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Highway Accident Modeling Influence of Geometrics

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ABSTRACT

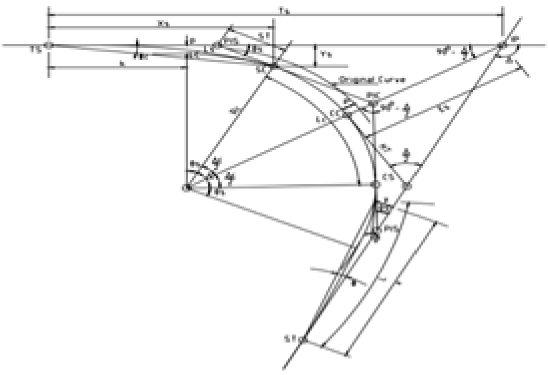
Road safety is an issue of prime importance in all motorized countries. The road accident results a serious social and economic problems. Studies focused on geometric design and safety aim to improve highway design and to eliminate hazardous locations. The effects of design elements such as horizontal and vertical curves, lane width, shoulder width, superelevation, median width, curve radius, sight distance, etc. on safety have been studied. The relationship between geometric design elements and accident rates is complex and not fully understood. Relatively little information is available on relationships between geometric design elements and accident rates. Although it has been clearly shown that very restrictive geometric elements such as very short sight distances or sharp horizontal curve result a considerably higher accident rates and that certain combinations of elements cause an unusually severe accident problem. In this paper, road geometric design elements and characteristics are taken into consideration, and explanations are given on how to which extent they affect highway safety.

1, BACK GROUND AND MOTIVATION

Motor vehicle accidents kill about 1.2 million people in a year world-wide and the number will grow to more than 2 million in 2020 unless steps are taken; a study released by the World Health Organization (WHO) and the World Bank. [Washington: Article-Traffic accidents becoming one of world's great killers, By Matthew Wald, April 8, 2004]. Any design solution mitigating this kind of individual human behavior cannot be predicted, only some safety rules can be enforced. Also, vehicle factors, related to mechanical behavior of vehicles are not the scope of civil engineering study. Hence, road factors are only considered as part of this study. It is very important for the highway to establish a harmony between all the three factors at the design stage of a highway. With a geometrically good design, it is possible to compensate for the other factors and thus decrease the number of traffic accidents

Horizontal Alignment

The horizontal alignment is the route of the highway, defined as a series of horizontal tangents and curves. Horizontal curve is the curve in plan to change the direction of the center line of the highway. The geometries of horizontal alignment are based on an appropriate relationship between design speed and curvature and on their joint relationship with super elevation and side friction.



Typical Horizontal Curve

Vertical Alignment

Vertical alignment is the longitudinal section of a roadway to provide easy and safe change of gradient.

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It is defined as a series of gradients and vertical curves. Gradient is the rate of rise or fall with respect to the horizontal along the length of a road expressed as a percentage or as a ratio or in degrees. Vertical curves to effect gradual changes between gradients with any one of the crest or sag types and result is safe and comfortable in operation, pleasing in appearance, and adequate for drainage. The typical vertical curve in crest condition is furnished in figure 1.2 as per IRC: 23-1989.

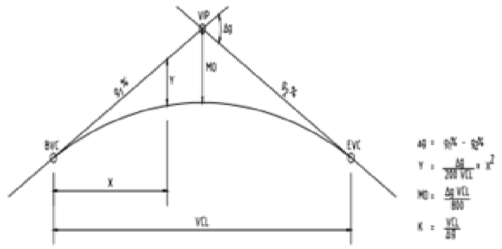

Figure 1.2: Typical Vertical Curve

Where

- VIP : Vertical point of intersection.
- g : Gradient
- MO : Mid-ordinate
- Δg : 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.

Accident Statistics

Road accidents carry high economic and social costs, which are not easy to measure. The cost of road related injuries and accidents can be viewed in terms of (a) medical costs (b) other cost related to administrative legal and police expenditure (c) collateral damage in terms of damage to property and motor vehicle and (d) loss due to income. In addition, accident survivors often live a poor quality of life and have to live with pain and suffering which are difficult to estimate. In economic terms, the cost of road crash injuries creates direct impact to gross domestic product (GDP) of the country.

2, LITERATURE SURVEY

The study is an effective traffic accident modelling in minimizing the accident rates depending on road factors and finding the impact of highway geometric elements. Hence, a literature survey was carried out in the field of accident causative factors and accident prediction and optimization modeling and presented as below

Accident Causative Factors Overview

Feng-Bor Lin (1990) studied on flattening of horizontal curve on rural two lane highways and found that horizontal curves on highways are on average more hazardous than tangent sections. As their curvatures increase, horizontal curves tend to have higher accident rates. He suggests that the differences between the 85th percentile speeds and the safe speeds have no statistically significant relationships with the accident rates. In contrast, the magnitudes of speed reduction, when vehicle moves from a tangent section to a curve, have a significant impact on traffic safety. Such speed reductions on horizontal curve with gentle grades are strongly correlated with the curvatures of the curves. Therefore, curvatures can be used as a safety indicator of the curves.

Y. Hassan et al. (2003) studied on effect of vertical alignment on driver perception of horizontal curves and found that perception of the driver of the road features ahead is an important human factor and should be addressed in road design. An erroneous perception of the road can lead to actions that may compromise traffic safety and poor coordination of horizontal and vertical alignments is believed to cause such wrong perceptions. Through statistical analysis, they suggested that the horizontal curvature looked consistently sharper when it overlapped with a crest curve and consistently flatter when it overlaps with a sag curve.

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Technology

Road and vehicle technology is improving all the time. The best motorways nowadays have variable speed limits, warning and traffic information signs, multicoloured cats eyes, SOS phone boxes every few hundred meters, congestion monitoring and digital speed cameras. In-vehicle technologies are being developed to make driving easier and safer, there are many different types, most are not in the remit of this project to describe but a few are worth considering due to their geographical nature (geographically). Features that reduce the complexity of the driving task (including automatic gears, windscreen wipers, climate controls, headlights etc.); features that detect and report mechanical faults; and improvements in basic features like power steering and anti-skid breaks are almost totally irrelevant here. Monitoring systems that record in cab conditions and to some extent driver behavior are similarly irrelevant here. Speed delimiters that prevent vehicles being driven above certain speeds and information systems that aid in navigation and provide details of the road ahead are more relevant. But perhaps the most relevant in-vehicle technologies are those which continually record and process the location, velocity and accelerations, along with other details of the vehicle. These are like a sophisticated Black Box Recorder (BBR) but are perhaps better referred to as Real Time Communicable Kinematic Geographical Positioning Transit Information System Onboard Processing Nodes. However, because that is such a mouthful, in this Section I shall refer to them simply as Onboard Information Processors (OIP).

Geographical analysis and geographical modeling

Many analyses of road accident incidence estimate the effect of variables such as traffic volume, traffic flow and characteristics (human and vehicular), road geometry and density, road and weather conditions, lighting conditions, temporal variables such as the day of the week, and other geographical variables such as the proximity of schools and hospitals. When estimating the effects of the vast array of variables, pre-selection of specific accidents is common. This can prevent the model becoming overly complex but can also be a source of subjectivity. take into account things like the severity of victim injuries. Developing predictive models of accident incidence depends both on the collection and manipulation of accident and related data, and on the choice or selection of variables for the modelling. One variable is usually chosen as the dependent variable and the variables used to estimate the values of this are called the predictors.

Muzzone et al. (1999) outlines a study of collisions in Milan, Italy in which some of the aforementioned variables are used to predict the number of accidents at intersections in a given time period using artificial neural netw

More on various geographical themes…

The differences between urban and rural Eight times more deaths occur on country roads than in urban areas. (Is it that the majority of rural deaths occur on motorways, or is it that rural road accident rates on all types of road are higher?)

Road Engineering Measures Rural/Urban

Unimproved rural single carriageways have accident rates second only to urban roads, with much higher accident severities due to higher speeds. Low cost remedial measures have been identified, but their effectiveness has yet to be determined, and because accidents are sparsely scattered on rural roads this can be difficult. (So in order to look at this problem a very large area study like the one in this thesis may help)

Four basic remedial measures:

Sea green bar markings on the give way approach to a priority junction; red calcned bauxite road surfacing on the main road approach to a junction; vehicle activated speed warning signs at bends; changes in speed limit along roads with bends with and without advisory bend warning signs. The final report is unpublished and shows that the use of bar markings on junction approaches and vehicle activated warning signs on bends have resulted in small reductions in vehicle speeds. The reduction of the speed limit from 60 mph

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to 50 mph appeared to have no effect on speed except when supplemented by other warning signs.

A focus on road layout and road characteristics

It is reasonable to expect an increase in road accident incidence (especially involving pedestrians) when a one-way road is changed into a two-way road and vice-versa. Perhaps going from one-way to two-way the reasons are more obvious, but anyway it can be argued that there is increased risk for the majority of road users. A pedestrian believing a street to be two-way and walking down the right hand side in the direction of road traffic might dangerously start to cross the right lane seeing no oncoming traffic prior to checking for traffic coming the other way.

The regional highways department in France estimated that road deaths in southern France would be cut by half if all the trees lining the roads were removed. Collisions with trees are involved in 38% of fatal traffic accidents in that region. However, others suspected that the real cause and an equally high percentage of such accidents involve excessive speed and/or drink driving. Nearly 10% of the 8,000 road deaths in France each year are associated with tree collisions. Buildings and large objects like parked Lorries and trees along the roadside are a danger to occupants of vehicles that leave the road.

Rates and risks

Rates: Rates are very interesting measures and can be calculated in many different ways to show subtly or completely different things. Rates are generally of the form of incidence as a proportion of exposure, in other words, occurrence of an event divided by the risk of an event, or observed over expected. Often both the numerator and the denominator have a very similar spatial and temporal pattern. Dividing one by the other (effectively normalizing the data) can be extremely useful in identifying the differences. Indeed, mapping the differences (the errors) between the observed incidence and the expected incidence from a model developed to predict the incidence is key to examining the variability in the model fit. There are many different error measures, they have varying levels of sensitivity but collectively can form a useful set of pictures which reveal the fitness of a particular model. Visualizing such fitness measures helps identify the situations in which the model predicts well and where it predicts poorly. This can offer big clues as to what exogenous factors are missing from the model and which parameters should be tweaked.

3, MATERIALS AND METHODOLOGY

Accident analysis has been carried out in order to determine the effects of different geometric elements of the highway with accident rate of the same highway. These geometric elements are horizontal radius, deflection angle, horizontal arc length, superelevation, rate of change of superelevation, vertical gradient, vertical curve length, K-value and visibility/sight distance. Finally, these geometric elements are statistically analysed and considered for model development which are statistically significant.

Accident Rate

The accident rate is defined as the ratio between the number of accidents which happened in a given year and the number of vehicles with kilometres of travels length during that same year. It is generally expressed in crashes per million vehicle-kilometres of travel

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

The variables in this equation are:

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

4, RESULTS AND DISCUSSION

Cross Section Determination

The Flow Chart showed in Figure 4.1 details a procedure to help determine the most appropriate cross section to be used. References to other relevant sections of the Manual are given for assistance.

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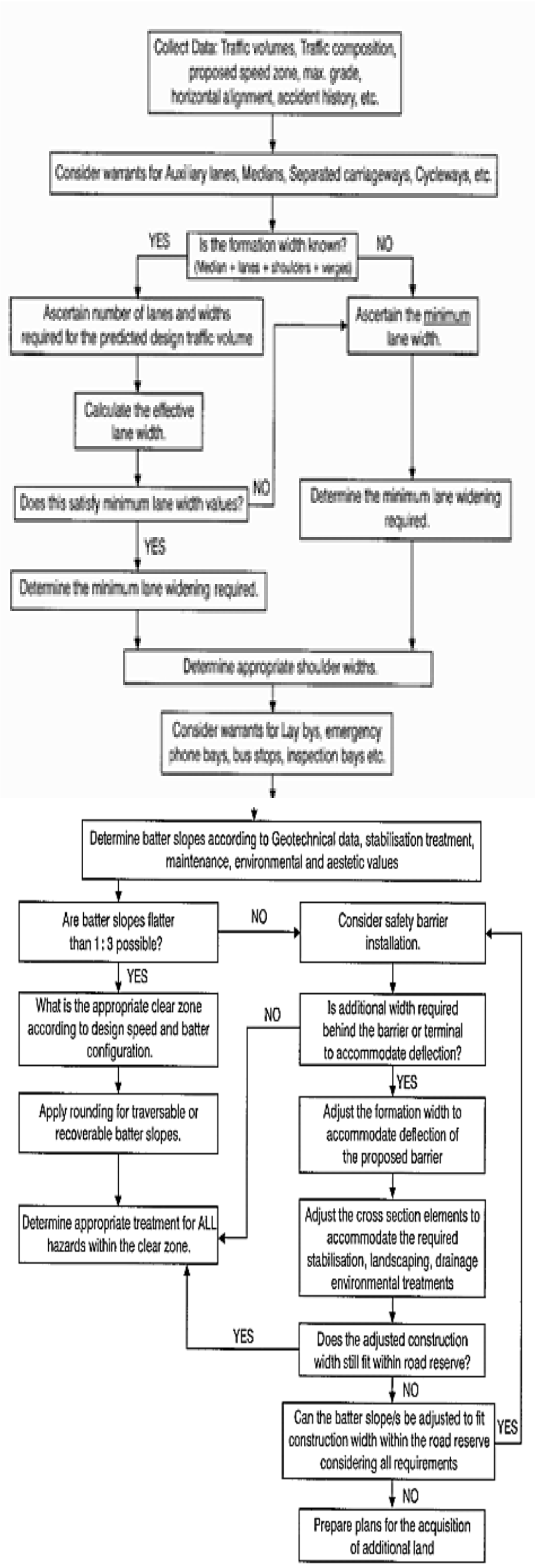
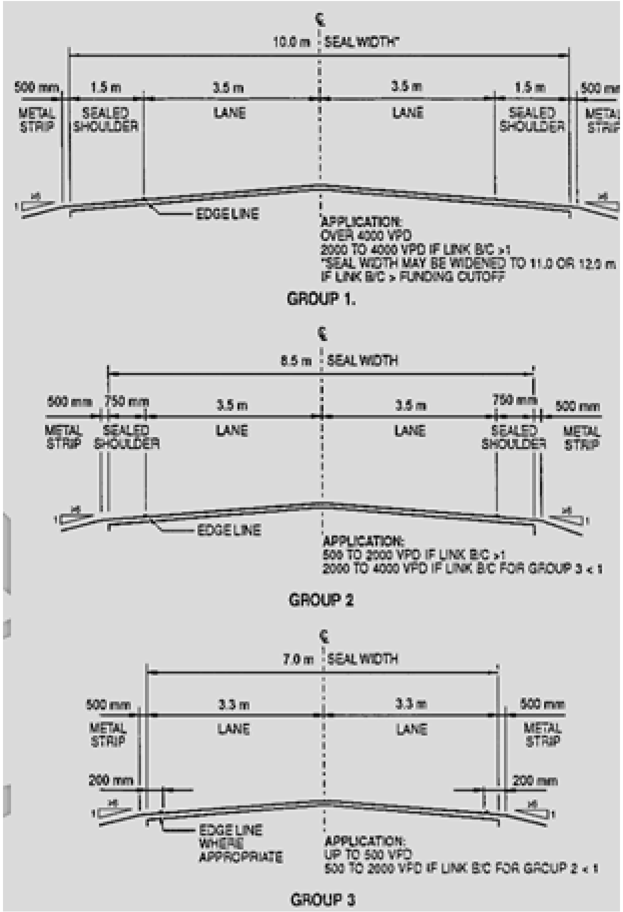


Cross Section Determination Flow Chart

Minimum Seal Widths for State Highways



Minimum State Highway Sealed Widths

CONCLUSIONS

After reviewing on the many studies which are related the safety of cross-section and alignment elements can be concluded the following:

- The presence of a median has the effect of reducing specific types of accidents, such as head-on collisions. Medians, particularly with barriers, reduce the severity of accidents
- Fixing the cameras everywhere and if the reaction of the traffic police works accordingly may create fear in the drivers then they also follow the rules it leads to decrease in the accident rate.
- providing underground transportation facilities in the highly traffic areas decreases the waiting time and the transportation time.

- Rates of ROR and OD accidents decrease with increasing lane and shoulder width. However, the marginal effect of lane and shoulder width increments is diminished as either the base lane width or shoulder width increases.
- On multilane roads, the more lanes that are provided in the traveled way, the lower the accident rates.
- Shoulder wider than 2.5m give little additional safety. As the median shoulder width increase, accidents increase.
- From the limited information available, it appears that climbing lanes can significantly reduce accident rates.
- Lane width has a greater effect on accident rates than shoulder width.
- Horizontal curves are more dangerous when combined with gradients and surfaces with low
  coefficients of friction. Horizontal curves have higher crash rates than straight sections of similar
  length and traffic composition; this difference becomes apparent at radii less than 1000 m.

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