Evaluation of highway geometric design to achieve clear visibility envelopes by using Mx road ss4

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***Abstract*: Highway projects are being carried out as a part of nation-building work for improving connectivity and promote the basic facilities for the development of the regions it is necessary to develop a safe and comfortable highway for the road users. As an up-gradation project is considered the safety must be given priority and also importance for the land use which is going to be consumed for the project. Highway projects designed for the up-gradation require more land use as the level of the service is to be increased to the desired level the carriageway configuration is enhanced with safety and comfort for the road user.In this project the analysis for the visibility envelopes is carried out for the D2ap configuration of the highway which has a lane width of two-lane with 9.3m the models for the geometric design are developed for the one-step below ,desirable minimum standards with highway of 120km.p speed ,which requires a sight distance of 215m by using the (Bentley Vi 8) MX road SS 4 for the design and analysis for the project highway . The command language is used to develop the model and design the stings for the design in the project.**

***Keywords*: Visibility, Sight distance, geometric design, strings, MX Road Software.**

I. INTRODUCTION

India is a developing country where various infrastructure works are being carried towards development. Infrastructure projects like highway projects are being carried out extensively for better connectivity as a part of nation-building work the road projects are playing a major role. Improvement of state highways to national highways etc. in this improvement the level of the service of the highway will be upgraded to the desired level. Which requires a very dynamic change in infrastructure by giving employment opportunities and the development facilities to promote health, agriculture, education, business, the overall growth of the region.
The highway project requires the land for widening if any it's upgraded to the desired level, the aim of this project is to give a brief purpose for the improvement measure to be adopted for the achieving visibility for safe and comfortable movement of the fright traffic with provision for crash barrier which can be used instead of the central median as per the Indian Road Congress standards the main purpose of using Vehicle Resistant System is to reduce the construction cost of the median and achieving the visibility along the highway with the comfortable sight distance for driving.

II. OBJECTIVES

To Develop a design model to such as to avoid the unnecessary usage of land for upgradation, which implies to develop a model which has a significant towards socioeconomic causes and a considerable reduction in accident rate by achieving the adequate sight distance without excessive land use[1]. By designing various curves with the safe values of sight distance without a reduction in design speed. In India as there is no provision for the improvement in sight distance, as new projects are designed for respective configuration with a median of constant width if the sight distance is not achieved then reduction in design speed is adopted.

- To carry out the geometric design as per the Design Manual for Roads and Bridges (Dmrb) standards.
- To develop a 3-dimensional surface for design.
- Carriageway design for Dual Two-lane all Purpose (d2ap) configuration for the project highway.
- Design of the superelevation for the carriageway.
- Analysis for the sight distance by visibility splay lines and assumption of crash barrier for a design speed of 120 km/h.

III. SCOPE OF THE STUDY

The project deals with the geometric design of a dual 2 lane all-purpose road which is designed in MX road by the creation of a 3-dimensional surface as the existing ground to resemble actual ground for analysis, the design carried out is compared with manual compilation by using the command language. The project design is carried out starting from survey points till the Finished Road Level (FRL) using the command language, it majorly deals with the analysis done after the design for the visibility envelopes which is an important factor in accident prevention, and concern towards land use while upgradation.

IV. FACTORS AFFECTING DESIGN SPEED SELECTION

- Road class
- Traffic volume counts
- Level of service required
- Alignment Constraint along the highway, etc.

• Right-of-way availability for the project.
• Environmental aspects.

V.GEOMETRIC DESIGN METHODOLOGY

A. HORIZONTAL ALIGNMENT BY IP METHOD

Horizontal design starts with tangents along a straight portion, further design of the curves along the intersection of the tangents. Transition part of the curve consists of the spiral of the infinite length which has a radius continuously changing along the spiral, due to the provision of the transition the movement of the vehicle along the transitions length is given by the formula.

$L_S = V^3 / 46.7 * Q * R$

Where Ls= length of the transition

q = 0.3 m/s^3 but can be increased to 0.6m/s

V = Design Roadway speed

R= radius adopted for designed curve.

Desirable minimum radius: values representing design highway with comfort values indicating speed. the first tier of the hierarchy, this turns out a high normal of road safety design values.

Relaxations: Desirable Minimum standards unnecessary increase in construction costs and also affect the environmental aspects and unnecessary land use, properties, etc. Designs with a minimum of required normal's can be adopted as a higher standard of safety on the roadway will be in initial priority[2].

Number of steps depends on the geometric parameter and design speed

• SSD relaxations of 1 step may coincide with 1 step relaxation of horizontal curvature, but all other combinations are not permitted.

Departures: In situations where it is difficult to provide relaxations, it should be designed as Departures from standards, if it is necessary to exceed permitted limitation of the design relaxation.

• Its third tier of the hierarchy, where the providing radius below the allowable relaxation and used when it is absolutely necessary to exceed permitted limitations of relaxations.

B. THE CHOICE OF CURVE RADIUS INCLUDES CONSIDERATION OF:

• Location of constraints.
• Design speed including associated considerations such as cross fall, transitions, curve widening, and visibility & Drainage conditions.
• Aim for a smooth, desirable alignment, avoiding short straights and curves.

C.VERTICAL ALIGNMENT BY IP METHOD

The alignment is drawn for the desired route option by inserting the intersection points of the tangents in the vertical plane of the design. Further which is provided with a horizontal curve of appropriate vertical curve length or the K value as per design speed adopted[3].

The vertical geometry road is governed by the speed considered for design, the topography of the land, traffic volumes of the proposed area, required sight distance adequacy, horizontal geometrics, clearances to be provided, drainages for surface& subsurface[4].

There are important aspects while the design of vertical profile as grades designed will affect the cut and fill quantity, which significantly increases in cost if not designed to the optimum.

1. Crest and Sag Curves

A. The crest curves occur at the top of the tangent intersection points when two tangents slope upward converging to intersect at top.

B. Sag curves: occurs when tangents converging at the bottom.

VI. HIGHWAY CROSS-SECTIONS DESIGN:

A.HARDSTRIPS

A hard trip provides a paved surface for the vehicle to park in an emergency.

B.VERGES

The extreme edge of the carriageway is provided with the verge which consists of the grass or the vegetation for the sustainability along the highway, here verges play an important role in the highway as they will have a prominent role in the visibility along the highway as they provide clear visibility for the straight as well as curves portion.

In curves, the verges play an important role as they are used to be widened if sufficient visibility is not achieved, which is reflected as verge widening[5].

B. SUPERELEVATION DESIGN

Rising of an outer edge over the inner edge for counteracting the generated centrifugal force, the tendency of a vehicle skid or overturn outer force.

C.DESIGN PROCEDURE FOR 3D MODELLING CONSISTS OF THE FOLLOWING.
The project has been carried out in the following stages
1) Importing the survey data.
2) Creation of boundary and triangulation (creation of the 3 Dimensional surfaces).
3) Analysis of the 3Dimensional surface for the surface checks and analysis of the surface.
4) Preparation of the horizontal alignment.
5) Preparation of the vertical alignment.
6) Develop the cross-section for D2AP configuration
7) Visibility analysis for the design model and study of visibility envelops for the sight distance of 215m.
8) Assign of Central reserve widening stings MCR0&MCL0 for left and right carriageway respectively along the centerline.
9) Analysis for through visibility after the creation of MCR0 & MCL0 strings and consideration of the same as a barrier after Improvement.

D.SOFTWARE USED

The Mx design tool is a useful and user-friendly tool used to design and analyze the geometric design of the highway. The major advantage of using the Mx design tool is here the command language can be used to design the string with precision and amending changes to specified accuracy can be adopted. Mx being a string-based software provides a platform to work comfortably with ease understanding the convenience of handling the command language. Line mode command language is a very strong and effective user-friendly tool that can be used to write the program. The 3-dimensional surface will provide accurately and precision in the model for design and analysis. The sight distance analysis is previously carried out with the visibility splay lines from object to target, which shows a clear demarcation between site lines at a specified interval.
Visualization enabling a clear perspective to differentiate the string.

VII. GEOMETRIC DESIGN AND ANALYSIS FOR THE D2AP ROAD CONFIGURATION

A.HIGHWAY CROSS-SECTIONS STRING DESIGN

The cross-section will be defined in terms of the strings with respect to configuration the following string naming conventions are used in the project. String naming convention as shown in Table no 1

Table 1: String naming convention

Master Strings	MCXX
Carriageway Edge	CEXX
Carriageway Shoulder/Hardstrip	SEXX
Verge	VEXX
Interface	IAXX

B.PAVED WIDTH
The carriageway is designed for a paved 9.3-meter width including one-meter hard strips on both sides.
Traffic Lane Width, it's considered as per the dmrb standards each lane of 3.65m total 3lanes as 7.3meter are designed Carriageway Edge is defined as CEXX

C. HARDSTRIPS
Hardships adopted here are of width 1m wide.
Carriageway Shoulder/Hardstrip is defined as SEXX.
where ?? contains 01 or numerical for the left carriageway where the fourth digit will vary and OI or the alphabets as the fourth place will vary for the right side carriageway

D.VERGES
Edge of carriageway after the paved width defined as VEXX.

E.DESIGN OF SUPERELEVATION FOR THE CARRIAGEWAY STRING.

Superelevation in this project is designed for the design speed of 120 km/h .following are the standards considered for the design.
1. Superelevation for design one step below desirable minimum is considered.
2. Minimum 5%and up to 7% at curves.
3. Normal crossfall of the carriageway is 2.5% as the transition starts the gradual increase in superelevation from 2.5% to desired value till 7% is raised, when it reaches the curve constant superelevation value for the curve is maintained and further at the end of curve the gradual variation is compensated into the transition till end of the transition two normal value of 2.5 %[6].
Superelevation computed manually is compiled in terms of command language as shown below.
Superelevation is computed by using the formula:

$S = V^2 / 2.828 * R$

Where S=Superelevation
V=Design Speed
R=Radius of Curve

The design model option 1containing the MC00 string is analyzed for the visibility envelopes, the details are as shown in table no 2

Table No.2: details of design option 1

Date and Time	"Wednesday, May 5, 2019, 07:57"
Reference Model Name	DES OPT 01 MAIN
Reference String Name	MC00
Model to Analyze	DES OPT 01 MAIN
Direction	Forward Analysis
Sight Distance Required	215
Type of Analysis	Line of Sight
Distance Measured Along	Arc Length
Eye Height	1.05
Eye Offset	-2.825
Forward String	CE00
Move Target	Yes
Target Height	0.26
Target Offset	-2.825

RESULT AND DISCUSSION

The results of visibility analysis carried out for the DESIGN OPTION 1 obtained are studied and the inadequate visibility at curves is taken into account to develop a safe model, the visibility improvement is achieved to have a safe and comfortable movement along the highway, during analysis a sight distance of 215m is adopted as a standard as per dmrb for the radius of one step below desirable minimum . The analysis carried out shows the curves where the inadequate sight distance is achieved, the table 3 shows the MX output obtained for design option 1.

Table No 3: output obtained for design option 1

Eye Position in meter	Target Position in m	Eye Level In m	Target Level In m	Sight Distance Achieved in m
1420.000	1634.060	86.258	91.350	214.100
1430.000	1635.870	86.491	91.404	205.900
1440.000	1637.680	86.736	91.457	197.700
1450.000	1639.700	86.993	91.517	189.700
1460.000	1641.930	87.261	91.582	181.900

Visibility Envelops where sight distance is not achieved.
Curve to improvement visibility Further, the improvement in the design of the design model Design Option 2 is prepared to contain strings MCR0 and MCL0 which are used along the right and left-hand curve respectively.
Existing design model MC00 with a barrier as obstruction visibility envelops are observed, the changes adopted to improve visibility envelopes are the incorporation MCL0 and MCR0 as central reserve widening to improve the visibility envelops to achieve the clear sight distance of 215m.
After the analysis for MC00 string, the central reserve is redesigned at the curves to improve the visibility envelops.
Radius is suitably varied to have a safer value of sight distance.
MCR0 string designed with following transition values.

$L_S = V^3 / 46.7 * Q * R$

Where Ls= Length of transition
$q = 0.3 m/s^3$ but can be increased to 0.6m/s
V = Design speed
R= Radius of the curve

For R=720m,
V=120km/h,
q=0.3
Ls=171.73m here maximum providable is Ls =85.653m

The following details obtained in the DESIGN OPTION 2

Table No 4: Horizontal Alignment for MCRO

For MCR0 String Curve no In MCR0	Hand of the curve in m	The radius of the curve in m	Transition leading in m	Transition lagging in m
Curve1	Left	720.000	85.653	85.653
Curve2	Right	760.000	162.290	162.290
Cuvre3	Left	650.000	94.877	94.877
Curve4	Right	780.000	79.064	0
Curve5	Right	670.000	85.653	171.306
Curve6	Right	850.000	0	145.106
Curve7	Left	720.000	154.176	171.306
Curve8	Right	800.000	129.413	154.176
Curve9	Left	720.000	171.306	
Curve10	Right	1050.000	116.359	

Table No 5: Horizontal alignment for the MCL0

For MCL0 String Curve no In MCLO	Hand of curve	The radius of the curve in m	Transition leading in m	Transition lagging in m
Curve1	Left	850.000	145.106	145.106
Curve2	Right	655.000	94.153	94.153
Cuvre3	Left	860.000	85.653	0
Curve4	Right	600.000	0	0
Curve5	Right	800.000	0	77.088
Curve6	Right	850.000	0	145.106
Curve7	Left	670.000	92.045	92.045
Curve8	Right	850.000	72.553	154.176
Curve9	Left	770.000	0	171.306
Curve10	Right	1020.000	60.461	0
Curve11	Left	780.000	28.452	158.129
Curve12	Right	953.075	129.413	0

The improved visibility analysis is analyzed for the model containing MCLO and MCRO strings which will be as a barrier for the analysis.
further, the data was analyzed for the design Option 2 with the details as shown in table 6, which contains the newly designed strings MCR0 and MCL0

Table No.6 Design option 2

THROUGH VISIBILITY			
Date and Time	Tuesday		May 6, 2019 10:16
Reference Model Name	DES OPT 02 MAIN	**Reference String Name**	MC00
Model to Analyze	DES OPT 02 MAIN	**Direction**	Forward Analysis
Sight Distance Required	215	**Type of Analysis**	Line of Sight
Distance Measured Along	Arc Length	**Move Target**	Yes
Eye Height	1.05	**Target Height**	0.26
Eye Offset	-2.825	**Target Offset**	-2.825

All the chainages achieved the visibility of the 215m, also visibility envelops for the construction lines are checked to verify whether the visibility is practically achieved.
The construction string indicated the clear visibility for the sight distance of 215m by consideration of the Strings MCL0 and MCR0 as objects i.e.as a barrier for forward and reverse visibility respectively.

CONCLUSION.

- It is difficult to design the roadway with the desirable minimum in up-gradation project due to the social impacts on the landowners along the said highway is drastically affected by the undesirable land acquisition which affects the residents and agricultural land being acquired for the project.
- To achieve the desired minimum standards huge increase in the cost of the project and the social impacts of the project considerably affect the small landowners by losing their precious cultivation land and regular source of income.
- The relaxation adopted will considerably reduce the social impact of the project by reducing the overall cost due to increase desirable minimum standards for upgrading the highway project.
- Three-dimensional surface provides a representation of existing ground which provides an actual ground design and analysis.
- The sight distance of 215m is achieved without a reduction in design speed across the highway.
- Analysis carried out it is possible to check the splay lines with accuracy as visualization of the real driver eye and target with specific height and distance as a string, straight lines at curves project outside carriageway due to curvature as sight lines are straight.
- For the Drivers, eye Height 1.86m and target height 0.26 m at an offset of 2.825 from the median for both driver eye and the object target, splay lines for clear visibility are not achieved due sight lines are being projected out due to the relaxation at a curve.
- Sightlines are positioned at 10 m interval at curves which provided, ensures the sightlines are continuously traversed giving accurate data along the curve.
- Incorporation of curves with an appropriate radius just to archive visibility at particular locations will considerably reduce the land use.
- Visibility envelopes overlapping and moving outside the carriageway are clearly distinguish to improvement for safe value.
- By designing the radius with relaxation in the horizontal curve at one step below and sight distance one step below the desirable minimum are
- provide as per code provision and it proves to be more effective.
- It's easily possible to design the unachieved the sight distance due to consideration of the visibility envelopes at the curves by making the visibility splay lines traversing the path on the carriageway. consideration of the barrier will provide the as build effect due to it, which can be eliminated at the design stage.
- The designs developed for the model will show a major improvement in safety by consideration of the barrier along the highway with vertical and horizontal geometrics playing an important role.
- The strings designed separate for right and left the side of carriageway provides easy clear envelops passing thought right hand and left-hand curve which enables exact locations of the splay lines passing outside the carriageway.
- Visibility splay lines improved with the correction in radius will enable a safe and comfortable highway.
- As there is no significant provision for the improvement in visibility in Indian projects, these type of analysis provides a clear and enhanced improvement in safety by keeping the comfort in consideration
- The loss of agricultural land is considerably reduced by reducing unnecessary radius provision in the up-gradation of highways with a median.
- Strings along the median are effectively utilized by keeping safety and aesthetics in mind.

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