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Develop Calibration Factors for Crash Prediction Models for Rural Two-Lane Roadways in Albania

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***Abstract*—This paper documents the development of calibration factors for crash prediction models for rural two-lane roadways in Albania. The crash prediction modes in the Interactive Highway Safety Design Model were developed using data from multiple states, therefore the models must be calibrated to account for local factors, such as weather, roadway conditions, and drivers' characteristics. In this study, the calibration factors were developed to give a better prediction of crash frequencies on rural two lane roadways in Albania.**

Keywords—Component; Highway Safety Manual, Safety, Calibration Factor, Safety Performance Function

I. INTRODUCTION

In recent years, the safety of the traveling public on roadways in Albania has been an area of interest for transportation engineers. Current focus is on the reduction of fatal crashes by any possible means. The release of the "Highway Safety Manual" (HSM) [1] in 2010 improved the quantitative approach to highway safety management. The Interactive Highway Safety Design Model (IHSDM) software based on HSM method can be used to predict the number of expected crashes on a roadway, through consideration of the cross-sectional geometrics and traffic volumes.

This paper will focus on rural two-lane two-way roadways, specifically the calibration of the HSM predictive method to this type of roadway in the Albania.

The HSM predictive method includes the use of three separate variables to model a roadway's safety: a safety performance function (SPF), crash modification factors (CMFs), and a calibration factor (C). The SPF was statistically derived from data obtained in several states and is intended to be used at the national level. Other SPFs developed by state or local agencies could be used in place of the national SPF and may better predict crashes in that specific country. Since SPFs are developed to predict crashes at a base condition, CMFs are needed when the cross-section of a roadway is altered from the base condition. Many CMFs are available and should be applied to accurately predict the crashes on roadways.

The calibration factor (C) is used to adjust the national models to local conditions. We are using IHSDM software for safety prediction and we need to calibrate for the specific state or geographic locations in Albania. The SPF needs to be calibrated to adjust for driver population, roadway conditions, traffic volumes, weather conditions, and other regional specific factors. The objective of this study is to calibrate the SPF for rural two-lane roadways for the Albania and compare the calibrated SPF with an SPF developed with Albania crash data. The calibration of the IHSDM predictive model will assist transportation engineers in the selection of safety improvements that will reduce the number of fatalities experienced on rural roadways in Albania. Use of the model is another step towards the national strategy on highway safety of moving toward zero fatalities.

Rural two lane roadways has the largest number of km in our road network in our country have the highest fatal rate of all road types. This means that persons living or traveling in rural areas are more likely to be involved in a fatal crash than those living or traveling in urban areas (MTI 2010 - 2014). [2] The calibrated IHSDM models can be used to predict crashes at any roadway segments, identifying contributing factors that may cause high crash rates.

II. LITERATURE REVIEW AND PREVIOUS STUDIES

An extensive literature review was conducted on prediction methods and factors contributing to crashes on rural roadways. It was determined that the geometric factors affecting the safety of a roadway including: lane width, shoulder width and type, clear zone distance, and road side hazards (Kalokata, 1994; FHWA 2010; FHWA 2009; Bahar 2009) [3].

Since IHSDM is a useful decision-support tool, several researchers have tried it out to check up on its applicability.

Bansen and Passetti [4] used IHSDM to evaluate alternatives and improve an intercity road with a significant accident rate. The conclusions of this study show that the software is a reliable support provided the initial data has the details and format required by the software.

Chuo and Saito [5] evaluated the capacity of the IHSDM software to help road safety experts find road segments with a high accident rate, and its capacity to help draw up different interventions and improvements. Three two-lane rural highway sections in Utah were selected for a sample application of CPM to safety audits. The results of this evaluation show that the CPM can produce reasonably reliable crash predictions if appropriate input data, especially alignment data, reflect existing conditions with reasonable accuracy. In other words the content of input data can greatly affect the quality of the prediction outputs). Moreover, the study highlighted some context-related issues. They concluded that CPM could be useful for engineering decision-making during safety audits of two-lane rural highways, to estimate crash occurrences for alternative improvements to existing sections. However, they stated that interpreting the outputs requires knowledge and experience in highway design.

Dominguez et al [6] presented an adaptation of the IHSDM to the Spanish conditions. The CPM basic algorithm was calibrated using Spanish highway and crash data, than the software was applied in the safety review of three highway sections in Spain. The results indicate that the application of this software could be useful in the verification of the geometric design of existing highways as well as in highway rehabilitation projects. They concluded that the calibration significantly improved the module's predictions. However, the use of IHSDM and the interpretation of its results demands caution and expertise.

III. CRASH PREDICTION APPROACHES

Traffic crashes are seen as rare events, so their prediction can be somewhat challenging. The factors causing crashes can be broken into the following groups: vehicle, human, highway, and context. In addition to the groups there are two ways to approach a safety analysis. The first is non-quantitative, which focuses on policy compliance, assessment using adjunct principles or guidelines (i.e. design consistency, driver work load, positive guidance, and other human factors), possibly within the context of a safety audit. The other approach is quantitative and uses crash reduction measures, statistical models, simulation surrogates, and driving simulators. Quantitative methods offer the most reliable approach to improve the safety of roadways (Pfefer, 2004), [7]. For the first time in Albania we are using this method of practice and are to develop an SPF for each road type and then determine the potential for safety improvement using a method of weighting (FHWA, 2010). The IHSDM is a quantitative method and more accurate than any current method of crash prediction.

IV. DATA COLLECTION METHODS

The data collected using the traditional method is similar to the data collection process using the IHSDM predictive method. The calibration factor (C) used in the predictive method is said to take care of this issue. Like most states Albania has its own regulation for recording crashes.

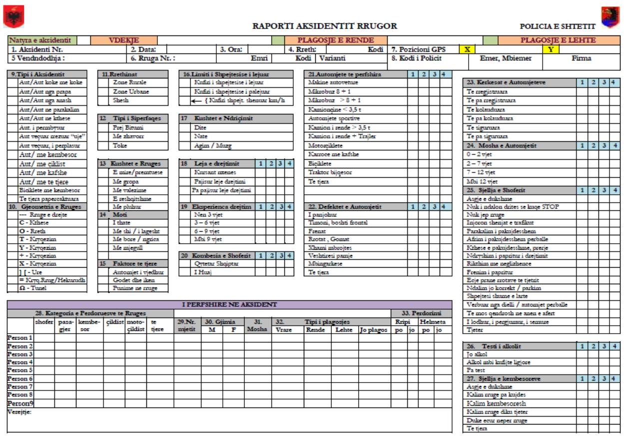

Figure 1 Accidents Records Form of Albanian Road Police

V. METHODOLOGY

CALIBRATION PROCEDURE

Before applying the IHSDM predictive method to state roadways, calibration factors needed to be developed to mitigate the impacts of weather conditions, driver populations, animal populations, and terrain.

The following five steps had to be followed to develop an accurate calibration factor. The first step was to randomly select segments to be used in the study. The second step involved obtaining the site specific geometrics and cross-sectional data of each segment. The third step was to use the IHSDM predictive model to predict the crash frequency for each of the selected segments followed by the fourth step, comparing the predicted vs. observed crash frequencies. The final step adjusted the model to local conditions by calculating the calibration factor (C).

The model could then be applied to regional specific segments and used to determine the number of expected crashes under various conditions. The model is useful when determining design improvements that will reduce the number of crashes along rural roadways.

The SFP for rural segments is a function of the Average Annual Daily Traffic (AADT) and segment length. It was used to predict the crash frequency for the base conditions. The base condition is defined as the condition that the SPF was developed for. When applying SPF to the real-world conditions, Accident Modification Factors (AMF) and calibration factor need to use to account for the non-base conditions. AMFs including: lane width, shoulder width and type, grade, driveway density, roadside hazard rating (RHR), calibration factor, and countermeasures, are applied where applicable. The calibration factor is then applied to the predictive model to estimate a regions crash frequency more accurately.

The IHSDM predictive model can be used to predict the expected crash frequency in future years, and can be seen in equation one (FHWA, 2010).

$$Nrs = Nbr \times Cr \times (AMF1r \times AMF2r \times ... \times AMFnr) \quad (1)$$

Where: Nrs = is the total number of accidents predicted in the road segment per year after application of accident modification factors;

Nbr = is the total number of accidents predicted in the road segment per year for nominal or base conditions and

AMF1r ••• AMFnr = accident modification factors for road segments

Cr = Calibration factor.

SAFETY PERFORMANCE FUNCTION (SPF)

The SPF used in the IHSDM method was developed at the national level, and is used to predict crashes at the selected segments.

$$N_{br} = (AADT)(L)(365)(10^{-6})\exp^{(-0.4865)} \quad (2)$$

where, AADT = Average Annual Daily Traffic
L = Segment Length

CRASH DATA COLLECTION

Traffic crashes are traditionally classified as either roadway segment or intersection related, with the recording officer using judgment to determine which. The IHSDM now classifies crashes as intersection related, if within 250 feet of an intersection. For segments the general rule is that all areas outside of the scope of an intersection are segment related. For the purpose of this study all crashes located at the distance of 250 feet or more from intersections are classified as segment crashes (AASHTO, 2010). During the IHSDM study, it is generally recommended that for modest traffic flows, it is recommended to manipulate several years of computational value, instead of using non-significant (small) values, so in these segments we are referring to the resultant values of the 2008 - 2015 years.

CALIBRATION FACTOR

Accident Prediction Algorithm requires the introduction of a Cr calibration factor that allows us to adapt the model predicted by the local road network conditions we are analyzing.

Although the factors related to the infrastructure and traffic features we have considered are: Cross-sectional section, plano-altrometric geometry, road boundaries, overtaking availability, are estimated through the values received during the assessment, we have one a number of other factors, such as driving mode, climatic conditions, type of accident data, requiring an adaptation of the accidental prediction algorithm.

$$Nrs = Nbr \times Cr \times (AMF1r \times AMF2r \times ... \times AMFnr) \quad (3)$$

In the model of Cr factor prediction, the default value equals 1. Calibration consists in determining the value of Cr, which averaged the average value of the number of accidents predicted with actually occurring. Therefore, in order to do "calibration" we need to have a sufficiently representative "sample" of the road for which we applied the model, comparing the total data obtained from the forecast with those derived based on information on actual accidents that occurred on that road.

For this purpose it is assumed as a reference complex of roads managed by the Durres district and Kruja district, the Fushkrujë - Laç segment, as the main interurban route with two lane for a total of 26 km + 175 m (from km 9 + 486 m in km 35 + 661m).

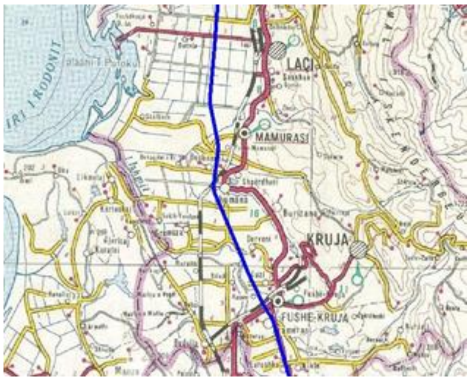

Figure 2 Route of the road SH 2.Fushë-Krujë - Laç

Figure 3 Road SH2 Tiranë–Krujë, x 492.1622,y 46.79,km 8 + 66 m

Figure 4 Road entrance in Fushkrujë, SH2,x 436,1460,y 28.39, km 16 + 655 m

VI. Development of Calibration Factors

The purpose of this study was to calibrate the IHSDM model for rural two-lane two-way roadways segments in Albania. In order to calibrate the model, was studied the segment Fushkrujë – Milot – Rrëshen (in the Lezha and Durrës region). This selection will ensure the model predicts the crashes on any rural segment accurately.

To calibrate the IHSDM model, the predicted and the observed number of crashes at the selected segments were needed. The sum of the observed crashes had to be divided by the sum of the predicted number of crashes. This yielded the calibration factor for the study area.

IHSDM software, generally recommend that for modest traffic flows, it is recommended to manipulate several years of computational value, instead of using non-significant (small) values, so in these segments we are referring to the resultant values of the 2008 - 2015 years.

To apply CPM, several types of data are required: Annual Average Daily Traffic (AADT), horizontal and vertical alignment, lane and shoulder width, cross slope, superelevation, driveway density (DD, number of accesses per kilometer), roadside hazard rating (usually based on the seven-point subjective scale developed by Zegeer et al [8]), speed limit and presence of an intersection. In the process of data collection this case study has already pointed out some “difficulties” in providing some of the required data on existing road.

Depending on the data we have analyzed, we have defined the following distribution of "Accident Sharpness Levels" (Accident Sharpness Level) according to what is required by default.

Table 1 - Total Accidents that occurred on the road of FK-Laç in the years 2008 – 2015

Year	Accidents in Total N%	Accidents only with damage N%	Accident s with injuries N -%	Accident and injured accidents N -%	Injured N -%	Killed N -%
2008 - 2015	515 100%	312 60.59%	96 18.64%	203 39.41	96 18.64%	107 20.78 %

Table 2 - Accidents occurring on the FK-Laç road that do not belong to intersections in 2008 – 2015

Year	Accidents in Total N%	Accidents only with damage N%	Accidents with injuries N -%	Accident and injured accidents N -%	Injured N -%	Killed N -%
2008 - 2015	370 100%	210 56. 76%	68 18.38%	160 43.24%	388	160

To apply CPM, several types of data are required: Annual Average Daily Traffic (AADT), horizontal and vertical alignment, lane and shoulder width, cross slope, superelevation, driveway density (DD, number of accesses per kilometer), roadside hazard rating (usually based on the seven-point subjective scale developed by Zegeer et al [8]), speed limit and presence of an intersection. In the process of data collection this case study has already pointed out some “difficulties” in providing some of the required data on existing road.

Depending on the data we have analyzed, we have defined the following distribution of "Accident Sharpness Levels" (Accident Sharpness Level) according to what is required by default.

If the calibration factor is determined to be greater than one, the model has under predicted the crashes in the study area. Another way to think of this is that the study area experiences more crashes per year then the national average. In contrast if the calibration factor is less than one, the model has over predicted the crashes in the study area, and needs to be adjusted accordingly.

The calibration factors calculated for each SPF were determined to be greater than one. This result provides evidence that the crashes on Albania rural two-way two-lane roadway segments are higher than the national average

TABLE 3 - DISTRIBUTION OF SEVERITY LEVELS OF ACCIDENTS

The consequences of the accident	Selection by IHSDM	Modified values
Dead	1.5%	2.5%
Permanent Disability	6.2%	9.6%
Medium injury	12.5%	18.6%
Wounded easily	16.5%	24.9%
Total dead / injured	36.7%	55.3%
Only with material damage	63.3%	44.7%
Total	100.0%	100.0%

VII. DATA ANALYSIS

CRASH PREDICTION

It is recommended to evaluate two different calibration levels of the Accident Prediction Algorithm, which vary depending on:

- *Types of traffic data,*
- *Availability and quality of accident data,*
- *The experience we have in the calibration process,*
- *Efficiency and availability versus calibration demand*

The basic calibration procedure is common for both calibration levels and consists of six consecutive steps:

1- We make the assessment by the degree of curvature and slope in the length of the selected itinerary

2- Accept or modify the set values depending on changing the other parameters of the road

3- Calculation of accidents assessed only for straight track segments using the Accident Prediction Algorithm

4- Make the assessment according to the curvature and slope of the chosen itinerary

5- Determining the number of accidents on the basis of data by avoiding accidents at intersections

6- Set the definite final (Cr) value of the Calibration Factor in the Software

The Cr calibration factor is calculated as the ratio of the total number of accidents predicted by the model (step 3) and the total number of accidents recorded (step 4).

TABLE 4 - DETERMINATION OF THE CALIBRATION FACTOR CR.

Total recorded accidents excluding those at intersections	370
Accident Prediction Year 1	64.43
Accident Prediction Year 2	64.43
Accident Prediction Year 3	64.43
Accident Prediction Year 4	64.43
Accident Prediction Year 5	64.43
Total	322.15
Calibration factor Cr	0.174

After defining the "Cr" factor, we enter this value into the "input" of the Accident Prediction Algorithm.

After determining the observed and predicted crashes an analysis was conducted to see which SPF predicted crashes on Albania roadways more accurately.

VIII. CONCLUSIONS

The calibrated IHSDM prediction method can now be used by transportation safety engineers to identify and make adjustments to problematic segments of rural two-lane two-way roadways in Albania. The calibration factors developed could also be used at a regional level if the climate, driver populations, animal populations, crash reporting thresholds, and any other local factors are comparable.

In this study, the assessment of the "level of risk" of the inclusion of the condition and parameters of the road infrastructure has been addressed, by individualizing an instrument such as IHSDM, which makes it possible to move from a conceptual formulation in principle to safety related issues on more accurate and concretely applicable engineering paths that can help reduce the serious road accidents.

As accident prevention algorithm has been applied for a concrete case, in a section of the "Nation's Road" section of the Fushëkrujë-Thumanë road segment. This application has evidenced how the Durrës County Road Information System could be used to carry out road safety analysis, both during the baseline calibration phase of the IHSDM model and on the application for a particular segment of a road the road itinerary we want to study, surpassing the difficulties we have in reality in Albania, associated with the lack of "historical data" regarding the geometric characteristics of the "Road Network Cadastre" infrastructure and a "Databases" related to accidents.

The achieved results not only allowed us to test the reliability of the algorithm with and without an accident history, but have shown us how to ensure the usability and completeness of the available data as a concrete basis for future research developments, such as an assessment of the existing correlation between independent variables acting on road safety, in order to improve the forecasting model used.

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