A STUDY OF TCT AT ZHENGZHOU YELLOW RIVER HIGHWAY BRIDGE

Rui FU, Dr. Eng.
Vice Professor
Faculty of Automobile Engineering
Chang'an University
Xi'an, Shaanxi, 710064 China
Fax: 86-29-5226411
E-mail:furui@xahu.edu.cn

Lang WEI, Dr. Eng.
Professor
Faculty of Automobile Engineering
Chang'an University
Xi'an, Shaanxi, 710064 China
Fax: 86-29-5226411
E-mail:weilang@public.xa.sn.cn

Yingshi GUO
Lecture
Faculty of Automobile Engineering
Chang'an University
Xi'an, Shaanxi, 710064 China
Fax: 86-29-5261532

Yong LUO
Lecture
Department of Automobile Engineering
Sichuan College of Technology
Chengdu, Sichuan, 610024 China
Fax: 86-28-46853124

Abstract: Zhengzhou Yellow River Bridge becomes a black spot of the national trunk highway 107 in the recent years. Study for traffic conflicts technical evaluation methods in this paper served for making improvement plans for the bridge and preparing technical approaches for the rapid evaluation of the improved projects. According to the peculiarity of research targets and the practicality of observation conditions, the conflict distance is chosen as the judgement standard for seriousness degree of traffic conflicts. A combination of stratified sampling and clustering analysis is used to determine the conflict observation sections and the number of samples. Then the traffic safety situation of Zhengzhou Yellow River Bridge was analyzed quantitatively using the conflict observing results and the causes of traffic conflicts were studied. Based on this work, the safety reconstruction measures and the TCT evaluation method were put forward.

Keywords: traffic safety, traffic conflicts technique, highway bridge

1. INTRODUCTION

Traffic Conflicts Technique (here-in-after TCT) is a newly-developed research method for non-accident statistics of traffic safety situation in the traffic safety field. Comparing with traditional accident statistics method, it has the advantage of large-scale sample generation in statistics and of the rapid and quantitative evaluation (Hiton 1994), therefore it adapts to the evaluation of traffic safety situation and traffic safety improvement results better. As a trial project for Henan highway safety improvement sponsored by the World Bank, the author performs a creative research for the availability of safety evaluation of a long highway bridge using TCT.

2. CONSTRUCTION OF JUDGEMENT STANDARD OF TRAFFIC CONFLICTS

The determination for traffic conflict degree is the important content in the application of TCT, because it's directly related to the reliability of safety evaluation. In the analysis for traffic conflict situation of Zhengzhou Highway Bridge, the conflict distance (DB) is chosen as the judgement for seriousness degree standard of traffic conflicts with the reference of TCT documented standards at home and abroad. From the traffic accidents from 1992 to 1996 on Zhengzhou Yellow River Bridge, a Balet Curve line of drivers' risk-avoidance behavior on the bridge can be presented (Niu 1997). According to Balet's arranging principles for main factors, a single behavior together with braking and by-passing behavior can taken as the typical behavior of drivers' risk-avoidance behavior. As the two typical selected behaviors contain braking factors, the braking parameter can be taken as the basic parameter in conflict measurement. Concerning traffic environment of Zhengzhou yellow River Bridge, the influential factors with greater differences in the smallest braking distance are climate conditions, vehicle types and tire types etc. According to the above conclusion, we can set the system of measurement standard of traffic conflicts for various vehicle types on Zhengzhou Yellow River Bridge on fine days (or cloudy days). Both in practical conflict training and conflict observation, it shows its convent, rapid and accurate judgement result.

Table 1. Measuring judgements for serious conflict degree on Zhengzhou Yellow River Bridge on fine days (or cloudy days)

Light vehicle: $M < 4.5t$	$DS_1 = 0.1225\,v_0 + 0.07288\,v_0^2$
Medium vehicle: $4.5t < M < 12t$	$DS_2 = 0.1825\,v_0 + 0.07288\,v_0^2$
Large vehicle: $M > 12t$	$DS_3 = 0.2375\,v_0 + 0.07288\,v_0^2$
Medium truck with tailor	$DS_4 = 0.2825\,v_0 + 0.07288\,v_0^2$
Large truck with tailor	$DS_5 = 0.3375\,v_0 + 0.07288\,v_0^2$

Where M is mass of the vehicle. DS is critical safety distance. v_0 is initial velocity.

3. SELECTION FOR CONFLICT OBSERVATION SECTIONS

Only those traffic safety analysis and evaluations based on investigation have certain reliability and practical value. When traffic conflict investigations have been done on the road sections with accident files, the recorded accident data should be made full use of. The identification methods for black spots should be properly used to determine the length of the road sections, and then the practical methods should be adopted to select the conflict investigation sections according to their lengths. Figure 1 is the procedures of doing it.

As there are no recorded accident files for the original road sections, the dangerous road sections cannot be determined according to accident files. In this case, road safety experts should be invited to determine preliminarily the potentially dangerous sections and then select the black spots according to traffic conflict investigations. Figure 2 is the procedures of doing it.

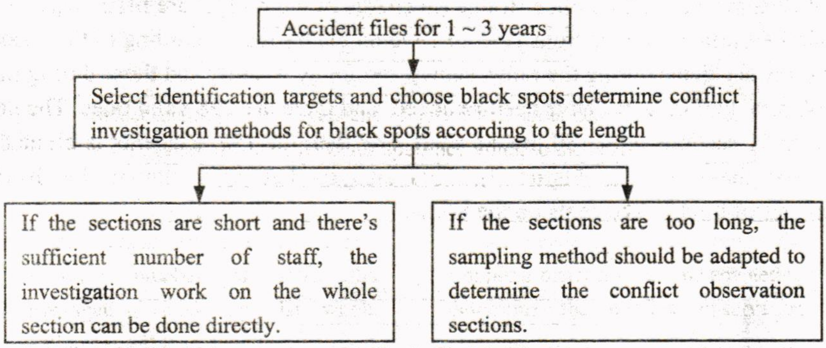

Figure 1. Determination chart for conflict observation sections according to accident files

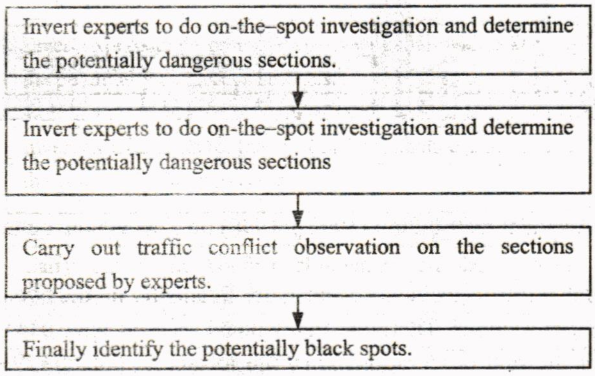

Figure 2. Evaluation chart for traffic safety on road sections without accident files

Zhengzhou Yellow River Bridge in this research is a black spot on the national trunk highway 107, the research team put forward the following requirements for the selection for conflict observation sections on the bridge.

(1) The overall traffic safety levels on the selected sections can better represent the existing traffic safety situations of the whole bridge.

(2) According to the traffic conditions and road facility features of the bridge, the selected sections should include the both end section of the bridge.

(3) The recorded data from conflict observation on the selected section can be better used to study the effectiveness of TCT on highway sections.

(4) The selected sections have not been reconstructed in the recent five years to improve the traffic environment and raise safety levels.

(5) The places for observation can ensure the observer's safety during the work.

According to the above requirements, the traffic accident data provided by the Seventh

Branch of Zhengzhou Traffic Police Bridge (in charge of the bridge) are firstly used. The data include all the traffic accidents from 1992 to 1996 on the bridge. According to the observation principles, the accidents during the rainy, snowy and foggy weather and those during the night (from 6:00 p.m. to 7:00 a.m.) have been removed, and there are 198 valid ones. The bridge is divided into 31 sections with 180 meters apart, and then the 198 accidents is divided by 31 sections (see the results in Figure 3). This analysis has fully shown the distribution characteristics of the 198 accidents on the bridge.

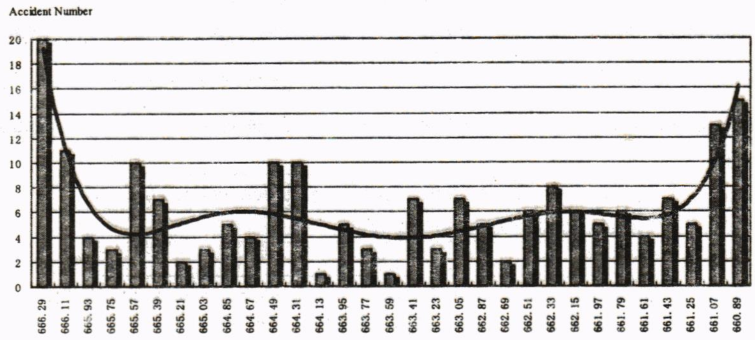

Figure3 Traffic Accident distribution (1992 ~ 1996) on Zhengzhou Yellow River bridge

The Figure 3 shows that traffic accidents occur more frequently on the two end sections of the bridge than on the other sections. Therefore the two end sections have been determined as the peculiar sections for the first observation. They are located at 666km+290m, 666km+110m, 661km+70m, 660km+890m. On the other parts of the bridge, a combination of stratified sampling and clustering analysis is used to determine the second conflict observation sections.

The stratified sampling is to divide N units into K stratification according to a certain mark. On each stratification there are Ni units ($i = 1, 2, \cdots, k$). Then n_i units are taken out at random from each stratification, forming the total sample volume n. The observation results on the samples can be used to determine one sampling organization form of the quantity characteristics and the general characteristics of each stratification (Li 1996).

In this research the number of traffic accidents of the bridge is taken as the stratification mark. According to the principles of clustering analysis, Ose distance, after the comparison of other distance, is taken as the shortest distance method in distance calculation (Yang *et al* 1989). Through the clustering analysis of the traffic accidents on Yellow River Bridge, there are three stratification of the bridge:

The first stratification is the section where the traffic accidents (1, 2, 3, 4) took place.

The second stratification is the section where traffic accidents (6, 8) occurred.

The third stratification is the section where traffic accidents (5, 7, 10) happened.

After determination of the number of stratification, the best allocation method is adopted to determine the required number of samples n_i. In the best allocation method, the number of samples n_i and the standard difference δ_i in each stratification has been fully considered. If the sample n is given, the variance in the estimation quantity of n_i can reach the smallest values. If the round figures are taken as the number of samples on each stratification, that is n_1=2, n_2=1, and n_3=3.

On the first stratification, two sections can be taken out at random. From the stratified sampling theory, the sampling in the stratification is of random nature. On the bridge sections with traffic accidents numbered 1, 2, 3 and 4, two sections can be taken out at random, which are located at 662km+690m(2) and 664km+570m(4). On the second stratification, only one section is taken out. The section 661km+790m(6) is taken out from traffic accidents numbered 6 and 8. On the third stratification, three sections are taken out at random from traffic accidents numbered 5, 7, and 10, their location are 663km+950m(5), 663km+50m(7) and 665km+570m(10). For the second conflict observation, six sections (except the two end sections of the bridge) should be taken out. There are four more sections on both ends of the bridge, altogether 10 sections. Their total length accounts for 31.88% of the bridge length, and the traffic accidents taking place there account for 46.97% of all the accidents on the bridge, therefore it can satisfy the requirements for the selection for conflict observation section.

4. IMPROVEMENT MEASURES AND EVALUATION OF THE IMPROVEMENT

The aim of the application of TCT is to detect the defaults of current traffic environment, and to evaluate the safety improvement. Its main task is applying the outstanding characteristic of statistics and relevant coefficient to analyze the validity of TCT.

During the relevance study, the recorded data of traffic conflicts and statistical information of traffic accidents on the 10 observation sections on Yellow River Bridge have been taken as the main research items. The comparison between the process of traffic accidents and traffic conflicts is a new and effective method. In the research, 6 representative parameters were used to examine the relevance between accidents and serious traffic conflicts on Yellow River Bridge. They are the main accident or conflict undertakers, type of accidents or conflicts, speed, time during a day, the date during a week and risk-avoidance action. The relevance examination of TCT on Yellow River Bridge has shown that:

(1) There is very strong relevance between traffic accident and traffic conflict observed on Yellow River Bridge. When 99% is taken as the reliability level on both sides, the relevant coefficient is as high as 0.99.

(2) There is obvious relevance among the five representative targets of traffic accident and traffic conflict on Yellow River Bridge. When 99% is taken as the reliability level on both sides, the relevant coefficient is as high as 0.85.

The above analysis and study have shown traffic conflicts can help predict the conditions of traffic accidents, and show safety trend of the bridge traffic system, therefore TCT is a better alternative accident method. After proving the validity of TCT on Zhengzhou Yellow River Bridge, we can do traffic conflict observation and safety analysis on Zhengzhou Yellow River Bridge. The following is the conclusions actually obtained from the conflict observation on Zhengzhou Yellow River Bridge:

(1) The number of conflicts according to their types is: tail collision accounts for 46.73%, collision in the opposite direction 35.78%, and collision in the same direction 17.49%.

(2) The main types of vehicles involved in conflicts and their arrangement (from the great to small) are: large trucks (53.15%), mini-buses (20.42%), agricultural vehicles account for 9.21%, truck with trailers (6.07%), small truck (4.85). These types of vehicles account for 93.7% of all the vehicles in the observation.

(3) The order of conflict speeds are: 50-60 km/h (26.1%), 40-50km/h (24.2%), 60-70km/h (22.3%), 70-80km/h (11.7%), 80-90km/h (6.1%). The five speeds account for 90.4% of all the running speed in the observation.

(4) The main risk-avoidance measures during the conflicts and their orders are: braking (58.99%), braking and passing by (21.88%), speeding and passing by (7.07%). The three measures account for 87.94% in all the measures taken during the conflicts.

On the basis of the results of safety analysis using TCT on Zhengzhou Yellow River Bridge, together with safe improvement principles of highway environment, the author gives several advises for safety improvement on Zhengzhou Yellow River Bridge as follows.

(1) Abolish double yellow line, and set up central locomotive isolation blocks of cement;

(2) Divide the large and light vehicles on their own lanes;

(3) Reconsider the grade of speed-limit;

(4) Reset the road-sign;

(5) Close south approach span of the bridge;

(6) Limit agricultural vehicle and over-loaded large-type vehicle to run on the bridge.

With the reference of TCT studies at home and abroad (Liu 1997, Rao V. *Et al* 1997), the author gives the following evaluation methods of safety improvement on Zhengzhou Yellow River Bridge. Conduct twice conflict observations, the second observation should be done on the next month after the improvement. All observation conditions, like conflict observers, equipment used, climate, observation time period, observation sections, should be the same.

Compare the conflict observation data of before and after the improvement. In this research, we come up with conflict ratio (ν_1) and conflict specific ratio (ν_2) as evaluation indexes. Because ν_1 hasn't remove the influence of traffic volume on conflicts, ν_2 can reflect the traffic safety improvement results better.

5. CONCLUSION

The author gives the judgement standard of traffic conflict measurement on Zhengzhou Yellow River Bridge. Through the real-world application, TCT is proved can be used as a tool of safety analysis on large-scale highway bridge. Two identification modules for dangerous sections are dealing with the road sections with and without accident files. Then the principles and methods of selection for conflicts observation sections of large-scale highway bridge are given. A combination of stratified sampling and clustering analysis is first adopted during determining the conflict observation sections.

After one-month traffic conflict observation on Zhengzhou Yellow River Bridge, we analyze quantitatively the safety disadvantages of the bridge. These analysis results by using TCT are almost the same as the results obtained by traditional accident-statistical method. As the above disadvantages concerned, we put forward safety improvement measures and its evaluation method.

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