A Study on Strategic Improvement of Road Safety Performance for Yangon-Naypyitaw Expressway

Saw Myat Khine, Khin Than Yu

Abstract—Today, road safety is propelling up to the front line in the world due to its climbing to higher ranks in the causes of death annually. In this study, review on current situation in Yangon–Naypyitaw expressway is presented using accident data during two year and its geometric data. Poisson - gamma Generalized Linear method is also used to find out the black spots. In this study, altogether 27 horizontal curves are surveyed for revealing their geometric design conditions. Three types of speed are used to monitor on curve portions. The design speed of this road is 60 mph only. Generally, for some curves, feasible speeds are higher than target design speed, ranging from 48 mph to 112 mph. Driver confidence speeds are predicted using equations developed in United State of America with survey data of respective regions. Unfortunately, 85 percentile of this speeds are even noticeably higher than feasible speeds. It is calling remedial measures for modification on curves of expressway.

Keywords—Analysis of accident data, Feasible design speed, Driver confidence speed, Safety factor.

I. INTRODUCTION

Road safety is the major issue of transportation sector worldwide. The number of people killed in road traffic crashes each year is estimated at almost 1.2 million, while the number injuries could be as high as 50 million [4]. Therefore, many traffic engineers are trying to find the best way to improve the highway transportation problem and road safety situation. It is found that average accident rates are higher on horizontal curves. It is a possible way to use highway safety factor (FS) as an indicator for geometric features induced road safety problems. Factor of safety must be at least 1. The advantages of the evaluation highway safety factor (FS) are; highway safety distribution can be known for the whole highway in curves and traffic and road management can be properly designed. Possible hazardous locations can be investigated in advance and required modification of radius and superelevation for better road safety performance can be known.

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II. STUDY AREA

Traffic accidents are among the current problem in the country because of high level of losses. Yangon - Naypyitaw Expressway is a portion of Yangon-Mandalay Expressway. The total length of Yangon-Naypyidaw portion is 202.125 miles and eight lanes were taken into consideration, although only four lanes are completed currently as phrase one. The relationship between safety and geometric design elements was tried to reveal for 27 horizontal curves on this road. Location map of the selected portion of highway is shown in Fig. 1.

Fig. 1 Location of Yangon-Naypyitaw portion
III. METHODOLOGY

Identification of high hazardous locations are carried out using frequency method and Poisson – gamma Generalized Linear model. Accident history, locations and other factors were collected and reviewed for the whole service life of the expressway.

Altogether 27 horizontal curves were surveyed for revealing their geometric design condition. This study examines the highway safety factor (FS) depends on the 85th percentile of operating speed, feasible speed and target design speed. Driver confidence speeds are predicted using equations developed in United State of America with survey data of respective regions as the function of radius of curvature R, super elevation, angle of curve and curve length of those portions of the highway.

Actually local driver confidence speed should also be surveyed for safety factor prediction. Feasible speeds are computed using equation for super elevation calculation of AASHTO (2004) [Eq. (5)]. Geometric design optimization are conducted for radius of curvature using some constant geometric parameter with four models: Lamm and Choueiri (1987) [Eq. (1)]; Morrall and Talaico (1994) [Eq. (2)]; Krammes et al. (1995) [Eq. (3)] and Castro et al. (2006) [Eq. (4)], where R= radius of curvature (ft);D= degree of curvature; L=Length of curve (ft) and \( \Delta \) = Central angle

\[
V_{85} = 94.39 - 3189/R \tag{1}
\]

\[
V_{85} = 102.44 - 2471.81/R + 0.012L - 0.1\Delta \tag{2}
\]

\[
V_{85} = 120.16 - 5596.72/R \tag{3}
\]

\[
e+f = V^2/15R \tag{4}
\]

IV. CAUSES OF ROAD SAFETY PROBLEM FOR YANGON-NAYPYIDAW EXPRESSWAY

The high speed is the single largest factor contributing to road deaths on Yangon - Naypyitaw Expressway. About 33.5% of road accidents are caused by excessive or inappropriate speed. So, the speed of motor vehicles is at the core of the road traffic injury problem. Speed influences on both crash risk and crash consequence. Crash risk increases as speed increases, especially at access and while overtaking- as road users underestimate the speed and overestimate the distance of an approaching vehicle. Accident data are showing that the higher the impact speed, the greater the likelihood of serious and fatal injury.

V. IDENTIFICATION OF HAZARDOUS LOCATION

The overall purpose is to identify hazardous spots, sections and zones based on the accident history.

A. Frequency of the Accident

The accident data from January 2009 to December 2010 are used for frequency analysis. The selected Road is divided into sections of 5 miles each as zones of accident consideration. There are total of 41 zones in expressway

B. Identification of Black Zones

The black zones are identified by using Poission-gamma Generalized Linear model. The lengths are chosen in order to limit the heterogeneity within each road zone and divided into 5 miles long sections.

The priority values can be calculated as follows.

\[
P = X + 3Y + 5Z
\]

Where, \( P \) is the priority value
\( X \) is total number of light injuries
\( Y \) is total number of serious injuries
\( Z \) is the total number of deadly injuries.

The result of priority values of each zone are expressed in Table 1.

![Fig. 2 Causes of Road accidents for Yangon-Naypyi taw Expressway](image)
If the priority value is above 15, this zone can be classified as high hazardous location (or) black zones. Based on this criterion, zones of 3, 5, 7, 17, 20, 24, 25, 29, 30, 31, 33 and 35 should be considered as "high hazardous location" in Yangon – Naypyitaw Expressway.

VI. ELEVATION OF HIGHWAY SAFETY FACTOR IN TERMS OF SPEED

Three different types of speeds for 27 curves in Yangon – Naypyitaw Expressway are calculated using the previous equations and survey data of these curves.

According to the above figure, feasible speeds are less than target design speed in some curves. Target design speed cannot be satisfied in some curves of Yangon-Naypyitaw Expressway. Factor of safety is low and even less than one for some curves.

According to FHWA 2004, the operating speed should be compared with design speed to detect if there is correspondence between the design parameters of the highway and the speed at which the vehicles circulate. Highway design can be categorized into three classes according to deviation of these speeds.

Good design: \( V_{85} - V_{\text{design}} \leq 6\text{mph} \)
Fair design: \( 6\text{mph} \leq V_{85} - V_{\text{design}} \leq 12\text{mph} \)
Poor design: \( 12\text{mph} < V_{85} - V_{\text{design}} \)

According to above criterion, almost all curves in this study are falling in the class of poor design. Highway factor of safety in terms of speed between feasible speed and target design speed are ranging from 0.8 to 1.87. Factor of safety less than 1 are found at least in 18 curves.

VII. GEOMETRIC DESIGN OPTIMIZATION FOR CURVE

In western countries, design speed of a highway is designed with V85, driver confidence speed. To design a highway to be in good design class according to FHWA speed criterion, design selection based only on geometric design calculation may not be enough because of favorable geometric data offers higher V85. This geometric design optimization should be done with parametric study. In this study, geometric design optimization is done for radius parameter with constant friction, central angle, length of curve and pavement super elevation.

Although minimum design radius and superelevation are 1200 ft and seven percent for target design speed of 60 mph, it is found that some curves are out of limit.
Fig. 5 Comparison between feasible speeds of modified design (modification on R only) on $\varepsilon=0.03$ and $V_{85}$ speed

Fig. 6 Comparison between feasible speeds of modified design (modification on R only) on $\varepsilon=0.04$ and $V_{85}$ speed

Figures 4, 5 and 6 are showing radius optimization information for superelevation of 2%, 3% and 4% for fixed central angle and length of curve. It is found that the higher the value of superelevation, the narrower the feasible radius ranges for good design. For the fair design, feasible radius range is not much different from all pavement of superelevation.

Among 27 curves, twenty one curves are within poor design and six curves are within good design. In poor design curves, four curves are higher target design speed and seventeen curves are lower target design speed. It can be said that after performing geometric design according to standards, radius optimization should be conducted for better safety performance of roads.

VIII. CONCLUSION

This study was investigate and identified the accident types, risk factors and hazardous locations in Yangon-Naypyidaw Expressway. In horizontal alignment, 27 horizontal curves are surveyed in detail for revealing their geometric design condition. It is found that some actual feasible speeds are lower than target design speed, especially in horizontal curves with radius less than 2000ft. We should be considered black zones as “high hazardous location”. Speed is the major cause of accidents. According to international scale, we should consider $V_{85}$ method and factor of safety on target design speed and horizontal alignment should take nearly straight for Expressway to reduce traffic accident.

ACKNOWLEDGMENT

The author would like to express her gratitude to her supervisor, Dr. Khin Than Yu, Pro-rector, Yangon Technological University, for her guidance. The author is also grateful to acknowledges the support of Public works and also deeply acknowledges her teachers of Department of Civil Engineering from Yangon Technological University for their invaluable suggestion and guidance.

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