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Mountainous Freeway Risk Degree Forecast Model of Case Study: Changjin Freeway in Jiangxi Province

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Abstract: The objective of this study is to establish the mountainous freeway risk degree forecast model. Highway safety, especially mountainous freeway, relates to person, vehicle, road and environment four aspects including many factors. Firstly, this study analyzed some researches about the highway safety from these four aspects respectively. Secondly, this study considered many factors of these four aspects, established the mountainous freeway risk degree forecast model, listed the survey content needed in the forecast model. Finally, this study took Changjin Freeway in Jiangxi Province, China as example, used 91 accident data from January, 2006 to July, 2012, adopted the multiple linear regression method using *spss* 17.0 to obtain each parameter value of the forecast model and analyzed some parameter values to the mountainous freeway safety. The mountainous freeway risk degree forecast model is necessary and useful to evaluate the risk degree for constructed mountainous freeway, to estimate the safety of unconstructed mountainous freeway and to provide basis to improve mountainous freeway safety.

Keywords: Highway safety, multiple linear regression, mountainous freeway, risk degree forecast model

INTRODUCTION

Freeway, which has brought much convenience for transportation, has been developed rapidly in the last decades in China. However, the safety of freeway has been a problem for a long time and freeway accidents have killed a large number of people. The influence factors of highway safety consist of the person aspect, the vehicle aspect, the road aspect and the environment aspect. The interaction of these four aspects directly influences the safety situation.

Person, which is one important factor related to highway safety, has been analyzed in many studies. For example the contribution of alcohol to fatal crashes dropped by more than one third in the past decades, but it still needs political leadership, state task forces and media advocacy to address the problem (Williams, 2006). Rhodes *et al*. (2005) analyzed the young drivers aged16-20 and found that risk-taking is more problematic than DUI (drug utilization index) in the 16-20 age group because movies and TV have conditioned our young people both to respect risk-takers and to act out risky behavior on the roadway; Islam and Mannering (2006) explored the differences in injury severity between male and female drivers and across the different age groups, in single-vehicle accidents involving passenger cars; Taubman-Ben-Ari and Katz-Ben-Ami (2012) examined the family climate for road safety and the findings indicated associations both between the familial and the social aspects and between these variables and driving styles, willingness to take risks while driving, reckless driving habits and personal commitment to safe driving. From these studies, we can know that the person aspect matters much to the highway safety.

Vehicle is also one important part influencing the highway safety and many accidents occur because of or partly because of vehicle aspect. Artus *et al*. (2005) holed the idea that the surface temperatures of the brake discs are closely connected to the braking efficiency and the braking efficiency are closely connected to the highway safety; many traffic accidents occur due to a loss of control on vehicle by the driver and this is mainly due to a loss of friction between tire and road (Ghandour *et al*., 2010); the vehicle speed is also connected to highway safety, the higher the vehicle speed was, once the accident occurred the more severe the result was, so many highways set speed limit to reduce accidents (Garber *et al*., 2006; Oh and Mun, 2012). So the vehicle is one aspect we have to consider connected to highway safety.

Road is another factor influencing highway safety. Choi *et al*. (2011) adopted the ordinal logistic regression model to find that terrain type is a significant independent variable that explains crash occurrences for rural arterial roads in South Korea. Hummer *et al*. (2010) thought that the horizontal curves related to the roadway safety. Vertical curves, which reduce sight distance, also affect highway safety (Rosey *et al*., 2008). Stine *et al*. (2010) used software CarSim to simulate the highway safety and found that the cross-section shape and width greatly affected the highway safety.

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Table 1: The accident survey content

Accident number	Death number	Injury number	Economic losses (*yuan*)
Person			
Age	Sex (0 female,1 male)		
Vehicle			
Vehicle type (0 small vehicle,1big vehicle)			
Road			
Horizontal curve radius (*km*)	Horizontal curve angle (degree)	Slope gradient	
Environment			
Time (*h*)	Weather (1 (clear), 2 (cloudy), 3 (rainy), 4 (foggy or snowy)		

Environment can affect the highway safety greatly. Environment characteristics including weather, light condition, dark without illumination and so on affect the highway safety (Weng and Meng, 2012). Khan *et al*. (2008) analyzed the weather-related crashes and results showed that weather had some role to play in the occurrence of some accidents. Also it was found that rain decreases the driver visibility and that would influence the highway safety (Konstantopoulos *et al*., 2010). Besides, the sun glare may impair drivers' vision and may result more accidents (Jurado-Piña and Pardillo-Mayora, 2010).

From these researches above, we know each aspect of person, vehicle, road and environment may affect the highway safety. However, few researchers analyzed the relationship between highway safety and these four aspects. Highway, especially mountainous freeway, safety is much important and lots of people died from accidents, so it is necessary to forecast the mountainous freeway risk degree. This study considered these four aspects and established the mountainous freeway risk degree forecast model.

METHODOLOGY

Considering these four aspects of person, vehicle, road and environment, the mountainous freeway risk degree forecast model is shown in Eq. (1):

$$W = \alpha \cdot Person + \beta \cdot Vehicle + \gamma \cdot Road + \eta \cdot Environment \quad (1)$$

where, α, β, γ and η are coefficients, W is the risk forecast degree and the specific meaning of W can be approximately represented in Eq. (2):

$$W = {e_{losses}}/{10000} + N_{injury} + \lambda \cdot (30 + N_{death}) \quad (2)$$

where,

e_{losses} = The meaning of each accident economic losses (*yuan*)

N_{injury} = The injured people number of each accident

N_{death} = The dead people number of each accident, besides, the value of λ is 1 if the

N_{death} The over zero and if the

N_{death} The zero, the value of λ is zero

In Eq. (1), Person, Vehicle, Road and Environment are meanings of person aspect, vehicle aspect, road aspect and environment aspect respectively, as shown in Eq. (3-6):

$$Person = A_p \cdot Age + B_p \cdot Sex \quad (3)$$

where, A_p and B_p are coefficients, Age means the age of driver and Sex means the sex of driver, which can be 0 (female) or 1 (male).

$$Vehicle = A_v \cdot k \quad (4)$$

where, A_v is the coefficient and k means the vehicle type, which can be 0 (small vehicle including car and small truck) or 1 (big vehicle including bus and big truck).

$$Road = A_r \cdot R + B_r \cdot Angle + C_r \cdot Gradient \quad (5)$$

where, A_r, B_r and C_r are coefficients, R (*km*) is the radius of the horizontal curve, Angle (degree) is the angle of the horizontal curve and Gradient is the gradient of the slope:

$$Environmet = A_e \cdot Weather + B_e \cdot Time \quad (6)$$

where, A_e and B_e are coefficients, Weather represents the weather condition, which can be 1 (clear), 2 (cloudy), 3 (rainy), 4 (foggy or snowy) and Time (h) is the accident time of one day.

All these parameters except coefficients can be obtained through survey and survey content is shown in Table 1.Then, according data from survey, all these coefficients can be obtained using multiple linear regression (Khashei *et al*., 2012; UI-Saufie *et al*., 2012) method. Finally, all these parameters including these coefficients are available and we can forecast the risk degree of one mountainous freeway.

RESULTS AND DISCUSSION

In order to verify the feasibility of mountainous freeway risk degree forecast model, this study took Changjin Freeway in Jiangxi Province as example, used the normal 91accident data (we excluded some missing data) from January, 2006 to July, 2012 to obtain these

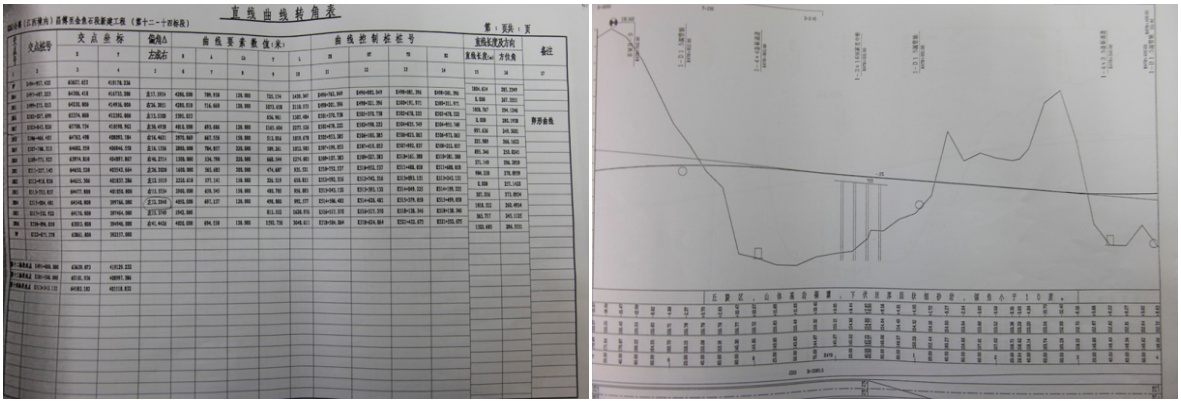

Fig. 1: Horizontal curve and vertical curve data

Table 2: Parameter estimates

			95% Confidence interval	
Parameter	Estimate	S.E.	Lower bound	Upper bound
A	0.212	0.198	-0.183	0.607
B	5.029	8.876	-12.628	22.686
C	3.345	3.775	-4.164	10.855
D	0.320	1.060	-1.789	2.429
E	0.084	0.206	-0.326	0.494
F	1.781	1.991	-2.180	5.742

coefficients to establish the Changjin Freeway risk degree forecast model.

The accident data we collected included the data saved in Microsoft Excel and some drawings (Fig. 1) made by software AutoCAD.

Eq. (3-6) were substituted into Eq. (1) and the Eq. (7) is obtained:

$$W = A \cdot Age + B \cdot Sex + C \cdot k + D \cdot R + E \cdot Angle, \\ + F \cdot Gradient + G \cdot Weather + H \cdot Time \quad (7)$$

where, the values of coefficients *A*, *B*, *C*, *D*, *E*, *F*, *G* and *H* are can be obtained through multiple linear regression by the software spss 17.0 and the results are shown in Table 2.

Then the Changjin freeway risk forecast model is Eq. (8):

$$W = 0.212Age + 5.029Sex + 3.345k \\ + 0.320R + 0.084Angle, +1.781Gradient \\ - 2.127Weathe - 0.207Time \quad (8)$$

From the model, we know that the older the driver is, the more severe the accident will be, the male driver is likely to confront more severe accident than female driver, when the driver is driving a truck, once the accident occurs, the results will be much severe.

Besides, the big horizontal angle and gradient can lead to severe accidents. However, from the model, the effect of horizontal radius and weather to safety is not consistent with what we know and that may be because the data is less.

CONCLUSION

Highway safety, especially mountainous freeway, does not relate to a factor but relates to many factors of four aspects of person, vehicle, road and environment. A large number of researchers analyzed the relationship between highway safety and these four aspects respectively, however, few researches considered all these four aspects. Then this study analyzed the highway safety, especially mountainous freeway, considering all these four aspects of person, vehicle, road and environment.

This study put forward the mountainous freeway risk degree forecast model creatively and established the forecast model based on factors of age and sex about person, vehicle type about vehicle, horizontal curve radius, horizontal angle and slope gradient about road and weather and time about environment. Besides, in order to establish mountainous freeway risk degree forecast model, this study listed the survey content needed.

The 91 accident data from January, 2006 to July, 2012 of Chagnjin Freeway in Jiangxi Province were collected and were used to establish the specific mountainous freeway risk degree forecast model. Multiple linear regressions were adopted to determine the parameter values and from the model, we can know the effect of each factor of these four aspects to mountainous freeway safety.

The mountainous freeway risk degree forecast model established in this study considering four aspects is useful for evaluating the risk degree of constructed mountainous freeway and is meaningful for estimating the risk degree of unconstructed mountainous freeway. What's more, it can also provide basis for measures to improve mountainous freeway safety.

However, there were still some things that we should improve:

- The relationship between the mountainous freeway safety and factors of these aspects may not be linear relationship, which led to some parameter estimates not consist with the fact
- Although we considered many factors of these aspects, more factors were supposed to consider such as the vehicle speed, the month of accident, the pavement condition and so on
- And the accident data was less. They are researches that should be done further in the future

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REFERENCES

Artus, S., V. Cocquempot, S. Hayat, M. Staroswiecki, P. De Larminat *et al*., 2005. CHV's brake discs temperature estimation: Results in open road tests. Proceedings of the 8th International IEEE Conference on Intelligent Transportation Systems. Vienna, Austria, Sep. 13-16, pp: 220-225.

Choi, J., S. Kim, T. Heo and J. Lee, 2011. Safety effects of highway terrain types in vehicle crash model of major rural roads. KSCE J. Civ. Eng., 15(2): 405-412.

Garber, N.J., J.S. Miller, X. Sun and B. Yuan, 2006. Safety impacts of differential speed limits for truck sand passenger cars on rural interstate highways: A modified empirical bayes approach. J. Transp. Eng., 132: 19-29.

Ghandour, R., A. Victorino, M. Doumiati and A. Charara, 2010. Tire/road friction coefficient estimation applied to road safety. Proceeding of 18th Mediterranean Conference on Control and Automation. Congress Palace Hotel, Marrakech, Morocco, June 23-25, pp: 1485-1490.

Hummer, J.E., W. Rasdorf, D.J. Findley, C.V. Zegeer and C.A. Sundstrom, 2010. Curve collisions: Road and collision characteristics and countermeasures. J. Transp. Safe. Secur., 2(3): 203-220.

Islam, S. and F. Mannering, 2006. Driver aging and its effect on male and female single-vehicle accident injuries: Some additional evidence. J. Safe. Res., 37: 267-276.

Jurado-Piña, R. and J.M. Pardillo-Mayora, 2010. Methodology to analyze sun glare impact on highwayunder prolonged exposure. J. Transp. Eng., 136: 1137-1144.

Khan, G., X. Qin and D.A. Noyce, 2008. Spatial analysis of weather crash patterns. J. Transp. Eng., 134: 191-202.

Khashei, M., A.Z. Hamadani and M. Bijari, 2012. A novel hybrid classification model of artificial neural networks and multiple linear regression models. Expert Syst. Appl., 39: 2606-2620.

Konstantopoulos, P., P. Chapman and D. Crundall, 2010. Driver's visual attention as a function of driving experience and visibility: Using a driving simulator to explore drivers' eye movements in day, night and rain driving. Accident Anal. Prev., 42: 827-834.

Oh, H.U. and S. Mun, 2012. Design speed based reliability index model for roadway safety evaluation. KSCE J. Civ. Eng., 16(5): 845-854.

Rhodes, N., D. Brown and A. Edison, 2005. Approaches to understanding young driver risk taking. J. Safety Res., 36: 497-499.

Rosey, F., J. Auberlet, J. Bertrand and P. Plainchault, 2008. Impact of perceptual treatments on lateral control during driving on crest vertical curves: A driving simulator study. Accid. Anal. Prev., 40(4): 1513-1523.

Stine, J.S., B.C. Hamblin, S.N. Brennan and E.T. Donnell, 2010. Analyzing the influence of median cross-section design on highway safety using vehicle dynamics simulations. Accid. Anal. Prev., 42: 1769-1777.

Taubman-Ben-Ari, O. and L. Katz-Ben-Ami, 2012. The contribution of family climate for road safety and social environment to the reported driving behavior of young drivers. Accid. Anal. Prev., 47: 1-10.

UI-Saufie, A.Z., A.S. Yahaya, N.A. Ramli and H.A. Hamid, 2012. Performance of multiple linear regression model for long-term PM_{10} concentration prediction based on gaseous and meteorological parameters. J. Appl. Sci., 12(14): 1488-1494.

Weng J. and Q. Meng, 2012. Effects of environment, vehicle and driver characteristics on risky driving behavior at work zones. Safety Sci., 50: 1034-1042.

Williams, A.F., 2006. Alcohol-impaired driving and its consequences in the United States: The past 25 years. J. Safety Res., 37: 123-138.