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Geometric Design Consistency and its relation Tosafety on Outer Ring Road

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ABSTRACT

Studies have shown that accidents tend to occur disproportionately at certain road stretches indicating that road characteristics plays a major role in collision occurrence, besides driver error. Therefore, achieving geometric design consistency is important issue of design and evaluation of highways. Inconsistency in highway can violate driver's expectancy leading to evasive manoeuvre and often accidents.Different methods have been used to identify inconsistent design which includes operational speed, alignment indices, drivers working load and vehicle stability.

Keywords:Geometric Design, road safety, accidents, Speed, Outer Ring Road

I.INTRODUCTION

The goal of transportation is generally expressed as the safe and efficient movement of people and vehicles. The Designer uses many tools and techniques to achieve this goal. Checking consistency of any roadway is one such technique and recently widely accepted as a good measure of safety. Design consistency refers to geometric design conformance with driver's expectation. The concept of driver's conformance being closely related to error committed by a driver while performing driving task, can be implicitly correlated with safety of the highway.

Road accidents are attributed mainly to one or a combination of the three elements of the traffic system: the driver, the road and the vehicle. Driver error is often cited as the leading contributor of accidents (Alexander and Lunenfeld 1986; Evans 1991). Driver errors and accidents are more likely to occur when there is some disparity between what drivers may believe to be a safe speed and the actual speed at which a feature can be negotiated safely (Wooldridge et al. 2003). Thus the abrupt change in geometric features beyond the drivers expectation, results in a speed error which leads to collision and accident.

Various approaches have been used to find the consistency of geometric design such as speed profile, vehivle stability and alignment indices. Models are developed for each criterion and checked for statistical significance. Crash data is collected and correlated with models developed using regression analysis.

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Design consistency is the conformance of highway section with drivers expectancy. A consistent design avoids abrupt change in geometric design there by maintaining consistent speed over a short period of time. Its successive element act in a coordinated manner and thus avoids any surprises thereby producing harmonize drivers performance. It ensures that the ability of motorist to guide and control a vehicle in a safe and efficient manner is not violated.

The importance of geometric design consistency and significant contribution to road safety can be justified with an understanding of driver-vehicle-roadway interaction. Roadway geometry, traffic condition and road side environment are the inputs to driving task and determine the driver's workload required to maneuver safely. The efficiency to handle these inputs depends on driver's expectancy and other human factors. Once these inputs are processed, are converted into vehicle operation. When inconsistency exists, it violates driver's expectancy and therefore driver may adopt an inappropriate driving or speed leading to collision. In fact, Lamn et al reported that half of the vehicle accident attributed to inappropriate speed adoption in rural highway, indicating that design consistency is related to safety. Yet, importance of geometric design consistency to road safety, it is not always maintained in current design approach.

II. SOURCE OF GEOMETRIC DESIGN INCONSISTENCY

There are a number of sources of geometric design inconsistency in traditional design approaches. The important sources of inconsistency are discussed as follows:

Inadequacy of design speed concept

One of the most important factor of geometric design inconsistency is geometric design standard which was developed long ago and still in use. The rationale of design is based on the stability of vehicle when it travels along the circular horizontal curve at constant speed. When vehicle is travelling along the circular horizontal curve, centrifugal force acts away from the center of the curve. Centrifugal force is countered by centripetal acceleration provided by side friction and super elevation.

Other sources of Inconsistency

Gradual change in geometric design standards over a few decades to address growing traffic demand, speed and safety concern have led to inconsistent design of highway along same section. There are other constraints such as financial inadequacy, environment problem have resulted inconsistent design.

III. OBJECTIVE AND SCOPE OF THE WORK

The broad objective of this study is to identify the factors affecting the traffic safety along outer ring road of Hyderabad by analysing the data and identify the courses of action that will lead to improved road safety.

i. To investigate and identify the factors influencing theconsistency in geometric design for the selected stretches of Outer Ring Road(ORR).
ii. To study the variation in accident rate on selected Stretch of ORR.
iii. To study the causes of accidents and suggest corrective measures at potential location.
iv. To develop models which explicitly consider design consistencies using geometric data, accident data, speed data.

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v. To identify the Black spot and to suggest alternatives.

IV. REVIEW OF LITERATURE

Messer (1980) presented a methodology to evaluate consistency based on driver behaviour principles associated with workload ratings for different geometric features. For example, because sharper curves are generally more troublesome, a driver's workload increases with the degree of curvature and with the deflection angle of the curve. Using the same reasoning Messe also suggested that excessively long curves were accidentally inducing and should be discouraged. Similarly, he proposed some general design recommendations for consistent horizontal and vertical alignments and intersections.

Lamm and Choueiri (1987) in Germany analysed the horizontal alignment of two-lane highways and developed several consistency criteria for the design characteristics. It was suggested that the difference between the 85th percentile operating speed and the design speed should be smaller than a set of criteria for good, acceptable and bad designs. Likewise, the difference in these same two speeds on two consecutive elements should be bounded by similar criteria. The researchers suggested that the sum of curvature change rates (CCR) between the horizontal curve and the adjacent spirals explained most of the change in operating speed along each section. No measure, however, was provided for the entire highway, including tangent sections.

Paul Watters and Margaret O'Mahony (2007) of university of Dublin, Trinty developed the relationship between geometric design consistency and safety of rural single way road. They have selected study area of 70 km in N52 and identified 19 curves and 19 tangents as controversial. Numerous geometric design features were measured on site and spot speed data was collected from midpoint of tangent and curves. Operating speed models were developed to estimate speed along the curve. Using these estimated operating speeds a sample geometric design consistency evaluation is carried out. The elements are classified as good, fair and poor using design evaluation criteria.

Bhuyan (2003) indicated that many factors may exhibit a measurable influence on driving behaviour and traffic safety on highways. These include, but are not limited to, Human factors such as improper judgment of road ahead and traffic, driving under the influence of alcohol or drugs, driver education and experience, young driver, age and sex. Anne et al. (2010) summarized those fatalities during a crash rises when drinking age is lowered and fatalities decreases when drinking age is raised. He showed a relationship between minimum legal drink age and highway crash relationship. He concluded that lowering drinking age to eighteen will increase fatalities rate among young people. Lee (2006) developed a real- time crash prediction model by taking total travel time and Crash potential reduction. The study result indicated the variable speed limit could reduce crash potential by 5-17%. Tornros and Boiling (2005) conducted an experiment with 48 drivers by covering a distance of 15 Km on a rural two-lane road. They concluded that driving performance reduced by dialling hand held phone and speed decreased with hands free phone. Reaction time to warning sign at road side decreased for hand held phone user. Oduro (2012) surveyed aboutdifferent types of accidents and found that 83% break failure result in accident. Brake ineffectiveness is due to vehicle overloading, uneven tyre pressure, incorrect

brake adjustment, air in breaking system, automatic brake adjuster not working, brake fluid on lining.Brake failure is due to broken pipe, low brake fluid level, cracked brake drum, brakes overheating. Somchainuek (2013**)** investigated road side safety on Thai National Highway. The result showed that speeding vehicles were involved in roadside crashes accounted for about 70% of the total crashes and 30% of road side crashes were due to road side trees.

V. METHODOLOGY

The methodology adopted in this study is based on data from various govt. sources namely; Hyderabad Traffic Police, Hyderabad Metropolitan Development Authority (HMDA) reports are the main sources for Accident data. The collected accident data includes the time of occurrence of accident, type of accident, vehicles involved in the accident, location of accident, number of affected persons etc. The collected data will be tabulated and the general analysis has to be carried out. The General analysis includes like total number of fatal and non-fatal accidents and total number of accidents by yearly wise, monthly wise, daily wise etc.

Outer Ring Road (officially: Nehru Outer Ring Road) is a 158 kilometer, 8-lane ring road expressway encircling the City of Hyderabad, Telangana, India.Hyderabad Metropolitan Development Authority (HMDA) reports are the main sources for Accident data. The collected accident data includes the time of occurrence of accident, type of accident, vehicles involved in the accident, location of accident, number of affected persons etc. The geometric data for this study includes the information about the curves such as: radius of the curve €, tangents length, curve length (CL), deflection angle (DA), degree of curve (DC), super elevation and lane width. Grades were also available but the range of the grades was such that it does not affect the speed of the vehicle to significant level. Hence it was ignored.For this study the stretches shown in Figure 1 was selected for data collection.

Figure1: Study Area

VI. ANALYSIS

Distribution of accidents by highest injury severity

The distribution of the total 459 road accidents by injury severity (based on the most severe injury sustained by any human involved in each accident) is shown in Figure 2. As it can be seen, more than 26% of the accidents examined during this study resulted in fatal or major injury. The time of occurrence of accidents is shown in Table 1

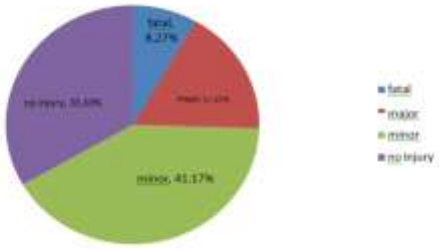

Figure 2: Distribution of accidents by highest injury severity

Distribution of accidents by time of occurrence

The total numbers of accidents used for the contributing factors study were plotted against time durations of 3 hours to identify times of occurrence (Figure 3). The data shows highest percentage of accidents (30%) occurred between 12:00pm to 06:00pm hrs.

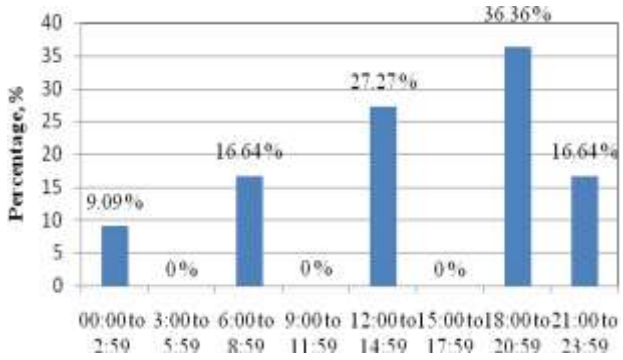

Figure 3: Time of occurrence of accidents

Percentage distribution of Accidents by road condition

The following figure 4, shows the distribution of accidents by road condition such as Straight road, Slight curve, and Sharp curve. More number of accidents is occurring on straight road sections of the road stretch.

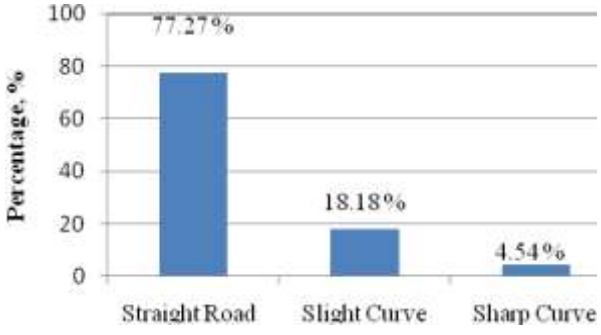

Figure 4: The percentage of accidents occurred vs. type of road condition

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The more number of accidents are occurring along straight road that is 77.27% of accidents are occurring on straight road whereas 18.18% of accidents are occurring on Slight curves of the road section and 4.54% of accidents on Sharp curves of the road stretch.

The following table 1, shows the distribution of various factors which are influencing the road accidents.

Table 1: Factors influencing accident

Factors influencing Accidents	No.of Accidents
Over Speed	7
Vehicle out of control	5
skid	5
vehicle factors	5

The major influencing factor of accident is Speed (31.82%) and followed by Vehicle out of control (22.73%). Even though the expressway has posted speed limits, drivers often ignore these or consider them inappropriate for the vehicle they are driving. Hence, there is an urgent need for scientific research to understand what drivers feel is a safe-speed based on the road features and the vehicle being driven. Many countries have improved on speed limits using speed management techniques.

Any new speed limits need to be effectively communicated. In addition to speed limit posts, communication of changes in speed limits can be enhanced through road markings and traffic calming measures. For example, in sections where trucks slow down to climb a grade, signage could warn approaching drivers of the slow traffic lane ahead. In the ideal scenario, the road environment itself would psychologically influence the driver to follow a safe speed limit. Good speed enforcement is the final alternative to control driver speeds.

VII. CONCLUSIONS.

In this study the selected section (km61.7 to km95 of ORR) was found to be consistent or fairly consistent since the design of the road is being done very recently(2015) and does not affect the crasheson the highway.Speed predictions were made at a location along the selected stretch by performing spot speed studies. From the obtained data, speed distribution curves are drawn. From the curves minimum percentile speed (V15) and maximum percentile speed (V85) are predicted.

Based on Accident data analysis the following conclusions are drawn:

1. From the analysis of accident data for the selected stretch it is observed thatfatal accidents (10%), Major accidents (15%), Minor accidents (45%), No injury accidents (40%).
2. Cars and trucks are the most affected road user types in accidents on the expressway. It is estimated that the vehicles involved in the accidents consists of cars (10%), Trucks (7%), Mini vans (7%).
3. More number of accidents is occurring on straight road (78%) and the majority of accidents are occurring during the time period 18:00 to 21:00.

4. The major influencing factors for occurrence accidents are Speed (32%), Vehicle out of control (23%) and others.
5. On the selected stretch km 92 to km 93 is considered as the black spot.

From the observations, the major contributing factor for the cause of accidents is the vehicles moving with higher speed i.e. more than design speed (100kmph). Hence, strict enforcement on speed limits and Lane violation should be avoided to reduce number of accidents. Operation and maintenance should be done at regular intervals and the damaged parts of the roads needs to be repaired immediately. Closed Circuit Television (CCTV) is to be installed at regular intervals of ORR and the number of patrolling vehicles needs to be increased. By using Highway traffic management system we can reduce number of accidents occurring.

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