STUDY OF GEOMETRIC FEATURES OF ROAD AND ACCIDENT RATE

A Thesis Submitted in Partial Fulfilment
of the Requirements for the Award of the Degree of

Bachelor of Technology
In
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CERTIFICATE

This is to certify that the thesis entitled, "**Study of Geometric features of road and Accident rate**" submitted by **Vikas Golakoti** is a record of original work carried out by him under my supervision and guidance in partial fulfillment for the prerequisites for the degree of **Bachelor of Technology, 2014-15 in Civil Engineering at National Institute of Technology, Rourkela.**

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/ Institute for the award of any degree or diploma.

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CONTENTS

ABSTRACT

The increase in traffic across the globe has resulted in the increase in the number of accidents on roads. This has resulted in the study of the reasons for accidents and also the factors which cause them. In this thesis, the factors affecting the accident rate have been studied and also how much they contribute to the accident rate has been found out using regression analysis and analysis of variance. A national highway of plain terrain has been studied and the results were found out. The accident rate has been found out by regression analysis for various geometric features of road such as horizontal radius, super elevation, K-value, vertical grade, visibility, and vertical arc length, rate of change of super elevation and accident rate.

The findings show that the accident rate is highly influenced by the factors such as super elevation, horizontal radius, K-value in case of plain and rolling terrain.

Key words: AADT (annual average daily traffic), AR (accident rate), Super elevation, Horizontal Radius, Geometric features, K-value, Visibility.

Chapter 1

1.1 INTRODUCTION

Transportation is important for the development of a country. Roads are easily accessible and are widely used for transportation purpose. With development comes increase in traffic and also resulting in increase of accidents. Accidents are mainly caused by three factors which are human, road and vehicles. Accidents are mainly caused due to human errors but it varies from human to human and hence the study of the accident rate based on this factor is difficult. Vehicle factors are also difficult to study because there are different types of vehicles and vehicles differ from person to person and hence their properties also differ. Hence the road factors are important and also contribute to the study. If the design of a road is good then there are less chances for the cause of accidents.

1.1 GEOMETRIC FACTORS OF ROADS

Terrain

Terrain is classified as the following depending on the slope of the land.

Terrain Classification	Slope of location (%)
Plain	Less than 10
Rolling	Greater than 10 up to 25
Mountainous	Greater than 25 up to 60
Steep	Greater than 60

Horizontal alignment

This is defined by tangents and curves horizontally. The horizontal curve is shown below as per Indian Road Congress (IRC) guidelines.

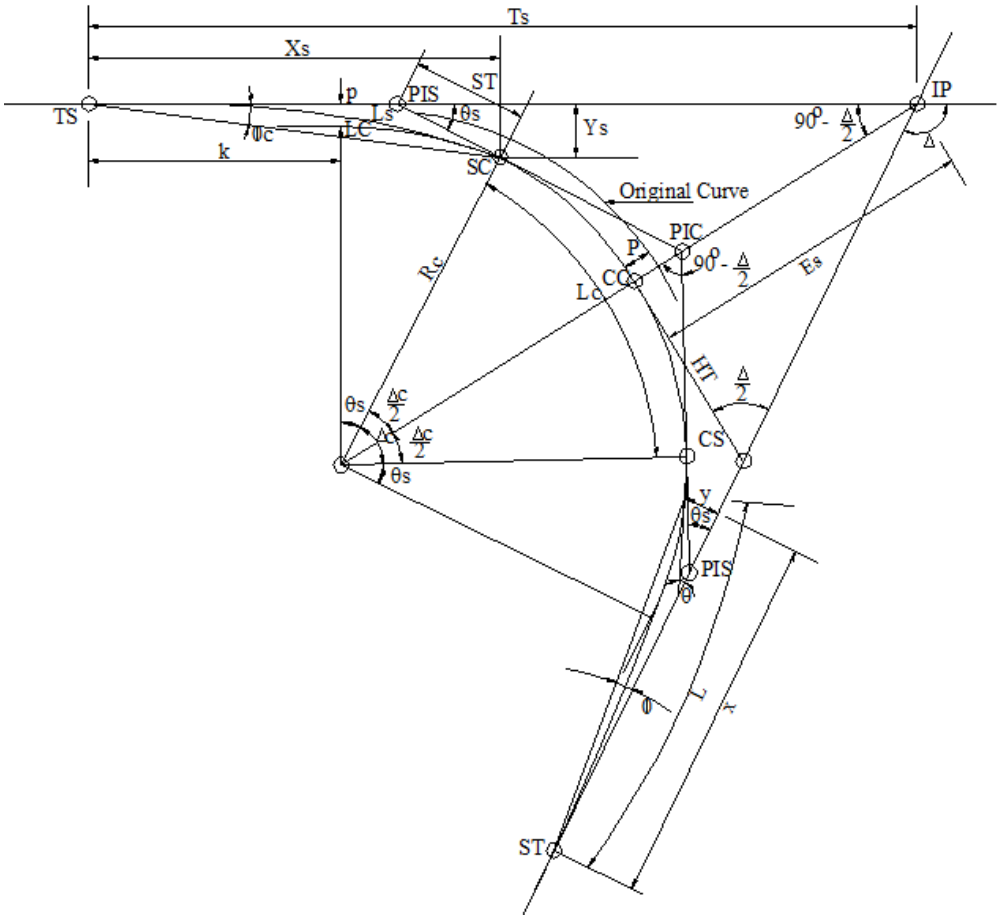


Fig: 1.1 horizontal alignment

Δ	:	Total deflection angle	L	:	Total length of curve
IP	:	Intersection point of tangents	ST	:	Short tangent
RC	:	Radius of circular curve	LT	:	Long tangent
LS	:	Length of spiral curve	Ts	:	Total tangent distance
LC	:	Length of circular curve	Es	:	External distance

Vertical alignment

It is the section of road in longitudinal direction for change of gradient. It is defined by gradients and vertical curves. The rate of rise with respect to horizontal along the length of road is called gradient and is measured in percentage or ratio in degrees. The figure of vertical curve is shown below as per IRC.

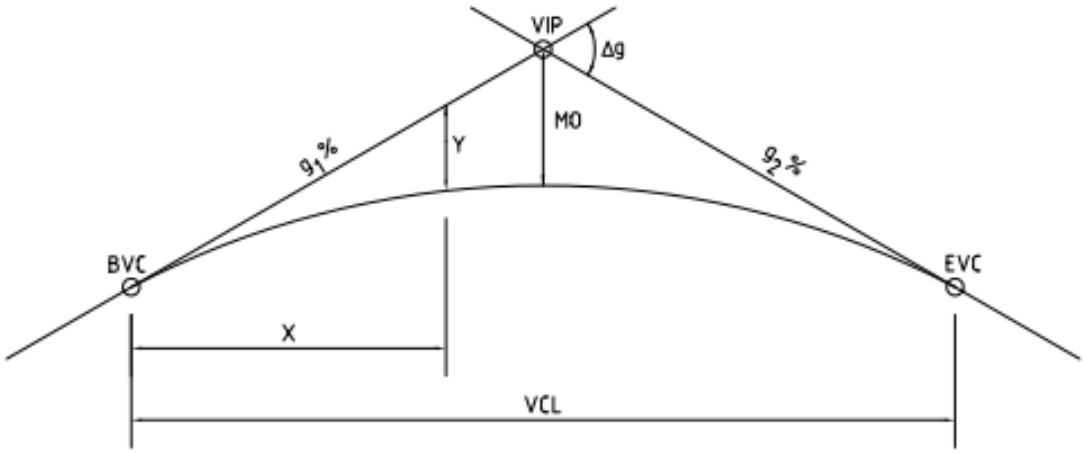


Fig: 1.2 Vertical alignment

$$K = \frac{VCL}{\Delta g}$$

$$\Delta g = g_1\% - g_2\%$$

$$Y = \frac{\Delta g}{200VCL} \times X^2$$

$$MO = \frac{\Delta g \times VCL}{800}$$

VIP	:	Vertical point of intersection.
G	:	Gradient
MO	:	Mid-ordinate
Δ g	:	Algebraic difference in grades (percent) of the grades tangents.
VCL	:	Vertical curve length measured horizontally.
BVC	:	Beginning of vertical curve
EVC	:	End of vertical curve
K	:	Horizontal distance required to effect a one percent change in gradient.

Super elevation

It is the banking provided on roads to resist the centripetal force on the vehicles while travelling along the curves.

Sight distance

It is the distance on the road up to which the person driving the vehicle can see the object or other vehicles to safely stop the vehicle.

Cross section of roads

Cross section of roads is the number of segments the road is divided into such as lanes, side walk, earth slope, etc.

Annual Average Daily Traffic (AADT)

Annual Average Daily Traffic is the number of vehicles crossing a point of the road in both directions in one year and then calculated per day in the year. This is done by dividing with number of days in that year.

1.2 OBJECTIVE

The aim of this study is to find the role of the geometric factors of road on accident rate in the case of plain terrain and also find the extent to which these factors affect the accident rate for rural areas. The study aims to find the impact of factors like extra widening, horizontal radius, sight distance, K-value, super elevation, horizontal arc length, vertical arc length, vertical gradient on the accident rate and aims to study the significant factors causing accidents and to find the values for future design of roads.

Chapter 2

LITERATURE REVIEW

This has been a problem all over the world. Hence many studies have been carried out on the accident rate dependency on geometric features. Some of the studies are listed below:

Lyinam et al (1987) studied that these geometric factors are responsible for road safety and the relationship can be found by regression analysis. These vary from country to country based on their conditions.

Fitzpatrick (2010) studied various accidents on horizontal curves and on tangent sections. The negative binomial regression models can best explain the effects of the factors on accident rate.

Yingxue (2009) found that the geometric variable of the highway have adverse effects on crashes.

Raymond et al (2009) evaluated measures for crash rates on curves and found that they are important. Superelevation is a very important factor in determining accident rate.

Sayed et al (2006) studied that sharp curves doesn't give the driver enough visibility or sight distance such that the vehicle cannot be stopped immediately in case of an obstacle causing accident.

Chapter 3

DATA COLLECTION AND EXTRACTION

For this thesis study NH-200 is selected which comes under plain & rolling terrain category. NH-200 has a total length of 741km it connects Chhattisgarh and Orissa. Now for this study the place called Bhojpur is taken which starts at 130/0 is chosen as starting point and ending point is at Chatabar 190/0. This part is entirely situated in Orissa. This is between 21° 25.92' N & 20° 56.84' N latitude, 85° 11.21' E & 85° 16.30' E longitude. The length of the part selected for study is 60 km.

3.1 METHODOLOGY

Accident records are known by enquiring the locals and with the help of police. Now the survey is done by taking the centre line of the road and levelling it for every 10m intervals. In case of curves the interval can be changed up to 5m. the survey can be done by using GPS or reference points from the data available in the location. Traffic survey is done to find out the Annual average daily traffic (AADT). To find out this a 3 day survey is carried out at the required location. And the data of traffic which is already available has been collected from various departments. To find out the geometric features of the road such as horizontal radius, super elevation, etc. the MX Road software is used.

3.2 DATA COLLECTION

It starts with a topographic survey which is done using total station. The survey is carried out at the places where the accidents have occurred. Total station projects the 3-d feature of the road when connected to a computer. It measures distance, angle, co-ordinates. By using the computer the data can be visualised in AutoCAD. Now the data is analysed for getting the geometric features of road using MX Road software.

Horizontal radius

The radius is found out from the alignment of the road at the location. The tangents are drawn from the centre line of the road and the radius with the tangents is found out. This gives the radius and is measured in metres. This is shown in the figure below

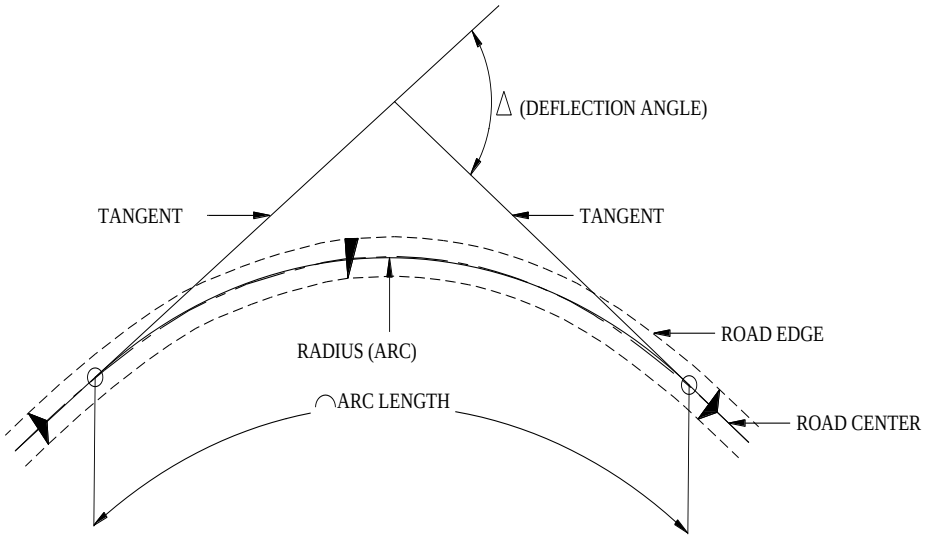


Fig: 4.2 Horizontal alignment data

Deflection angle

From the figure above we can see that the angle subtended by the tangents is the deflection angle.

Horizontal Arc Length

From the figure arc length is measured from the starting point of one tangent on the curve to the starting point of other tangent on the curve. This is known as horizontal arc length and measured in metres.

Superelevation

From the MX Road software a Digital terrain model has been developed and from this we can get the super elevation of the road. It is normally higher at the edge of the road which is away from the curve.

Rate of change of Superelevation

From the digital terrain model developed using MX Road software the super elevation is calculated and also the change in super elevation for every 10 m interval is calculated and thus the rate of change of super elevation is calculated. The units are 1 in n metre.

Vertical Gradient

From the model developed using MX Road the section of the centre line of road is available by software and the vertical grade is measured from existing section of the location.

Vertical curve length

The vertical curve length (VCL) is calculated from the model developed by the software. This is in the form of a parabola which is obtained by measuring the arc length between the two grades. It is measured in metres.

K-value

It is also known as equivalent radius of vertical curve. It tells us about the flatness of the vertical curve. It is the ratio of vertical curve length and change in vertical grade. K-value is the distance required to effect a 1% change in gradient. It is expressed as

$$K = \frac{VCL}{\Delta g}$$

VCL is the vertical curve length as mentioned above and

Δg is the change in gradient

Visibility

Visibility or sight distance is obtained directly from the software along the road for 10m intervals. It is the distance up to which the driver can safely view the road without any obstacles or it is the distance available to stop the vehicle before crashing in to the obstacle on the road.

Extra Widening

Horizontal Alignment includes extra widening also along the curves. This is studied from the book transportation engineering by Tom V Mathew. It is the extra length of the road provided on the curves and turnings more than the carriageway provided for straight alignment. It is done because the rear wheels of a vehicle usually travel a shorter path than those of the front wheels. Also it is also by psychological reason which is the tendency of the drivers to travel along the edges when travelling on the curves. It increases the effective width of the space for the vehicle.

The extra width which is provided than the normal to allow the vehicles to take a safe turn is extra widening. It is calculated by formulae provided in the code. This provision of extra widening which is the widening of pavements also affects the accident rate. If extra widening is not provided then there is a high chance that accidents occur along that curve. Also set back distance which is the distance from the centre line to the obstacle while on the curve also affects the accident rate.

Chapter 4

RESULTS AND DATA ANALYSIS

Accident Rate

It is the ratio between number of accidents in a year and number of vehicles with length of study corridor in that year. It is expressed as crashes per million vehicle-kms of travel.

$$AR = \frac{C \times 100{,}000{,}000}{V \times 365 \times N \times L}$$

AR = Accident Rate expressed as crashes per 100 million vehicle-kms of travel (100mvkm)

C = Total number of crashes in the study period

V = Traffic volumes using Annual Average Daily Traffic (AADT)

N = Number of years of data

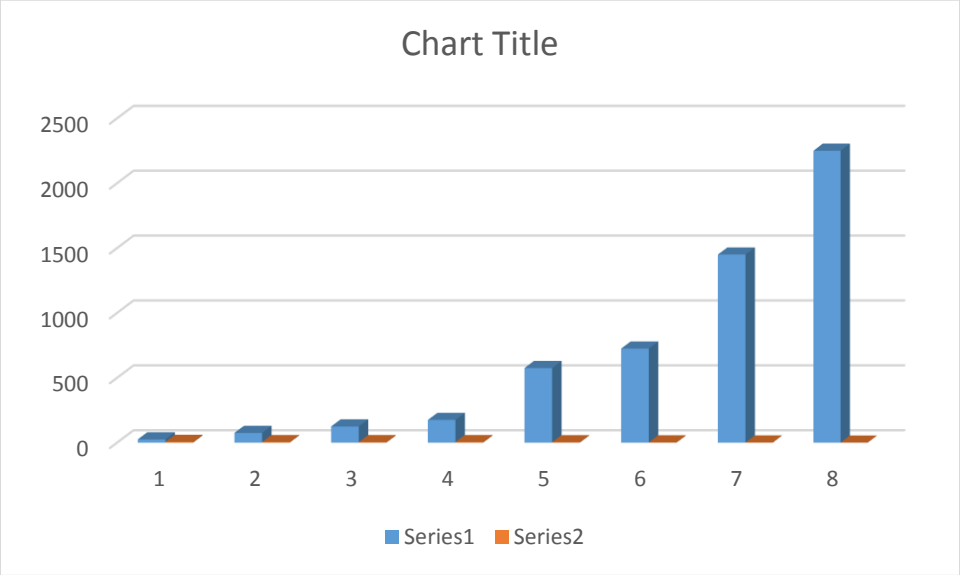
L = Length of the roadway in km

The data is of Annual average daily traffic and crashes are obtained from the respective departments with which they are concerned and the analysis is carried out. The results of the analysis are further explained below.

4.1 Analysis of Geometric parameters

4.1.1 Horizontal Radius

The number of crashes within range of radius are counted and accident rate has been calculated for the respective range of radius and histogram is plotted as shown below. From the data we can say that we could observe a significant change in the accident rate and that this should be given importance while design of roads. Also for small values of radius the value of accident rates are high which proves the fact that for steep curves the probability of accidents is more than that of the curves with larger radii.

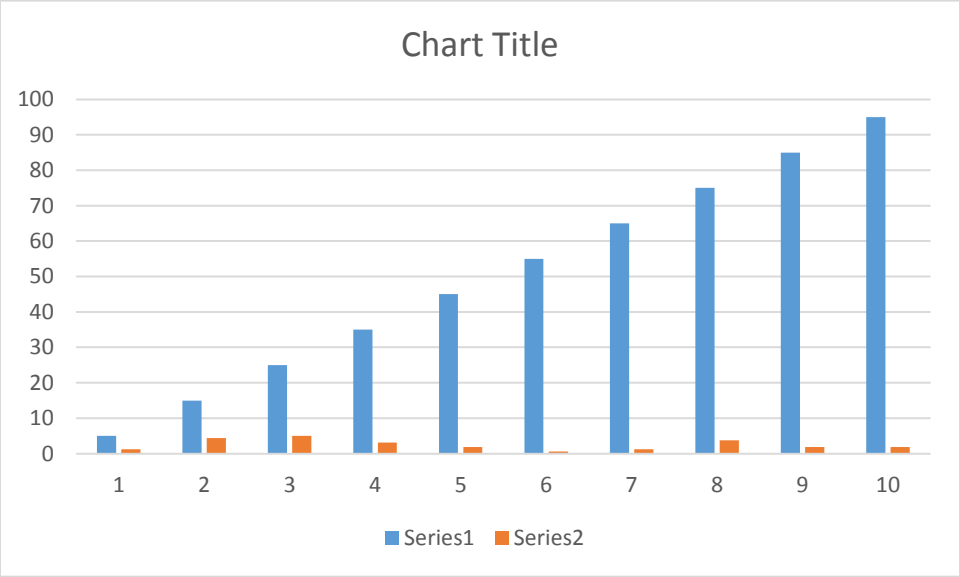


Series 1 – Horizontal Radius

Series 2 – Accident rate

4.1.2 Deflection angle

The accidents in every 10^0 interval of deflection angle are measured and the accident rate has been calculated and comparison Histogram has been shown below. From this it can be clearly said that the deflection angle doesn't have a significant change in the accident rate the value of accident rate in this case are very less when compared with other geometric factors.



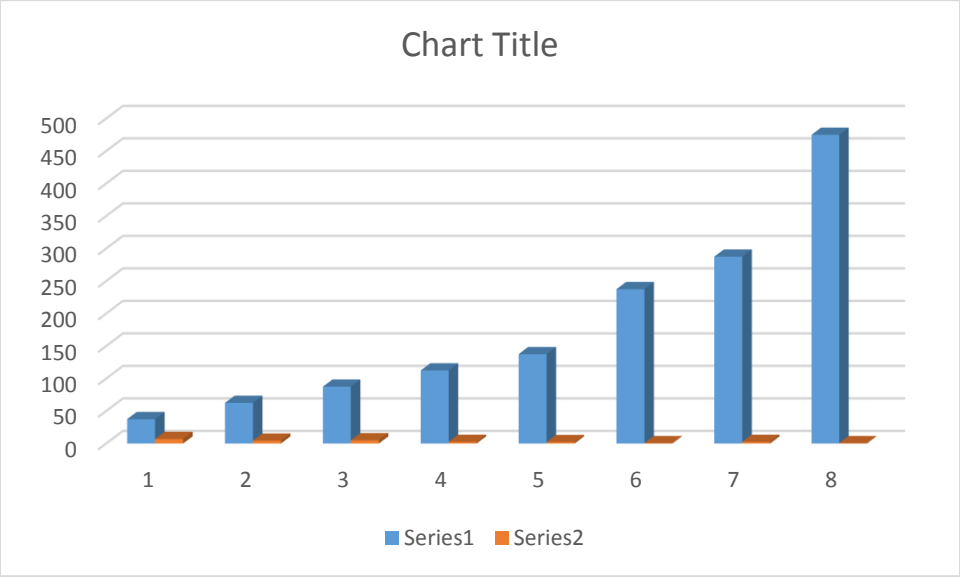
Series 1 – Deflection Angle

Series 2 – Accident rate

4.1.3 Horizontal Arc Length

The accident rate has been calculated for the range of arc length.

The comparison plot between horizontal arc length and accident rate is shown below. From the plot we could say that the accident rate decreases with increase in the horizontal arc length but it is very less when compared with other geometric factors like super elevation and visibility.

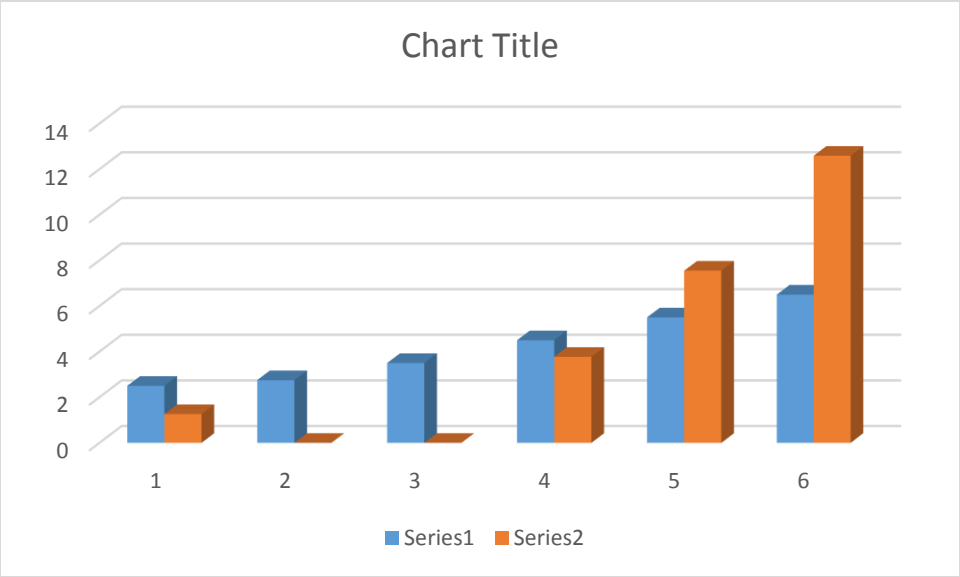


Series 1 – Horizontal Arc Length

Series 2 – Accident rate

4.1.4 Superelevation

The number of accidents are counted in one percent interval of super elevation and accident rate has been calculated and plotted below as histogram. The comparison shows that for very low values and for high values of super elevation the accident rates are high and they are comparatively for super elevation values between 2.5 to 4. Hence this has to be kept in mind while designing the road.

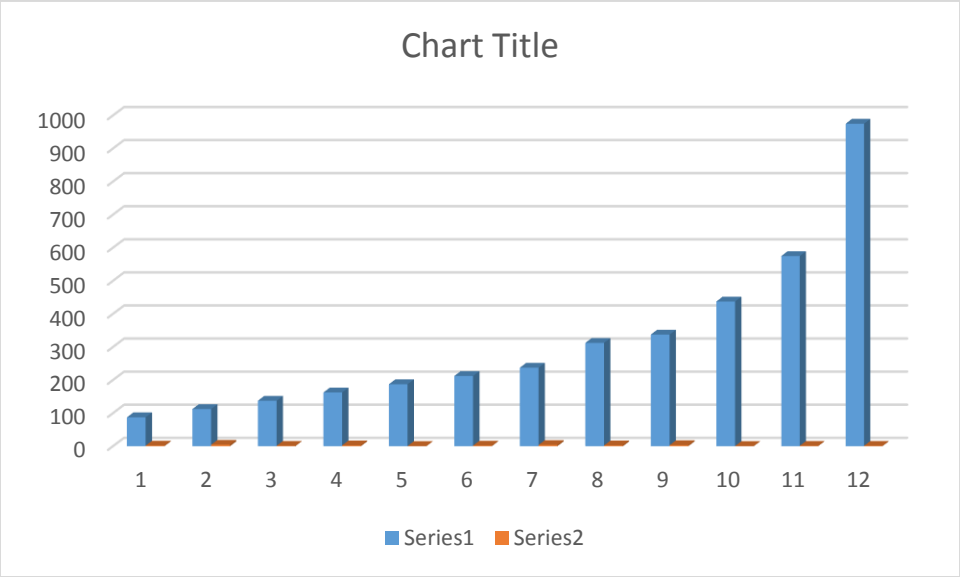


Series 1 – Superelevation

Series 2 – Accident rate

4.1.5 Rate of change of Superelevation

The accident rate has been calculated by counting the accidents within the range of change of super elevation. The histogram is shown below which clears that there isn't much change in the accident rate with respect to the rate of change of superelevation. Hence this might not be an important geometric factor which needs attention.

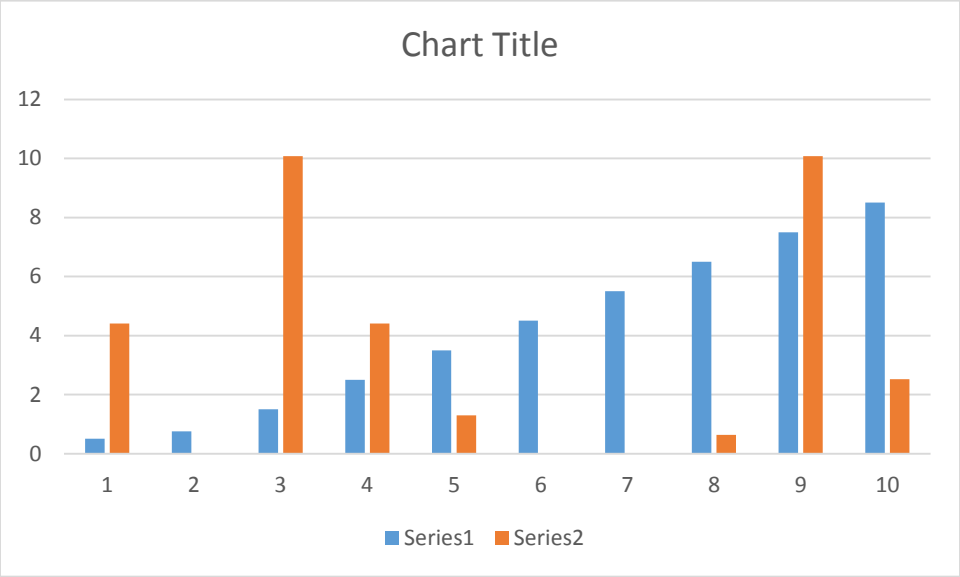


Series 1 – rate of change of superelevation

Series 2 – Accident rate

4.1.6 Vertical Grade

The accident rate has been calculated by knowing the number of accidents in one percent interval of vertical grade. The comparison histogram is shown below from which we can observe that the values of accident rate are very irregular and doesn't follow a trend with vertical grade. However from the data we could observe the range where accident rate is high and hence we could design the road according to that.

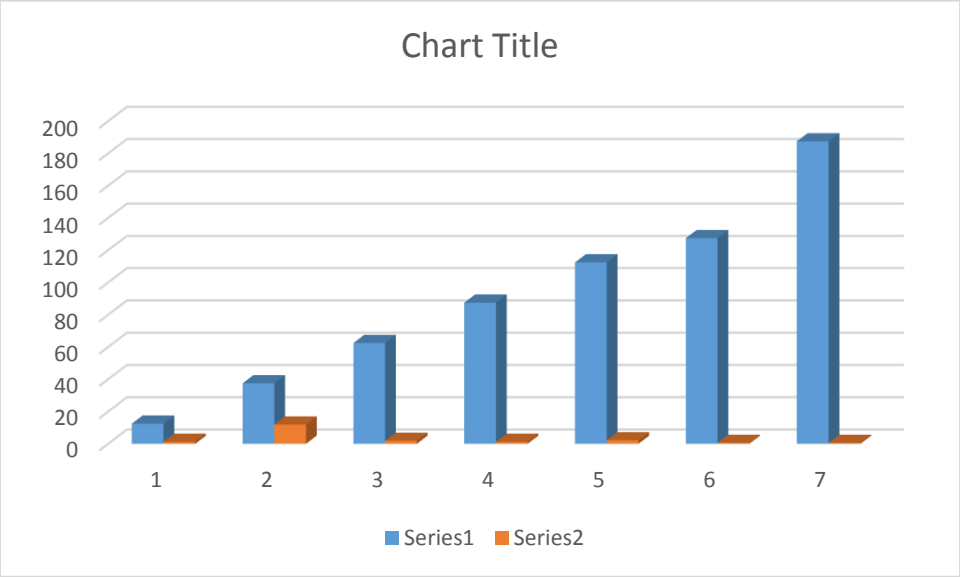


Series 1 – Vertical gradient

Series 2 – Accident rate

4.1.7 Vertical curve length

In 25 m interval of the vertical curve length the accidents have been counted and the accident rate has been calculated. The comparison is shown below in the form of Histogram and from the comparison we can say that it varying irregularly with the vertical curve length but however for the range of 25-50 the accident rate is the highest observed. Hence proper precautions should be taken while providing the vertical curve length during the design.

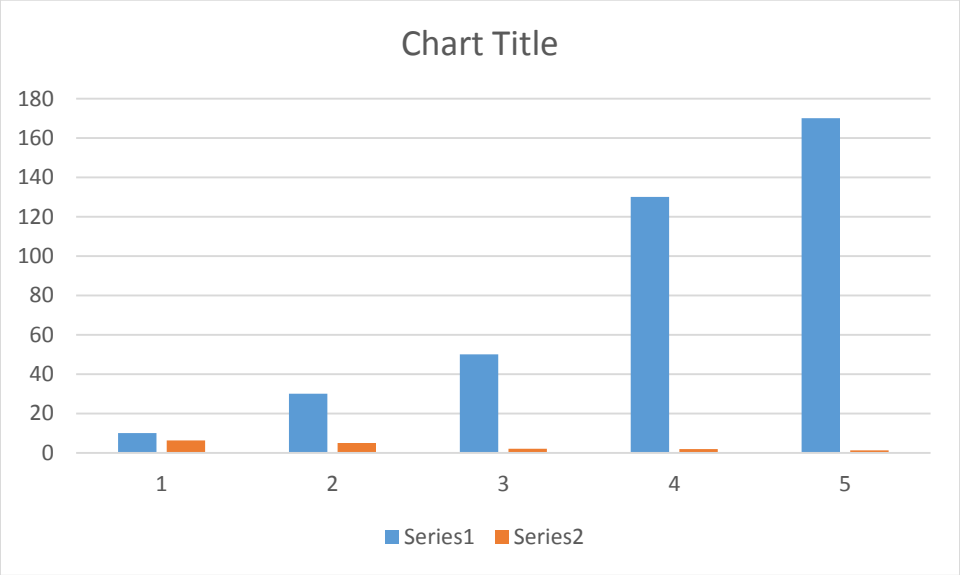


Series 1 – Vertical Curve Length

Series 2 – Accident rate

4.1.8 K-value

The number of accidents have been counted for K-value that is the distance required to change 1% in grade and accident rate has been calculated. The comparison as shown below shows that for lesser K-values the accident rate is more and it went on decreasing for increase in the K-value. Which means that the accident rate is inversely proportional to K-value and the fact that the distance provided to change the gradient when provided insufficiently could lead to accidents. The comparison histogram is shown below.

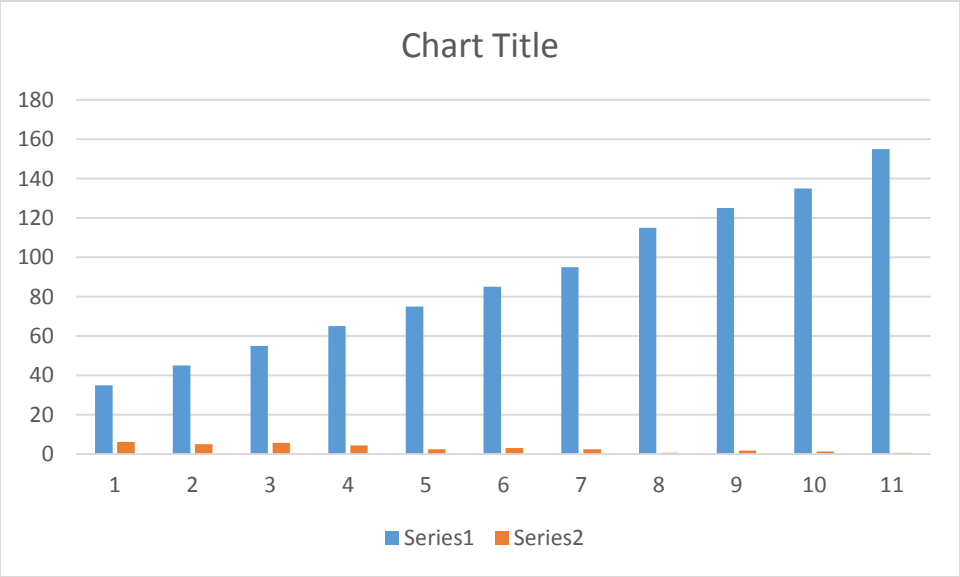


Series 1 – K-value

Series 2 – Accident rate

4.1.9 Visibility

The number of crashes has been measured in 10 m interval of visibility and the accident rate is calculated. The comparison is done and shown below and we can observe from the diagram that for the less visibility values the accident rate is more which proves the fact that the sight distance should be provided sufficiently for the safe journey on roads.



Series 1 – visibility

Series 2 – Accident rate

4.2 Results of Analysis

It is used to summarize a group of data. Analysis of variance is used to find the differences between group means and their association. The geometric factors have been analysed with accident rate as shown below. The regression is done and the result is obtained from this the R^2 value for Horizontal Radius is found to be 0.82 which is nearer to 1 and hence it can bring a significant change in the accident rate, which means that it affects the accident rate very much and should be given more importance while designing the road. Also from the results the R^2 value for Superelevation is found to be 0.89 and is nearer to 1 and hence is a significant factor. The R^2 value for K-value and visibility are found to be 0.87 and 0.89 respectively and are also the significant factors which affect the accident rate in the case of a highway in plain and rolling terrain.

The P value is <0.005 for 95% level of significance which is the probability and hence the values obtained above are significant.

Chapter 6

SUMMARY AND CONCLUSION

In this study the study corridor is NH-200 between Chhatabar and Bhojpur. The section of 60 km length is chosen and studied for the geometric features of the road such as horizontal radius, super elevation, K-value, Visibility and others and the analysis is done and in the analysis the value of R^2 are nearer to one for the geometric features such as Horizontal Radius, Superelevation, K-value and visibility. From the regression we can say that the factors which have their R^2 value nearer to one have a greater effect on the accident rate. Hence for NH-200 which is of plain and rolling terrain the geometric features that influence accident rate more are horizontal radius, K-value, Superelevation and visibility.

Hence while designing a road in plain and rolling terrain these geometric features namely Horizontal radius, K-value, Superelevation and visibility has to be given more importance.

Chapter 7

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