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Geometric Design of Horizontal Curve Using MXROAD Software

Smit Panchal[1], Jaydip Jadia[2,] Dipika Gupta[3]

1Student, Department of Civil Engineering, HGCE, Vahelal, Ahmedabad, India
[2]Assistant Professor, Department of Civil Engineering, HGCE, Vahelal, Ahmedabad, India
[3]Assitant Professor, Department of Civil Engineering, ASOIT, Gota, Ahmedabad, India

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Abstract - *Geometric outline concerns the plan of street arrangement that fits in with the site requirements and models. The fundamental destinations are to improve productivity and wellbeing while at the same time limiting expense and natural harm. Once A Road/Highway Engineer is familiar with the basic road properties or road characteristics, the next stage is to import and increase horizontal curve design into the design standard applied in the MXROAD Software. Bentley MXROAD is an advanced string based modelling tool that enables rapid designing of all road types with accuracy. Using MXROAD creation of design alternatives for the construction of an ideal road system can be managed with ease. Once a design alternative has been authenticated, further details that are to be added to the design process can also be automated while using MXROAD modeling tool, saving both time as well as money. The dynamic placement and change functionality in MXROAD helps speed up the creation of 2D and 3D alignments.*

Key Words: Horizontal Curve, Geometric Design, MXROAD Software, IRC Design Standard for Curves.

1. INTRODUCTION

Horizontal curves are a necessary part of any highway system, yet they can present significant safety concerns. In general, curves represent only a small fraction of most state highway systems, but a disproportional number of serious crashes occur at these locations. Research shows that curves are associated with more crashes because of their decreasing radius or speeds on the roadway increase.

Horizontal curves designed in accordance with Green Book criteria have been generally shown to provide substantial margins of safety with respect to vehicle skidding and rollover, for both passenger cars and trucks. Previous research, however, has considered friction data measured in the 1930's and 1940's, which were used to develop limiting values of friction used in horizontal curve design policy. Since then, the vehicle fleet has changed considerably, as has tire design, pavement design, and friction measurement methods, but still there is not any considerable change in friction values occurred since 1940's.

2. MXROAD SOFTWARE

1. Design Creativity

The dynamic placement and change functionality in MXROAD helps speed up the creation of 2D and 3D alignments. The "Rubber band" flexibility unique to MXROAD allows the user to place and edit alignments, and also encourages design creativity and a quick assessment of design alternatives, the software enables cut/fill calculations 'on the fly', which gives informative inferences, thereby promoting better quality design.

2. Junction Design

Junction design, just like other functionalities in MXROAD, is a string model based functionality. String modeling gives users the ability to design and dynamically re-grade junction as per requirements. For instance, problematic areas, such as flat spots, can be identified and resolved during the design phase itself rather than incur high costs and delays due to re-work on site.

3. Super-elevation Design

The automated feature of super-elevation design in MXROAD is an extremely fast and effective tool handy to the user. Super-elevation standards are stored in a rules file for quick application of the correct local, company or project standards. The super-elevation Wizard allows for efficiency whilst retaining the ability to apply engineering judgement.

4. Pavement Layer and Subgrade Design

The Pavement Layer Generator helps model an entire road pavement construction replete with variable pavement configurations both across and along the road. Volumes are produced as by-products of the design process, delivering the information required for fast and accurate reactions during bid situations.

5. Final Drawings

All three MXROAD Environments offer the ability to automate the production of final drawings. The stand-alone environment enables presentation of complete contract drawings without the need to move or use a separate CAD drafting system. If for any reason the design is amended, design changes ripple through to the drawings automatically. Thus, users can "do it all and never leave MX".

6. MX Command League and Input Files

The MX Command League uses simple, repeatable commands that can be recoded and replayed using Wizards. This powerful feature, unique to the MXROAD family saves time while exploring different design scenarios and iterations. New design can be quickly and easily created through the use of Input Files.

3. FACTORS AFFECTING ROADWAY ALIGNMENT

1. Centrifugal Force & Centripetal Force

Ratio of centrifugal force to the weight of the vehicle p/w is known as "centrifugal ratio" or "impact factor" ($p/w=v^2/gr$). Centrifugal force has two following effects, first is tendency to overturn the vehicle outwards, second effect is tendency to skid the vehicle laterally.

2. Design Speed

The design speed is the one of the most important factors on which geometric design of road depends. Design speed affects various aspects of highway alignment including radius of horizontal curve, rate of super-elevation, extra widening of pavement at horizontal curves, etc.

Table -1: Design Speeds according to IRC 38:1988

Sr No	Road classification	Design speed (kmph)							
		Plain terrain		Rolling terrain		Mountainous terrain		Steep terrain	
		Ruling design speed	Min. design speed	Ruling design speed	Min. design speed	Ruling design speed	Min. design speed	Ruling design speed	Min. design speed
1	N.H & S.H	100	80	80	65	50	40	40	30
2	MDR	80	65	65	50	40	30	30	20
3	ODR	65	50	50	40	30	25	25	20
4	Village Road	50	40	40	35	25	20	25	20

3. Super-elevation

In order to counteract the effect of centrifugal force and to reduce the tendency of the vehicle to overturn or skid, the outer edge of the pavement is raised with respect to the inner edge, thus providing a transverse slope throughout the length of the horizontal curve. This transverse inclination to the pavement surface is known as "superelevation" or "cant" or "banking". The rate of superelevation is defined as a ratio of the height of the outer edge with respect to the horizontal width.

4. Curve Resistance

The vehicles are steered by turning the front wheel, while rear wheels do not turn corresponding to front ones. While turning through the horizontal curve direction of front and rear wheels are different. Turning is affected due to lateral friction between front wheel and pavement, thus when a vehicle is driven rear wheels turn along horizontal curve and provides increased resistance and if the same speed is maintained, higher tractive effort is required.

5. Radius of Horizontal Curve

Horizontal curves are designed for specified ruling design speed of the highway, if this is not possible than curves may be designed considering the minimum design speed. Centrifugal force is dependent on radius of horizontal curve. To keep centrifugal force within the limits, radius must be correspondingly high.

4. STUDY AREA

Kotarpur is a very densely traffic populated location as the location is in the vicinity to the Sardar Vallabhbhai Patel international and domestic airport. The curve portion of the area at the lower exit or at the ending site of the airport is considered as an accident prone zone of the area. The curve provided at the kotarpur is considered to be the biggest horizontal curve of the Ahmedabad city. There are plenty of factors which should be considered as the reason of the high accident rate of the area, but the main two factors which should be focused on are Superelevation and Lateral friction.

Kotarpur study area is located very close to the Sardar Vallabhbhai Patel airport Ahmedabad, Gujarat, India. Proper location of the area is at 23°05'34.6"N 72°38'54.5"E.

Figure -1: Study Area Location on Google Map

The Defined curve has a plain terrain with a covered fair drainage condition. Channelized T intersection is provided at the end of the curve for diverging the traffic from the location to reduce the congestion.

Channelized T intersection is provided at the end of the curve for diverging the traffic from the location to reduce the congestion. On the left portion of the curve location is being used for the vegetation and as a village area named Kotarpur, while at the right side land is being used as Sardar Vallabhbhai Patel International Airport.

Table -2: Road Inventory Details

Curve Section		Shoulder			Carriageway			Formation width (m)	Pavement (m)	Side walk (m)
		Type	Width (m)	Condition	Type	Width (m)	Condition			
Straight	Outer edge	BT	nil	G-Good	BT	11.7	F-Fair	11.7	Width 1.27	Width 1.32
	Inner edge		nil			6.8		9.88		
Circular	Outer edge		3.85			11.6		15.45		
	Inner edge		7.42			13.2		20.62	Height 0.38	Height 0.17
Straight	Outer edge		3.68			10.25		13.93		
	Inner edge		3.7			11.15		14.85		

Type: BT = Bituminous CC = Cement Concrete GR = Gravel ER= Earthen
Condition G = Good F = Fair P = Poor VP = Very Poor
Terrain: P- Plain, R- Rolling, M- Mountainous, S- Steep
Road Side Drain: CD- Cover Drain, LD- Lined Drain, UD- Uncovered Drain

5. DESIGN OF HORIZONTAL CURVE

5.1 General

Geometric outline concerns the plan of street arrangement that fits in with the site requirements and models. Once a street or roadway build knows about the nuts and bolts of street geometric outline, the subsequent stage is to upgrade their esteem by learning programming for the utilisation of the essential information. Bentley MXROAD is a propelled, string based displaying software that empowers the perfect street framework.

5.2 Layout of the Study Area

The overview of the study area is a very first requirement to know before proceeding to the geometric design stage. Therefore it is quite necessary to have the through information about the road layout before starting to design a street in any software. Layout plan of the addressed study area is drawn or drafted into the AutoCAD software.

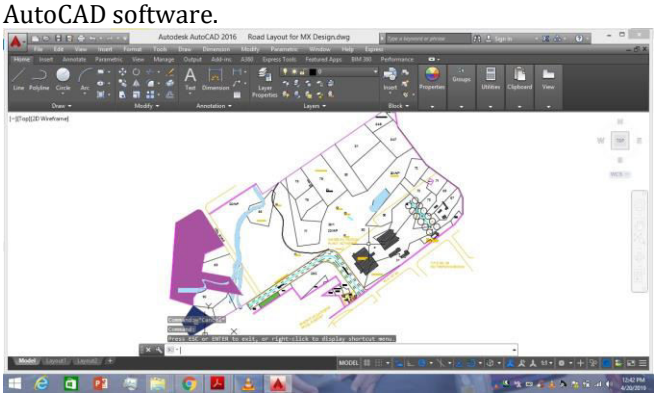
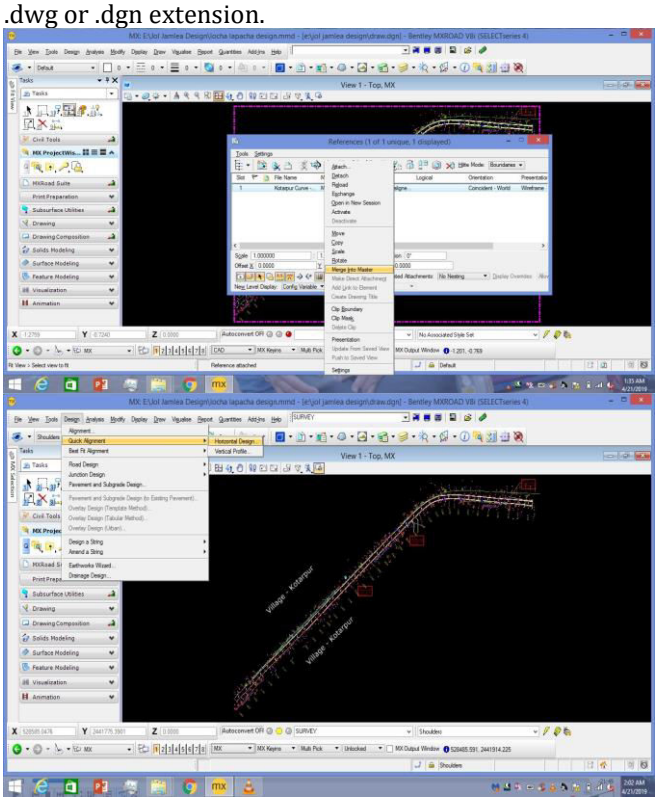
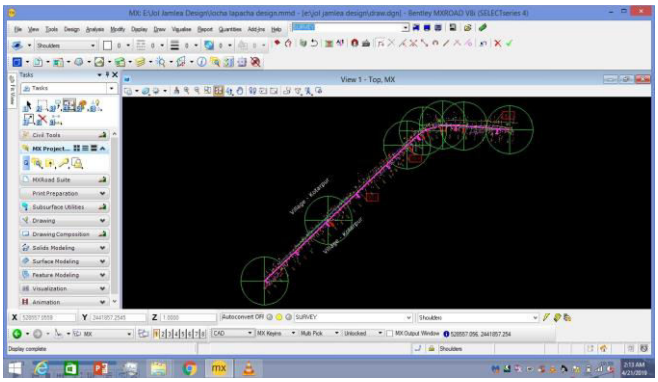


Figure -2: Layout Plan in AutoCAD Software

5.3 Design Procedure in MXROAD Software

The very first step in the design of any geometry in MXROAD software is to import the AutoCAD file in .dxf, .dwg or .dgn extension.





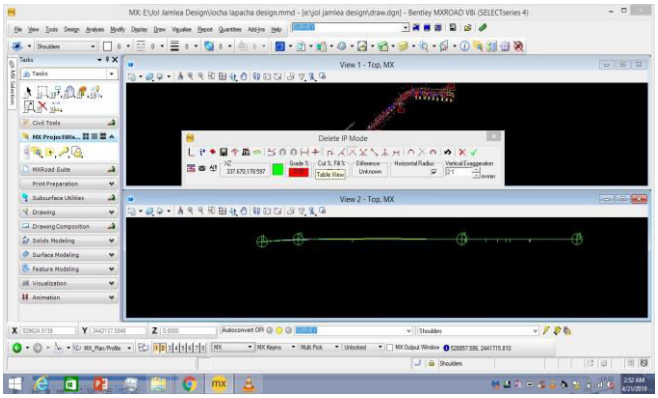
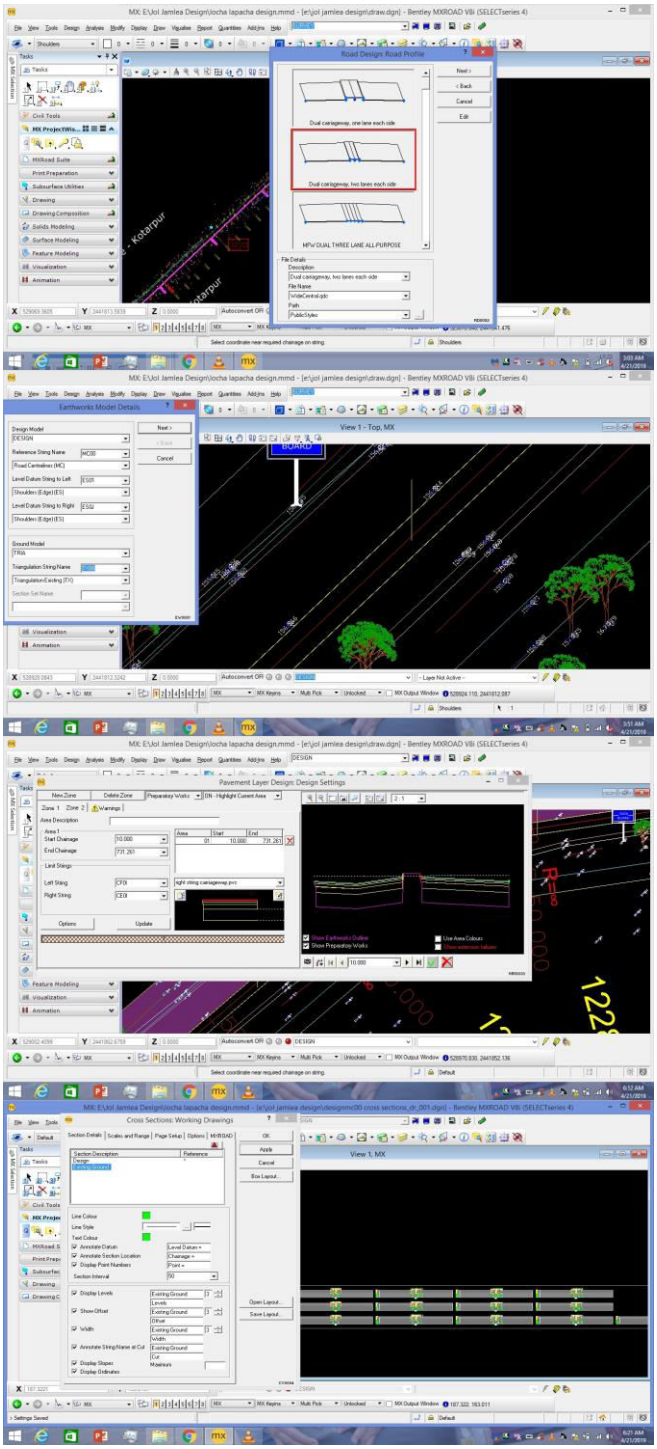


Figure -3: Importing Cad file, Horizontal & Vertical Alignment Design

The next step is to merge the reference file into master file and convert the drawing lines to the strings and create model as a basic reference to the software for further design process. Triangulation of the model is required to divide the area for vertical alignment model and report generation. The next process in the design is to create a design model and make horizontal alignment according to the centreline provided in the topographical survey. Further work is to do the Vertical alignment in the design model taking master centreline string as a reference string.



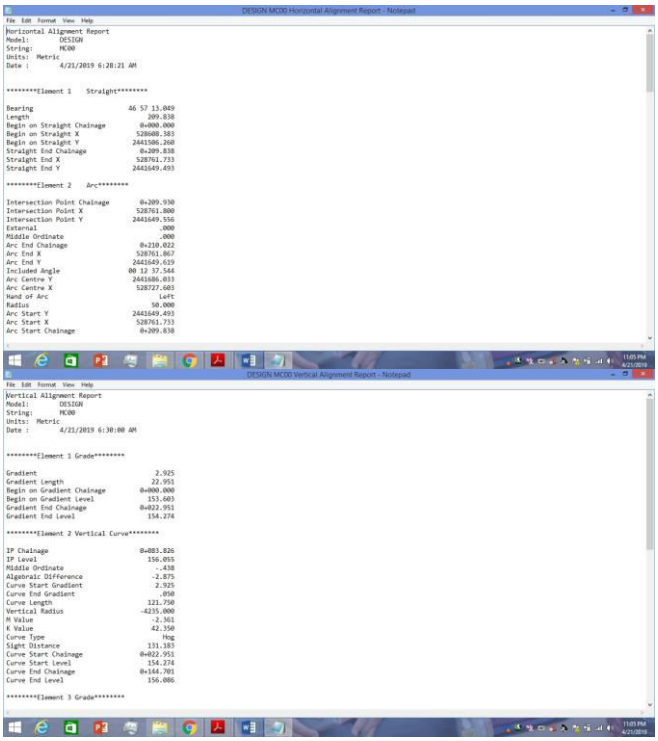


Figure -4: Carriageway, Shoulder, Pavement Layer Design with Horizontal & Vertical Alignment Report

The design process follows to the carriageway and super-elevation design. The process continues to design shoulder selecting the carriageway strings as a reference. To design the shoulder, new horizontal string has to be created and master centreline is taken as a reference string while carriageway string is taken as a subsidiary reference string. Forwarding the process the next step is to provide surface and subsurface detail design. In this step design is to be done only at single side of the centreline, the software provides a mirror copy of one side to design the each side as a same. The next and final step is to workout the cross-sectional drawings selecting the intervals as per requirement.

6. SUMMARY & CONCLUSION

Primary horizontal curve is created with the use of Bentley MXROAD software. The final layout plan is also created of the particular study area with the help of the AutoCAD software. The software design gives the through idea about the onsite condition and work hours plus the manpower going to be required to design any type of road geometry. Horizontal curve is design from 40 to 70 kmph speed in the study. The major factors addressed in the study are super-elevation and lateral acceleration rate at the considered study area. The design study area is having a radius of about 50 km. Curve has been designed according to IRC guidelines considering all the safety measures. Design accuracy and precision with sufficient time saving can be achieved with the MXROAD software. Plan layout is created using AutoCAD software, while working cross section are created at every 5 point chainage difference.

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