RESEARCH ON THE ROAD CONDITION CAUSES AND COUNTERMEASURES OF TRAFFIC ACCIDENTS IN CHINA

Y. L. PEI & J. MA
School of Transportation Science and Engineering, Harbin Institute of Technology, Harbin 150090, China
yulongp@263.net

ABSTRACT

With large numbers of actual traffic accidents of Shenda Freeway, Liaoning Province, Harbin City and so on in China, parameters and the effect on accidents of horizontal alignment, vertical alignment and cross section are studied systematically, and the disciplinary analysis of the effect is presented. The critical value and the reasonable range of curve radius and angle of deflection are put forward in view of road safety. The safe grade value and the proposed critical grade are raised in vertical alignment design. The effect on accident of the number of lanes and type of cross section are analyzed, therefore safety influence factor of lanes number (SIFLN) and safety influence factor of cross section type (SIFCST) are presented and suggestion values are given. The viewpoint is put forward that high subgrade and steep slope are against to traffic safety. The suggestions of design parameters of the Design Criteria and the corresponding countermeasures are advanced for safety.

KEY WORDS

ROAD TRAFFIC ACCIDENT, ROAD CONDITION; CAUSES; COUNTERMEASURES

1 INTRODUCTION

Road traffic accident occupies the primacy of three road traffic disasters and brings serious consequences to human society and life. In order to cut down traffic accident number and severity degree, many people have been striving and exploring for that. An accident is always ascribed to driver's incaution, mistake and vehicle's mechanical problems by many public consensus and official statistics of traffic management administration (Vasconcellos, 1996 ; Orfeuil, 2000; Elsner and Reichwein, 2001; Page, 2001) . The road condition cause of traffic accident is ignored.

In order to obtain the consistent and excellent design criterion, eight Europe countries prepare the SAFEATAR program (1999, Zheng), whose emphasis is on the road network of Europe. The effect of road on traffic safety is more and more obvious. The paper studies the relationship between accidents and road conditions which include horizontal alignment, vertical alignment, cross section and presents some corresponding countermeasures of traffic accidents prevention.

2 HORIZONTAL ALIGNMENT

2.1 Curve radius

Traffic safety is close with the geometry alignments, as accidents often occur at curves, especially steep curves. The average accident rates of Shenda Freeway corresponding to different radius from Jan. 1994 to Jun. 1995 (Pei and Meng, 2000) are collected to give statistical analysis.

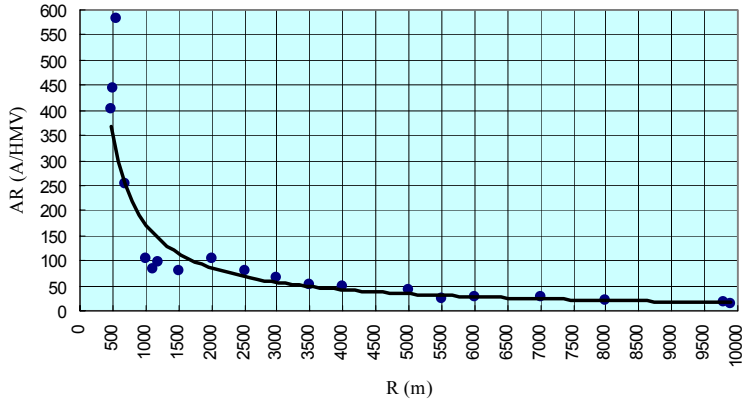

Figure 1 - The relationship of AR and radius on Shenda Freeway

From the scatter figure, it's clear that there is a power relationship between AR and radius, as Figure 1. The model is obtained by statistics:

$$AR = 189194R^{-1.0143} \quad (R^2 = 0.926) \tag{1}$$

where, *AR* is average accident rate per a hundred million vehicles, A/HMV. *R* is curve radius, m.

From the regression curve and the model above, AR reduces with the radius increasing. When the radius exceeds 2000m, AR is under the average level of the whole Shenda Freeway (68.73A/HMV). When the radius is less than 1000m, AR increases greatly with the radius falling. When the radius reduce to 400m or 600m, viz. approximately close to the ultimate minimum radius of the hills, AR is 5 or 6 times of the average AR of the whole Shenda Freeway, which displays very dangerous and severe. The curve radius inflexion of the Shenda Freeway is about 1000m.

The statistical analysis in China is approximately the same with abroad. The inflexion of American highways curve radius is 400m (Lamm, Psarianos and Mailaender, 1999), which is representative for integration of all classes of highways data. According to the limit error principle, the radius is 200m corresponding to the AR which is taken after the AR of 400m is double. Thereby, AR of 200m is the limit acceptable reliability level of traffic safety. There is no enough statistical data for aggregate analysis and parameter calibration. This research result adapts to the high-class highways. Therefore, the curve radius inflexion of the highways for safety is still 400m, and the limit acceptable radius is 200m as well.

The curves with same or similar radius are safer than that with difference radius. It is especially dangerous that a small radius curve is inserted into long and straight line.

Modification of horizontal alignments is one of the most effective measures to improve traffic safety to highways.

2.2 Angle of deflection

Angle of deflection is the influencing factor as well. The accident rates per a hundred million vehicles of Shenda Freeway corresponding to different angles of deflections from Jan. 1994 to Jun. 1995 are shown as Figure 2 (Pei and Meng, 1996).

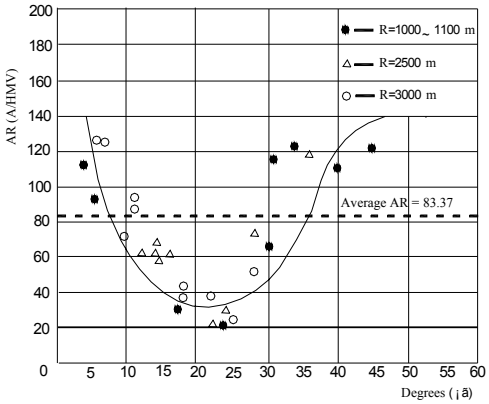

Figure 2 - The relationship of AR and angle of deflection

From the result of fitting, when the angle of deflection varies from 0° to 45°, the relationship of AR and angle of deflection is parabola approximately, which means that AR decrease with angles increasing and reaches the minimum level (the extreme point) when angle of deflection increasing to a certain value, and then rises with angles increasing. When angle of deflection is less than or equals to 7° (small angle of deflection), AR is higher than the average level of 30 sample points (viz. 83.37 A/HMV), which proved a conventional viewpoint that small angle of deflections lead to the illusion of steep curves to drivers and are unfavorable to traffic safety.

3 VERTICAL ALIGNMENT

There are more accidents on the roads with grades. Emergency braking often occurs in the course of driving. As the brake distance of down grade is longer than that of up grade, there are more accidents at down grade.

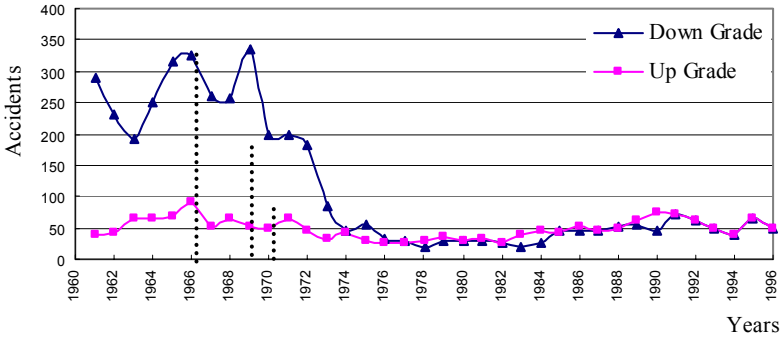

Figure 3 - Accidents at down and up grade

A highway of 7.2km in American FIzer Mountain is shown in Figure 3, from which we can find that the accidents of down grade are much more than that of up grade before any safety

measures are taken. Accidents of both down and up grade decrease after increasing two-direction lane in 1969, especially for down grade to falling down obviously. Again accidents at down grade decrease greatly after installation of speed-limit signs, as well as that of up grade. All accidents fall down after operation of auto-radar control of speed, and accidents at down and up grade keep stable both in absolute value and in relative trend in the end of 70's. Thus it can be seen that safety measures at grade such as increasing lanes and installation of traffic signs are necessary to improve traffic safety.

4 CROSS SECTION

4.1 Number of lanes and type of cross section

The number of lanes and type of cross section are very important to traffic safety, so it's necessary to present the concepts which are Safety Influence Factor of Lanes Number (SIFLN) and Safety Influence Factor of Cross Section Type (SIFCST). SIFLN is the influence degree of different number of lanes on AR, which is also an important index to measure traffic safety. SIFCST is the influence degree of different type of cross section on AR. No matter to SIFLN or SIFCST, the factor value is greater; the impact of the corresponding number of lanes and type of cross section on traffic safety is sharper.

Based on accidents data of 76 streets in Harbin which is the provincial capital of Heilongjiang Province in China, AR of different lanes number and cross section type is obtained as Table 1 and Table 2.

Table 1 - SIFLN of urban streets

Number of lanes	Type of lanes	Accidents	AR (A/HMV)	Sample streets	Average AR (A/HMV)	AR of different lanes number (A/HMV)	SIFLN
Double lanes	Double lanes	169	1584	18	88	88	1.02
Four lanes	Four lanes	511	2075	25	83	86	1.00
	Four lanes with median strip	4	150	2	75		
	Four lanes with separation strip	59	404	4	101		
Six lanes	Six lanes	357	1078	11	98	83	0.97
	Six lanes with median strip	20	76	1	76		
	Six lanes with separation strip	214	450	6	75		
Eight lanes	Eight lanes	109	273	3	91	81	0.94
	Eight lanes with median strip	75	162	2	81		
	Eight lanes with both median strip and separation strip	220	284	4	71		

Table 2 - SIFCST of urban streets

Type of cross section	Accidents	AR(A/HMV)	Sample streets	Average AR (A/HMV)	SIFCST
Without any strip	1191	10011	61	164	1.26
With median strip	111	520	4	130	1.00
With separation strip	273	1341	10	134	1.03
With both median strip and separation strip	220	415	4	104	0.80

4.2 Height and Gradient of Subgrade

It's disadvantageous for high subgrade to traffic safety because of severity in case of accidents. The statistical analysis results of highways accidents in Liaoning Province from Jan. to Jul. 2000 are presented as Figure 4 and Table 3. It can be seen that turnover accidents occur easily by reason of high subgrade, especially for the high-class highways. The death rate of turnover accidents is usually higher than the average death rate of traffic accidents, so turnover accidents are more serious.

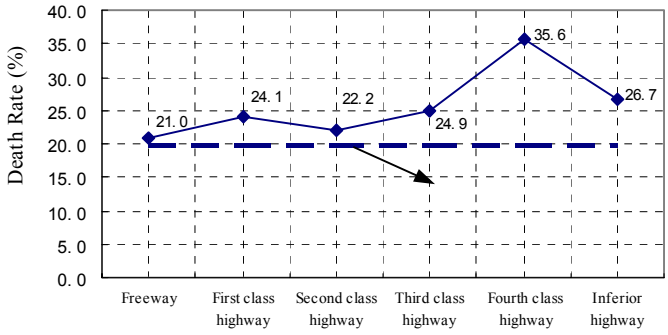

Figure 4 - Comparison of turnover death rate and average death rate of highways in Liaoning Province

Therefore, it is better to avoid the possibility of turnover accidents in road design, which means discreet consideration of high subgrade choice. Especially for high-class highways, as the Design Criteria leads to "high standard of design", namely High Subgrade, and the speed is high as well, the vehicle rushes out of roadside safeguard and turn over to the end of high subgrade in case of out of control, which results in the accidents of death and destroy.

Table 3 - Statistical analysis of turnover accidents of highways in Liaoning Province

Highway	Turnover accidents	Injury persons	Deaths	Death rate (%)	Total accidents	Average death rate (%)
Freeway	187	49	13	21.0	1984	19.58
First class highway	49	44	14	24.1	3661	
Second class highway	150	137	39	22.2	5881	
Third class highway	200	157	52	24.9	5972	
Fourth class highway	52	47	26	35.6	1690	
Inferior highway	56	66	24	26.7	1877	

Steep gradient of subgrade is another factor to accidents. When vehicle running on with the steep gradient subgrade, the accident is close to falling down in case of emergency. If gradient is decreased to be gentle, the vehicle can run through a certain distance so as to reduce the degree of collision and the accident severity.

5 COUNTERMEASURES

Road safety is closely bound up with design standard. Good design standard can alleviate or prevent casualties in accident. Through analyzing and studying above data, it is indicated that highway sections with complicated alignment are sometimes accident black spots. Therefore, scientific and efficient way must be adopted to design reasonable standard, and corresponding traffic safety technical countermeasures also must be implemented to solve the problem of traffic safety in road design. Applying above analysis results of influence factors of road design, and comparing with actual road design standard, reasonable values of road design parameters are put forward from the point of view of road safety.

5.1 Curve radius

As Table 4 shown, at present actual “Highway Engineering Technical Standard” prescribes minimum curve radius of all classification highway. From the point of view of safety, curve radius has three critical values, viz. 200m, 400m and 2000m. Many minimum radius of “Highway Engineering Technical Standard” are less than safe critical value, which will cause traffic accident. It is suggested that minimum radius should be corrected for safety based on above analysis. And it is recommended minimum curve radius adopt suggestion value in Table 4.

Table 4 - Minimum radius of all classification highways

Class of highway		Freeway				First class highway		Second class highway		Third class highway		Fourth class highway	
Design speed (km/h)		120	100	80	60	100	60	80	40	60	30	40	20
Limit minimum radius (m)	Values of criteria	650	400	250	125	400	125	250	60	125	30	60	15
	Suggestions	800	600	400	200	600	200	400	100	200	60	100	30
Minimum radius (m)	Values of criteria	1000	700	400	200	700	200	400	100	200	65	100	30
	Suggestions	1000	800	600	400	800	400	600	200	400	100	200	60
Minimum radius without superelevation (m)	Values of criteria	5500	4000	2500	1500	4000	1500	2500	600	1500	350	600	150
	Suggestions	5500	4000	2500	1500	4000	1500	2500	800	1500	400	800	200

5.2 Angle of deflection

In selection and design of alignment, something should be considered in order to ensure

road traffic safety.

(1) Safe value of angle of deflection ranges from 15°to 25°, of which 20° can meet the request of visual characteristic of driver and running field of vision best.
(2) Angle of deflection should be less than 30°.
(3) Angle of deflection should be no less than 7°.

5.3 Grade

According to study results, three suggestions are advance on design of road grade.
(1) Maximum grade should not exceed 6%.
(2) Appropriate grade ranges from 0.3% to 2%.
(3) When traffic volume is heavy and AR is high, it is suggested that adding lanes and setting speed limit sign, especially on the side of downgrade.

5.4 Height of subgrade

Criterion prescribe merely that subgrade height should make the edge of road shoulder be higher than ground seeper height on both sides of subgrade, and the effect of groundwater, capillary water and frost should be considered at the same time with the least effect on the intensity and stability of subgrade. However, it fails to control subgrade height from the point of view of safety, which cause illusion to designer that better it is, higher subgrade is. Study above indicates subgrade, especially of high-class highways, should be as low as possible under the precondition of ensuring the request of flood prevention, crossing road and interchange approach.

In China, low subgrade is often rejected as a result of groundwater, drainage, soft subgrade, combination of alignments, and waving of vertical alignment by lateral culvert in the demonstration and evaluation of projects. In fact, if we compare serious of problems such as incipient safety fault, cost of safeguard, increased valuation cubic meter of earth and stone, land waste (viz. area of gaining and dropping soil) and environmental damage (Leisch, 1971 ; Mohamed and Radwan, 2000) with the increased cost and the construction of handling with low subgrade, it is not appropriate as above. Of course, it is not absolute good to avoid the high subgrade. It's necessary to do so in the case of flood prevention, channel installation and interchange approach.

6 CONCLUSION

Road condition is only one of the objective factors, and there are still vehicles, traffic and climate causes. In the times of wide applications of ITS (Dissanayake, Turner and Lu, 1999; Ross, 1996), how to apply the advanced information technology and positioning technology with high precision to safe design of roads is the next objective to decrease AR and improve accidents prevention, accidents positioning and road management.

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