Driver Workload Evaluation on the Basis of Design Criteria in Rural Road of Kaski, Nepal

Er. Prakash Baral

Abstract— **Road fatalities are severe these days not only in developing countries but also in developed countries too. Various criteria (methods) are explored to minimize fatalities like continuous speed profile, alignment index, and vehicle stability and driver workload method. Though most of the explorations are based on continuous speed profile, this paper focus on estimation of threshold value of driver workload (V_d) based on design criteria and crash rate (CR) for a rural road section. Three test curves were observed on Methlang-Gyarjati road section and analyzed based on variation in speed, vehicle stability and driver workload itself.This paper focus on utilization of different design criteria in the estimation of driver workload in rural road of Kaski. Visual demand (V_d) is determined from pre-determined model (V_d =0.173+43/R) where road geometric feature radius is taken into consideration. The moderate value of workload 1.2 was obtained from test curve section 1 which is between 1.9(maximum) and 0.7(minimum).From criteria 1, test curve holds good during design evaluation with a value of 9.59 which is less than 10Km/hr, but vehicle stability method (Δf_R) holds poor for all the test curve section under observation. Driver workload is minimum of all and crash rate is also minimum with a value of 5.83 for test curve section 1.So, overall from the above evaluation improvement on curve section 2 and 3 are required from driver workload(visual demand) point of view in comparison to 1 which holds good criteria on the basis of variation in speed. Therefore, from safety criteria aspect as well as design consistency the threshold value of driver workload (visual demand) is 1.2 which is good to meet the driver expectations in rural road of Kaski district.**

Index Terms— **Vehicle Stability, Driver workload, Operating speed, Vehicle stability**

I. Introduction

Improper road geometry along with different road geometry (curve, lane width, shoulder) is the major cause of accidents in most of the roads which are major issues these days in global scenario. Beside these, road users as well as different vehicle characteristics cannot be neglected regarding this aspect.

Road crashes are major problem in our society. Every year 1.2 million of people are killed and between 20 and 50 million people are injured due to road accidents. In European countries most of the accidents occur in rural roads, for example in Spain approximately 63% and Ireland 57% occur in rural roads [1]. Basically, lack of geometric design consistency is major leading cause regarding to safety issues in rural road of Kaski. The geometric design consistency is met when driver expectations and road behavior fit. If there are sudden changes in geometric features then driver could not process the information within short time with increase in workload resulting crashes.

Previous research includes primary task, secondary task, direct measurement psychophysiological variables and the information storage method. Most of all research is based on information storage (vision occlusion) method which results in development of relationship between driver workload and different road geometry such as curve radius, degree of curve to estimate driver workload. This study focus on estimation of threshold value of driver workload along with the use of other design criteria and predetermined model of crash rate which is required to balance driver expectancy and to maintain safety in rural road of Kaski.

II. Procedure for Paper Submission

According to AASHTO, most of the road crashes occur every 21 minutes due to lane departure. Research has shown that over 80% of these collisions are due to the driver's error. This accounts for 25,000 fatalities each year almost over 60% of the nation's fatalities in the United States. [2]

Similarly, in the scenario of Nepal vehicle accident has been tremendously quantified over a few years. Poor condition of roads, over speed, risky overtake, careless and untrained driver, poor visibility of road, various natural calamities, lack of maintenance, inconsistent road design and so on.[3] Road with good consistency level is the one in which its behavior and what drivers expect are very similar, so that driver will not be surprised while driving along them. A poor consistency means bad fittings, surprising events and also high speed variability along different road segments and among different drivers which may increase the likelihood of crash occurrence. [1]

Most of the research and development of design consistency are based on four main areas which include operating speed, vehicle stability, alignment indices and driver workload respectively. [4] Operating speed is related to study of variation in speed along a road section. Similarly vehicle stability is related to frictional demand and supply.

Alignment indices are quantitative measure of general changes in character of alignment between the segments of the road .Higher the changes over some small length of road section lead to geometric inconsistencies. Likewise, driver workload is the demand or expectations of the driver as per changes in geometric features to operate vehicle in correct guidance path successfully.

Prakash Baral, School of Engineering, Faculty of Science and Technology, Pokhara University,Khudi,Pokhara

Many researches had made interpretation on the basis of operating speed. Alignment indices are simpler quantitative approach to evaluate design consistency which is based on general character of an alignment in a section of road.[5].The design evaluation criteria(Table no.1) shows most common set of criteria which is used to determine the consistency [6].Criteria I and criteria II are based on operating speed and criteria III is based on side friction supply(fR) available to meet the side friction demand(fRD) as the vehicle moves on a horizontal curves (ΔfR=FR-FRD). of relationship between driver workload and different road geometry such as curve radius, degree of curve to estimate driver workload. This study focus on estimation of threshold value of driver workload along with the use of other design criteria and predetermined model of crash rate which is required to balance driver expectancy and to maintain safety in rural road of Kaski.

Design Evaluation Criteria

Table 1

Design Evaluation	Criteria I	Criteria II	Criteria III
Good	V85-VD|≤10Km/h	ΔV85≤10Km/h	$f_R=f_R-f_{RD}\leq 10.0$
Fair	0<|V85-VD|≤10Km/h	0<ΔV85≤20Km/h	$0.01>\Delta f_R\geq -0.04$
Poor	V85-VD|≥20Km/h	ΔV85≥10Km/h	$\Delta f_R< -0.04$

Here, Good= No alignment correction required Fair= No alignment correction is required, but correction may be desirable to sign, cambers.

Poor= alignment redesign is recommended.
Driver expectancy is an important component of driver workload. Consistency roadway geometry allows the driver to accurately predict the roadway path with little effort; in turn leaving much of the driver's mental capacity to be devoted to obstacle avoidance [7]

The empirical data were used regarding to driver expectations of roadway features and violations were related to those expectations to driver workload.(Messer et al.,2003).It is expressed as: $VD_{LU}=0.173+43/R$. The relationship is highly dependent on horizontal curve radii. The crash rate are determined using safety model [8] .It is expressed as $CR=0.0041(V_{85}-V_D)^2+0.2118(V_{85}-V_D)+3.4325$

Different tools and techniques (NASA TLX, DALI technique) were utilized to evaluate the geometric consistency on the basis of driver workload. However, most are expensive and could not be affordable and implemented in developing countries like Nepal.

The development of threshold value of driver workload on simple field basis survey data and safety evaluation criteria holds good in evaluating geometric consistency of rural road on the basis of driver workload such that maintenance, upgrade and re-design of road geometry can be planned to achieve safety in long run.

III. Aims & Objectives of the Research Works

The objectives are:

To evaluate the driver workload on the basis of design criteria in the rural road of Kaski.

To estimate crash rate on the basis of Pre-determined model for individual Design criteria to evaluate safety.

IV. Statement of the Problem

Abrupt changes in road geometric features are major aspect for geometric inconsistencies which lead to accidents. The visual demand (workload) of driver is affected due to geometric inconsistencies which are the major issue to be address to attain the desire level of safety.

V. Methodology

The methodology includes selection of study site, field survey, data collection and data analysis. Field survey data are collected by mobile sensor. Design speed is taken from Nepal Rural Road Standard 2071.Design evaluation criteria and predetermined model for visual demand are taken into consideration to meet the objectives.

- Data Collection:

The required data are collected on the basis of field survey using mobile sensor and GPS. The data related to geometric characteristics (chainage, curve length, deflection angle) were collected.(Table no.2) .Operating speed is then calculated (Table no.2)and Crash rate is determine based on pre-determined model which is based on operating speed and design speed of the vehicle respectively.

Data Collection and Calculation Sheet

Chainage (m)		Curve length(m)	Radius(m)	Deflection angle(Δ)	V_{85}	R.L.(m)	Remarks
From	To						
0+013.2	0+028.1	14.90	38.85	22^0	5.41	925.0	C_1
0+036.01	0+044.82	8.81	24.05	21^0	3.50	926.55	C_2
0+063.89	0+090.81	26.92	73.49	21^0	3.37	927.83	C_3

Table 2

- Data Analysis:

Data analysis includes calculation of operating speed (V_{85}) and design speed (V_d) difference as a safety criteria for evaluating road consistency. Likewise, side friction supply (f_R) and side friction demand (f_{RD}) variation calculation is another vehicle stability criteria for evaluating geometric consistency.
These both criteria evaluate road consistency as good, fair and poor respectively. Similarly, driver workload calculation is made using predetermined model obtain from vision occlusion test ($V_d=0.173+43/R$) .Crash rate(CR) calculation are done on the basis of predetermined model

using variation in operating speed and design speed $CR=0.0041(V_{85}-V_d)^2+ 0.2118(V_{85}-V_d)+ 3.4325$

VI. RESULTS

The results of the analysis are summarized as per different design criteria (Table no.3) along 3 different test curve section of the selected site.

S.no.	Criteria	Curve no. 1	Curve no.2	Curve no.3	Remarks
1.	$\|V_{85}-V_d\|$	9.59	11.5	11.63	Good, Fair
2.	$\Delta f_R= f_R- f_{RD}$	-0.00167	-0.00084	-0.007	Poor
3.	$Vd=0.173+43/R$	1.279	1.960	0.758	-
4.	$CR=0.0041(V_{85}-V_d)2+0.2118(V_{85}-V_d)+3.4325$	5.83	6.40	6.44	-

Summarization of the results:

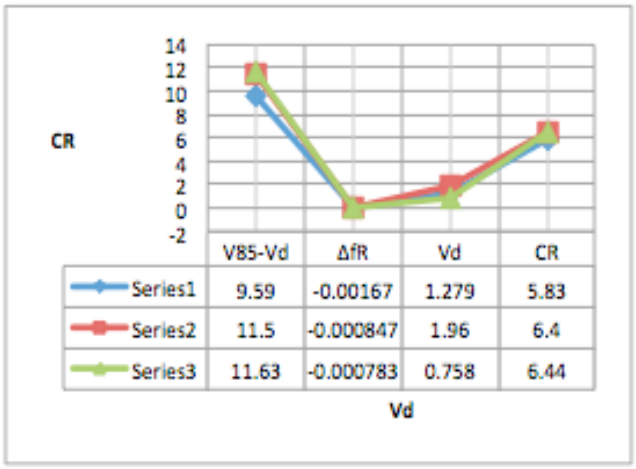

Fig. 1 Driver Workload Estimation

VII. DISCUSSION

- On the basis of $|V_{85}-V_d|$ criteria (Lamm, 1988) curve section 1, has lower variation between operating speed and design speed having value of 9.59Km/h which is less than 10Km/h is designated as good during evaluation from safety criteria.

- On the basis of vehicle stability criteria [5] all the curve section under study are poor as value of Δf_R is less than – 0.04.
- The driver workload obtained from pre-determined model for pre-test curve sections are 1.279, 1.960 and 0.758 respectively.

- Crash rate prediction shows a lower value of 5.83for test curve section 1, followed by curve section 2 and 3 with their corresponding value of 6.40 and 6.44 respectively.

Overall, the calculation and graphical plot shows that on the basis of design criteria curve section 1 holds good design criteria with a workload value of 1.279 and crash rate (CR) value of 5.83 .So, workload value that must be adopted for good consistent design in study area is 1.279 which if could maintain than driver expectancy can be address which assist to maintain safety in long run at Kaski on basis of driver workload (Visual demand).

VIII. CONCLUSION

It can be observed from the above calculation that criteria I holds good for all curve section of rural road with 'Good' and 'Fair' evaluation which is most notable and applicable geometric design consistency measures. Vehicle stability criteria are not feasible to be implemented in such topographical condition which appears to be 'poor' for all set of curve section. Likewise, visual demand (driver work load which is another method/criteria to evaluate consistency) of first set of curve obtain is moderate (neither high nor too low) in comparison to other set of curve under observation which also holds design criteria good. Similarly, crash rate obtained for first set of test curve were also of smaller value in comparison to other set of test curves.

So, overall it can be concluded that for rural road of similar topography, alignment and elevation the driver workload value should be maintain 1.2,considering operating speed design criteria to minimize crash rate, thus maintaining safety in rural road(middle mountain region) of Nepal.

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Prakash Baral, School of Engineering, Faculty of Science and Technology, Pokhara University,Khudi,Pokhara