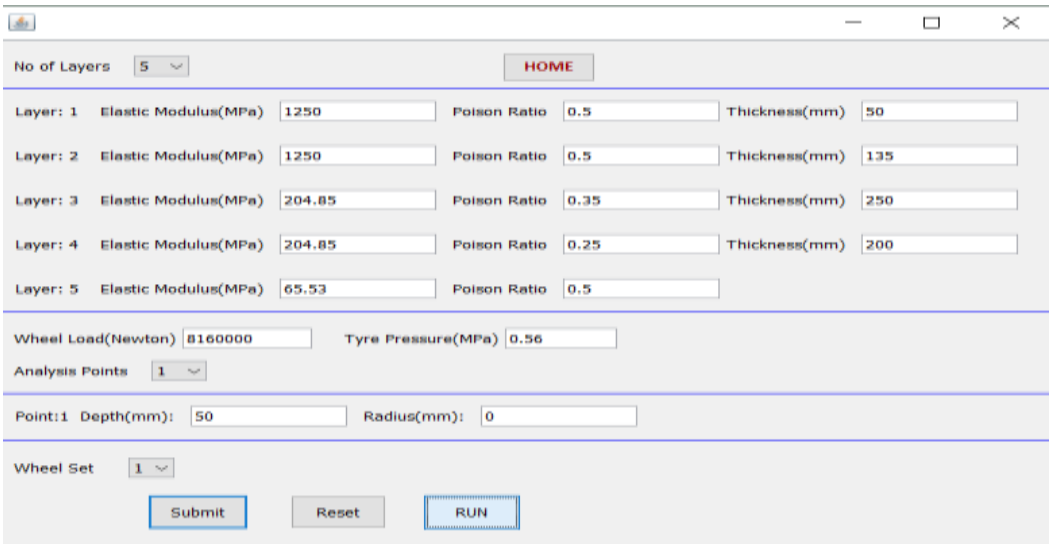

Figure 18: Input for IIT pave software 5

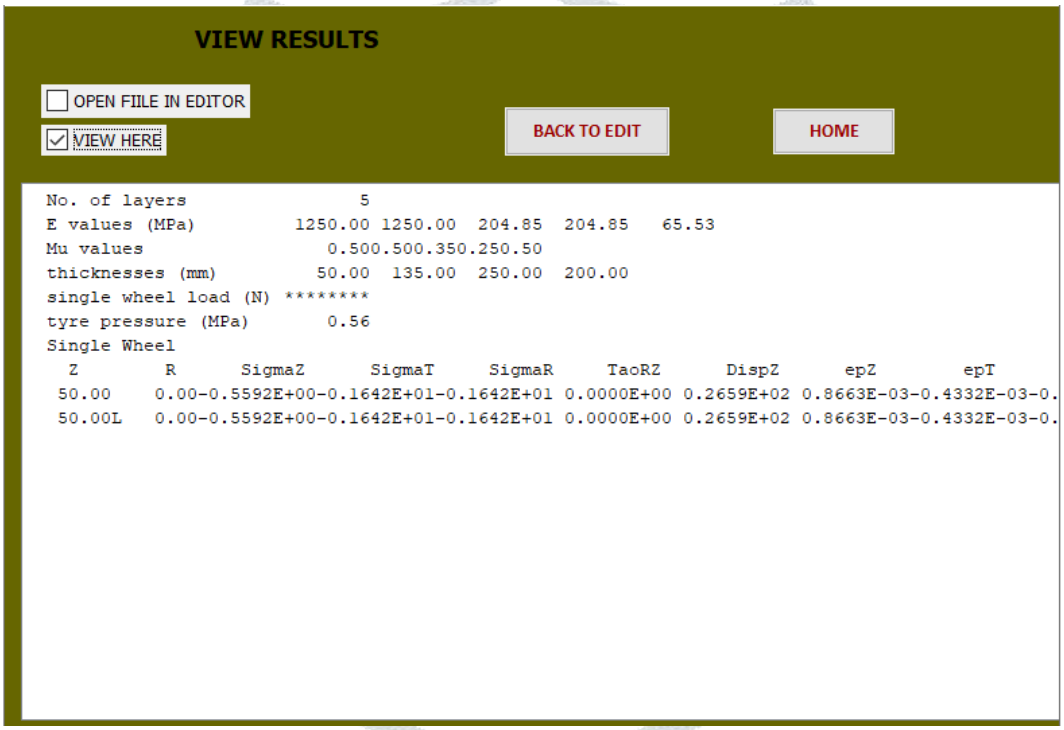

Figure 19: Results of thickness identified by IIT pave based on input data

On the basis of the above data the open road software allows to prepare the template which helps to prepare the corridor.

The thickness of each layers provided in software which are 50mm ,150mm, 250mm &200 mm of Bituminous layer, Granular base, Granular Sub-base & Natural Subgrade.

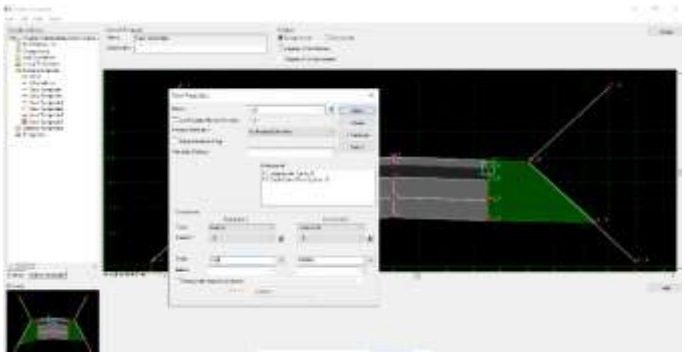

Figure 20: Template Creation according to IIT Pave parameter

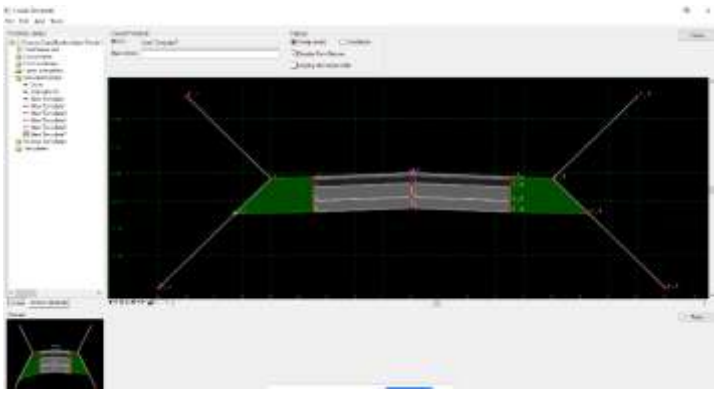

Figure 21: Final Template Creation

Step No. 6: Corridor modeling

Corridor modeling is an integral part of the highway design which provide with respect to the template created as per the CBR using IIT pave software. Corridor help to prepare the 3D and 2D plan of the highway using which we can identify the offsets and the width of pavement.

Corridor represents the edge lines of layers from which we can identify the distance with respect to the center line of the road.

Open road Software provide 3D visualization of a highway as shown in following figures, due to which we can able to identify the 3D adjustments. Corridor modeling having few importance because it prepared based on horizontal alignment and vertical alignment. So, the terrain area Cut & Fill can justify and the earthwork quantity able to identify using this function.

Implementation of corridor helps to identify the Cross Section of highway and Material takeoff of each layer which is considered in the template. Generation of plan and profile requires the reference corridor due to which the outcome become more integrative.

Based on the objective the corridor modeling plays important role for providing the Plan & Profile of an defined alignment with cross section and material takeoff.

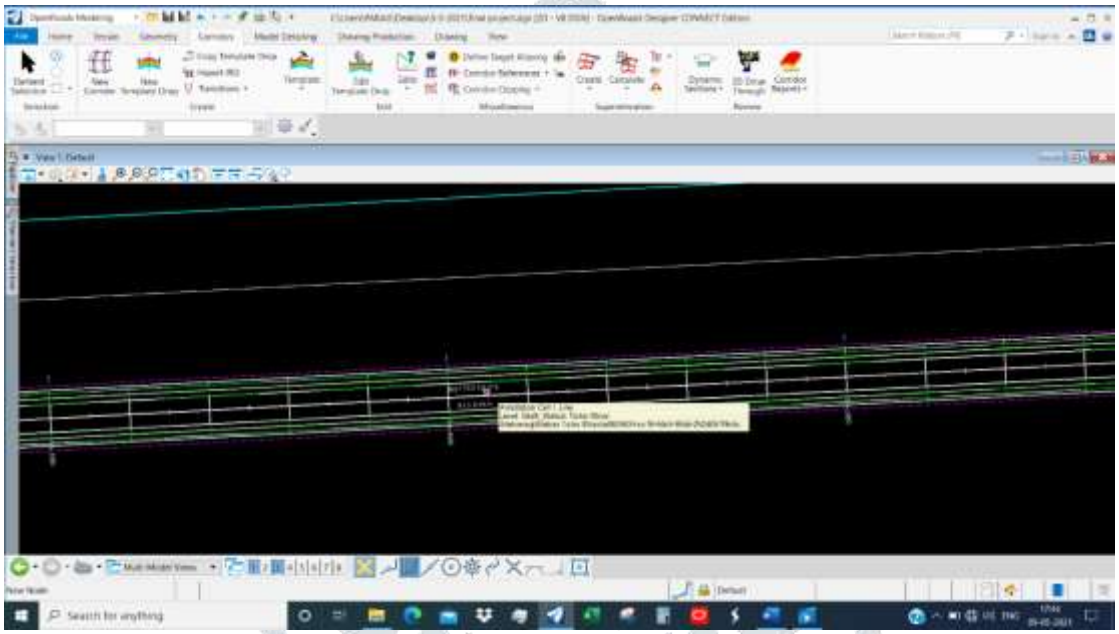

Figure 22: Corridor Creation in ORD Software

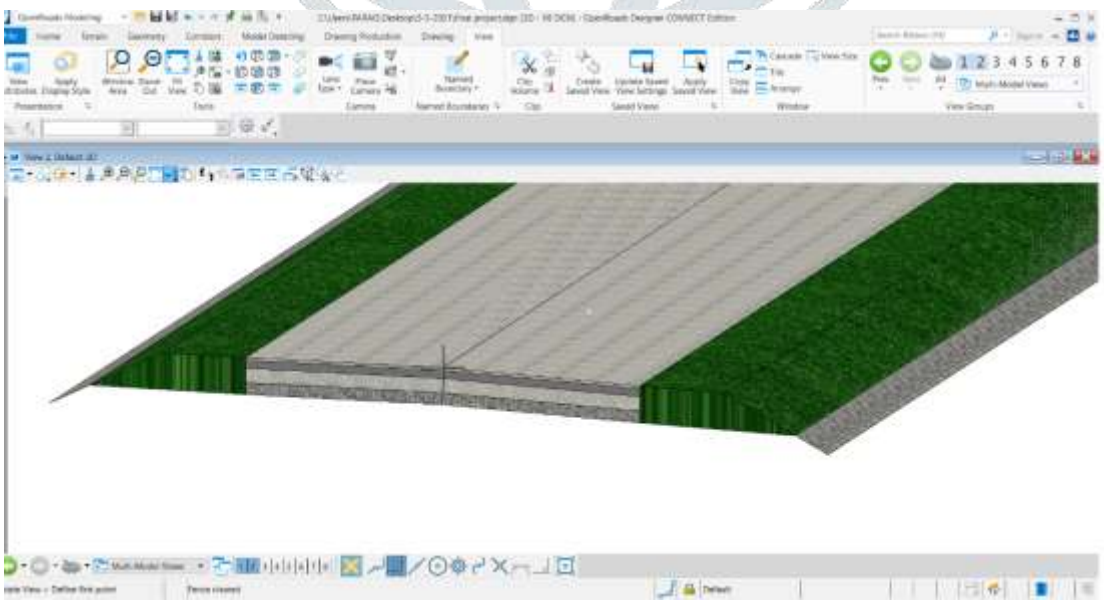

Figure 23: 3D view of Highway

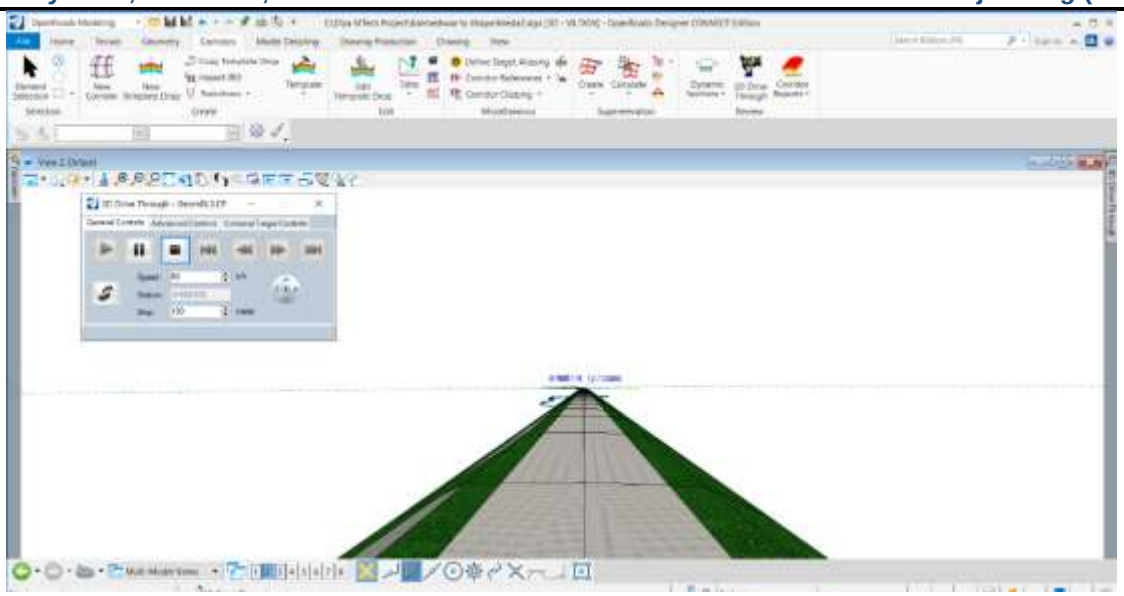

Figure 24: 3D Drive Through in ORD software

Step No. 7: Cross Section Preparation

Cross section preparation is typical Cross Section of road, where it involves earthwork such as embankment subgrade preparation GSB, WMM, DBM and at last BC. The Cross Section involves Median, camber and shoulder.

As shown in figure it is observed that open road software able to identify the quantitative output of a highway for a defined chainage. Example if site engineer wants to calculate the quantity of materials required for the execution. The cross section will able to perform the same and able to procure the material over the 1-month period to overcome the future delay activity.

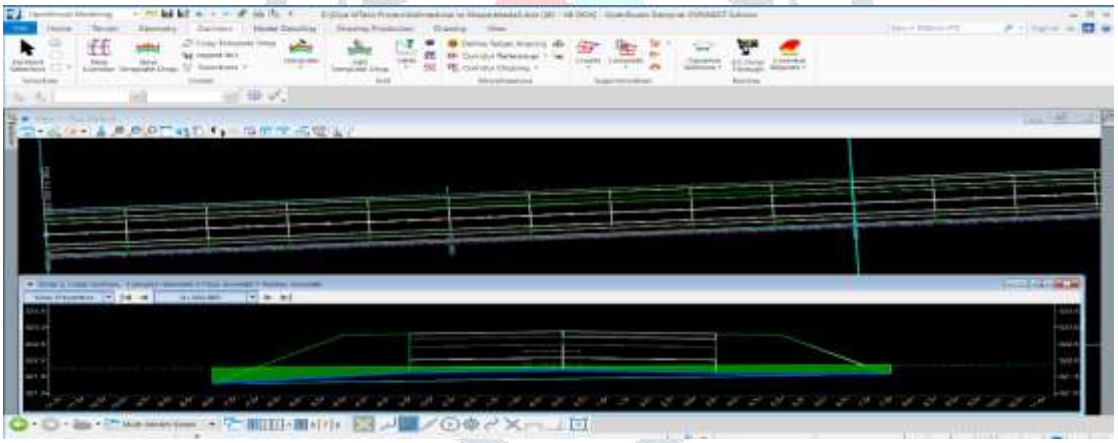

Figure 25: Cross section creation

Step No.8: Quantity Takeoff

Accumulate data is always required to perform the cost of construction. Open road application allows to calculate the whole quantity of defined materials of the layers in the highway. Rate analysis function also available but it helps only in descriptive way as defined in the following figure.

Figure 26: Accumulated Quantity of Highway Layers

Step No.9: Plan & Profile Creation

Client, Concessionaire & Independent Engineer or Authority Engineers required the project output in the perm of plan and profile of an highway. In this project I learned based on my methodology.

Plan and profile drawing consist the final design plan of horizonal alignment and vertical profile with all details. Plan and profile is the final drawing which concessionaire can utilize for construction after approval form competent authority.

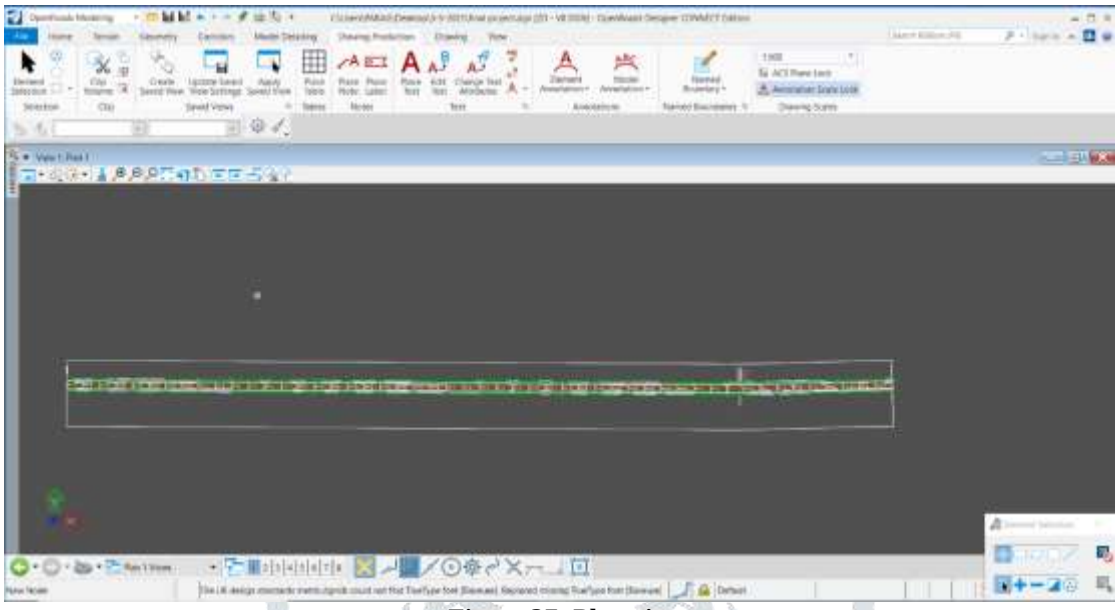

Figure 27: Plan view

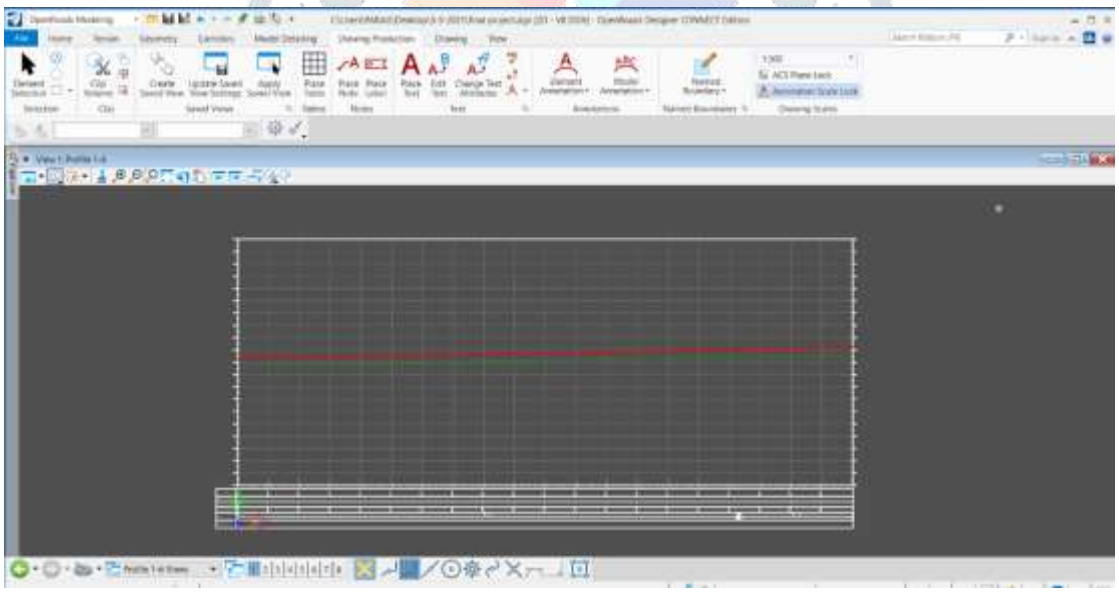

Figure 28: Profile View

VIII. CONCLUSION

- Highways Geometric design with the help of Open Road can be said to be extremely useful and also user- friendly for a three-dimensional roadway design.
- Open Road supports design checks for different codes and thus provides global platform for design and analysis.
- Horizontal and Vertical Geometry improved with the desired standards in minimum time.
- Open Road is a convenient tool to design assembly and corridor for design highway.
- Quantity of earthwork can be preciously calculated.
- Super elevation calculated and implemented according to standards.

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