Accident Prediction Models for Partial Cloverleaf On-Ramp Loops for Michigan

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ABSTRACT

Accident prediction models, popularly known as safety performance functions (SPFs) play an important role in roadway safety analyses and evaluation processes. The 2010 Highway Safety Manual (HSM) provides a number of SPFs that can be used locally after calibration to reflect local conditions. However, most of these SPFs focus on intersections and roadway segments. A limited number of studies have developed SPFs for interchanges and especially on-ramps and their related sections such as ramp segments and point of freeway entry. This study was an effort to develop Michigan-specific SPFs for urban partial cloverleaf (parclo) on-ramp loops at freeway entry. A number of factors associated with crash frequency on these facilities were examined, and the SPFs developed for urban partial cloverleaf loops, are presented.

INTRODUCTION

Safety performance functions (SPFs) are models used to estimate the expected number of crashes using traffic and highway-related variables such as AADT, length of roadway segments, shoulder width, number of lanes and other roadway and surrounding environmental characteristics. Such estimates are critical to evaluation of traffic safety investments. Due to transferability issues, it is critical that accident prediction models be designed to reflect local conditions. Examination of Michigan freeway crashes indicated concentrations at the point of entry to the freeway for partial cloverleaf (parclo) on-ramp loops (see Figure 1). The study focused on this section of freeways.

Source: www.aol.com

METHODS AND DATA

This study focused on a 500 ft segment: 250 ft downstream and 250 ft upstream of the confluence the point. The Negative Binomial (NB) regression, which relates the expected number of crash occurrences to a vector of explanatory variables, X_i as follows, was used:

$$\lambda_i = EXP(\beta X_i)$$

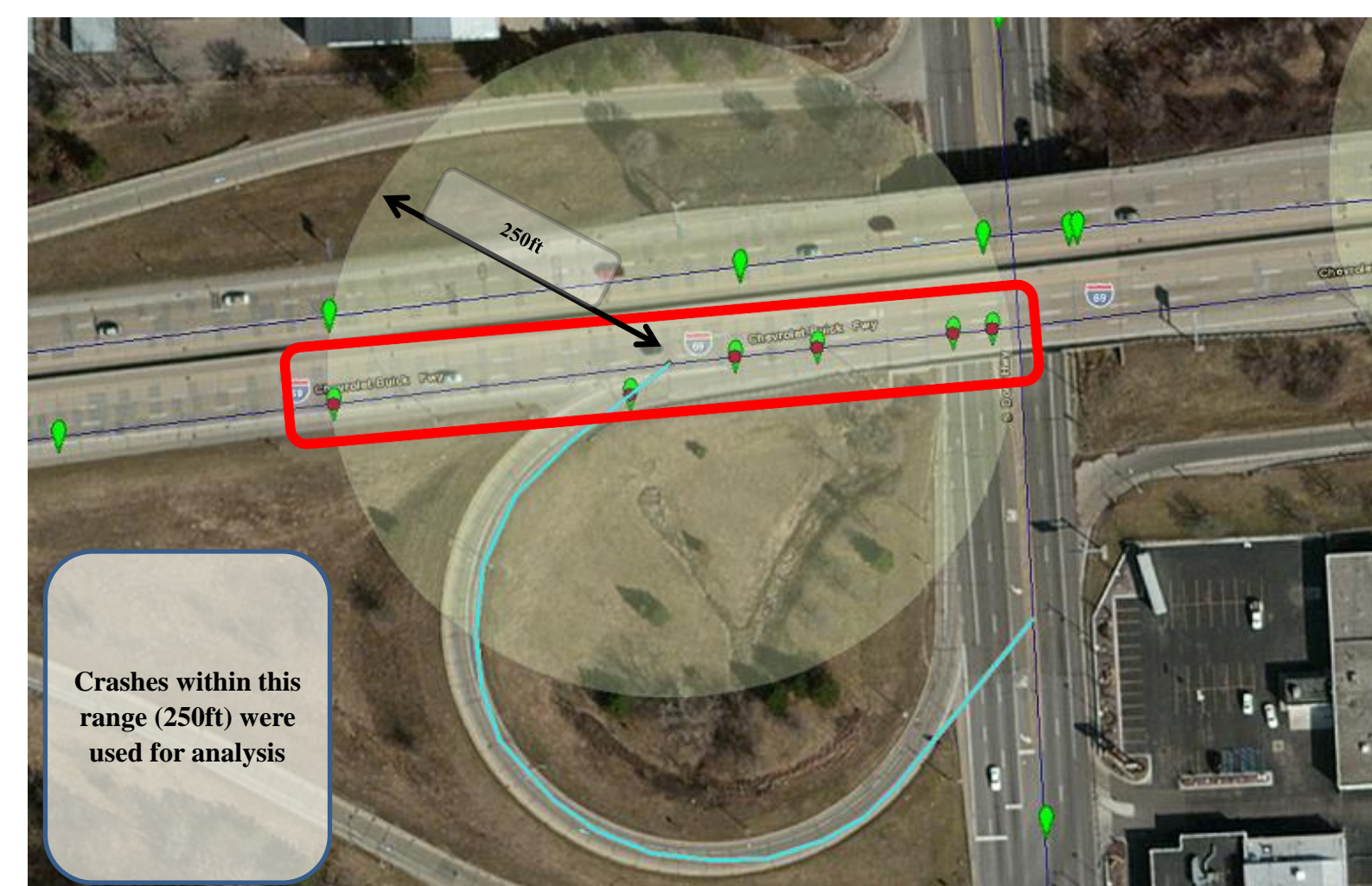Goodness of fit between competing models was evaluated using the Bayesian Information Criterion (BIC).

Crashes within this range (250ft) were used for analysis

Fig 1. Crashes concentration within a 500-ft segment

Traffic Data: Loop ADT, Mainline AADT.

Other Data: Lane type (weaving, merging or added lane), acceleration lane length, ramp speed limit, mainline speed limit, average shoulder width and percentage of commercial vehicles.

Crash data:
- crash data for three years (2009-2011)
- 238 fatal and injury (F+I) and 1149 total crashes

Loop ADT Distribution

LoopADT(veh/day)

Table 1. List of variables

Variable	Minimum	Average	Maximum	Standard Dev.
Fatal & Injury Crashes/Site	0	2.62	20	2.81
Total Crashes/Site	2	12.63	45	9.17
Lane Type: Merging	0	0.87	1	-
Lane Type: Weaving	0	0.11	1	-
Lane Type: Added	0	0.02	1	-
Loop Speed Limit (mph)	15	25.83	35	3.66
No. of Lanes on Mainline	2	2.80	5	0.65
Mainline Speed Limit (mph)	45	68.68	70	4.70
Average Shoulder Width (ft)	4	9.44	12	1.18
% Commercial Vehicles	1	9.80	37	6.19
Length of Acceleration Lane (ft)	100	951.65	4100	491.57

Distribution of Mainline AADT

Mainline AADT (Veh/day)

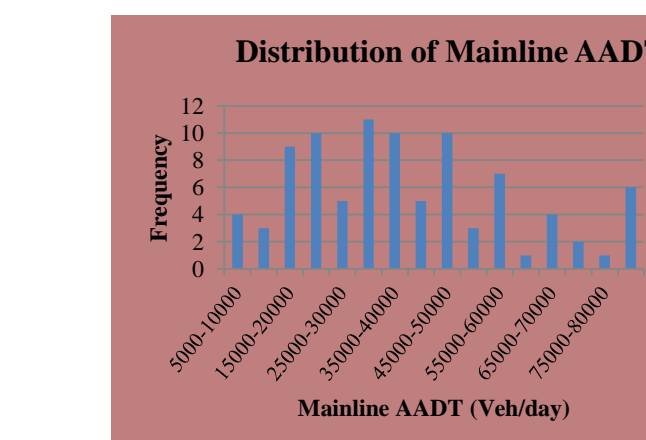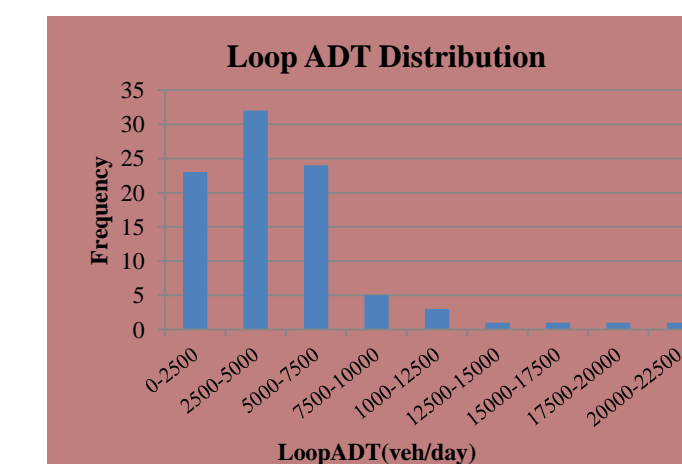Figure 2. Traffic Distribution

RESULTS

A constant of three years (**Time_expos**) was used (since three years of crash data was considered) as a substitute of the exposure variable to convert the three years period prediction models to per year crash prediction by adjusting the intercept (constant).

Two final models (**Table 2**) were chosen, one for each category of dependent variable. The resulting SPFs are:

Expected Fatal and Injury (F+I) Crashes per Year

$$\lambda_{F+I} = Loop\_ADT^{0.4265203} \times Main\_AADT^{0.7953589} \times EXP(-11.20701 - 0.3185778(Mainline\ No.Lanes))$$

Expected Total Crashes per Year

$$\lambda_{Total\_Crashes} = Loop\_ADT^{0.1857744} \times Main\_AADT^{0.6522343} \times EXP(-7.008672)$$

Table 2. Detailed Results of the Two Models.

Fatal and Injury Crash Model

F+I_Total	Coef.	Std. Err.	z-statistic
Ln_Loop_ADT	0.426	0.126	3.36
Ln_Main_AADT	0.795	0.251	3.16
Mainline No. Lanes	-0.318	0.201	-1.58
Constant	-11.207	2.260	-4.96
ln(Time_expos)	1	(exposure)	
alpha	0.288	0.102	

No. of obs = 91 ,
Log likelihood = -176.10724 ,
LR chi2(3) = 30.92 ,
Pseudo R2 = 0.0807,
Prob > chi2 = 0,
Likelihood-ratio test of alpha=0: chibar2(01) = 22.10
Prob>=chibar2 = 0.000,
BIC=374.7688

Total Crash Model

Total_Crashes	Coef.	Std. Err.	z-statistic
Ln_Loop_ADT	0.185	0.074	2.49
Ln_Main_AADT	0.652	0.099	6.53
Constant	-7.008	1.039	-6.74
ln(Time_expos)	1	(exposure)	
alpha	0.193	0.041	

No.of obs = 91 ,
Log likelihood = -285.8498 ,
LR chi2(2) = 51.77 ,
Pseudo R2 = 0.083;
Prob > chi2 = 0,
Likelihood-ratio test of alpha=0: chibar2(01) = 112.25
Prob>=chibar2 = 0.000;
BIC= 579.6996

DISCUSSION

For Fatal and Injury Crashes:

- Loop ADT and mainline AADT (as expressed by the log of these variables) are associated with increasing the chances of fatal and injury crashes as they increase (**0.427** and **0.795**).
- Mainline number of lanes is associated with decreasing the chances of fatal and injury crashes **(-0.319).**

For Total Crashes:

- Only loop ADT and mainline AADT (as expressed by the log of these variables) are associated with increasing the chances of total crashes as they increase (**0.186** and **0.652**).

All other variables were found to be insignificant.

CONCLUSIONS AND RECOMMENDATIONS

SPFs for predicting both fatal and injury (F+I) crashes and total crashes for urban parclo on-ramp freeway entry were successfully developed with log transformed loop ADTs and AADTs as predictor variables as well as number of mainline lanes for F+I total crashes.

With the traffic data at hand, only traffic volumes were found significant.

More site-specific and local accident prediction models incorporating both roadway and traffic characteristics need to be explored.

ACKNOWLEDGEMENT