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IMPROVEMENT IN THE QUALITY CONTROL METHOD TO DISTINGUISH THE BLACK SPOTS OF THE ROAD

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Abstract: It shows several differentiating methods in this paper and the quality control method is improved. The quality control method is used to differentiate the Black Spots in the same condition of the road and the traffic. When applying the method to practice, it assumes that the probability of the traffic accident obeys the Piosson distribution, then a mathematic formula is set up. But the stat character of the accident frequency μ which takes record is not analyzed, this makes precision of the result decrease in the method. Some literature are consulted, and it takes n_b and $1/t_b$ as the parameters of the Gamma distribution to compute the equal accident rate λ, which makes λ rational and the result exact .At last, it takes the example of Shen-Da expressway to analyze the Black Spots by the method and achieve the rational result.

Key Words : Accident rate, Black Spot, Quality control method

1. INTRODUCTIN

The field where the road traffic accident often occurs is called Black Spot, is the sections of road or intersections where the road traffic accident is outstanding more than other sections and intersections. It is the first and a pivotal step for improving the road safety level to confirm the sections of road or intersections that need improving the road safety level place, distinguish light and weight and take the good measure to improve the road safety level effectively.

Black spots badly decreases the road serve quality, and there is characteristic that the proportion of the accident number accounts for the total number is high. So it is economy and effective method for improving the road traffic safety condition to differentiate the black spots, analyse the cause of black spots and raise the comfortable measure. Especially when the fund is lack, it is advisable to firstly improve the road safety level.

2. DISCUSSING IDENTIFICATION METHODS

There are several methods to identify Black spots in or out of china, as follows:

2.1 Accident Frequency Method

This method is that taking an accident number as identification criterion, if the accident number of identified section is more than the criterion, the section is regarded as Black spots. It is good for the method to choose, calculate and be clear at a glance. But shortcoming is that it is difficult to identify the Black spots when this accident number is as much as that, that is because the difference of road condition and traffic condition is not taken into account in the method. It may result in thinking nothing of Balck spots as Balck spots. So it is the conclusion that the method is suitable for the section and intersection of mini-scope.

2.2 Accident Rate Method

After 1940, the developed country develops the traffic survey. When identifying Black spots, the accident rate method is advanced because of holding the great of traffic number data. This method takes the accident number of million motor-kilometer of one year as identification criterion in section, million motor in intersection. So when the accident rate exceeds the criterion, the field is regarded as Block spots. This method is better than accident frequency method, but it is two shortcomings for the method, one is that accident rate value is high in the section where traffic number value and accident number value is low, another is that accident rate value is low in the section where traffic number value and accident number value are high. So when taking use of this method to identify, it may make identifying result inaccurate.

2.3 Matrix Method

This method takes accident number and accident rate as the criterion, the level axis denotes accident number, upright axis presents accident rate. One matrix cell expresses one section of road. The matrix cell value shows the degree of risk of section. The riskiest section has the highest accident number and accident rate in down right corner of the matrix. It is merit for method to think over the accident number and accident rate, but there are some shortcomings. It can show the degree of risk of section, but can not distinguish these sections in which accident number is low and accident rate is high or accident number is high and accident rate is low, only to regard them as nothing of Black spots and can’t consider the criterion and severity of accident.

2.4 Total Equivalent Accident Number Method

If the value of accident number, severity of which is different, simply calculates, it results in that the identifying result is inaccurate. For example, the number value of two sections is the same, but the death number value of one is higher than another. Apparently, the fatalness in the section where the death number value is high is higher. To identify Black spots correctly,

taking into account the severity of the accident, the total Equivalent accident number method is developed (Pei, 2002). This method calculates the degree of severity of accident through calculating modulus of injured number and death number. Because of lack of thinking over traffic number and the length of section, it is the same shortcoming as accident rate method and the modulus have great influence on the identifying result.

2.5 Quality Control Method

In 1956, the people such as Norden, develops quality control method which is different from others. firstly, on the assumption that the accident number in section submits to the Piosson distribution, then compare the accident rate with the equal accident rate in the similar section. According to notability, the highest value and the lowest value of synthesis accident rate are ascertained in Black spots. If the accident rate is higher than the highest, the section is though of as Black spots. In fact, quality control method is one that bases on hypothesis. It is shown that the method is better than others when applied, but the precedence order that Black spots is reconstructed is not fixed and the severity of accident is not considered.

2.6 Critical Rate Method

In 1997, J. S. CHEN and S. C. WANG summarize the merit and shortcoming of methods above to develop Critical rate method. In this method, the accident rate which the user of road can stand is regarded as critical rate. According to notability, there is different lowest value of accident rate corresponding to different critical rate. When the accident rate of one section is across critical rate, the section is thought of as Black spots. Thinks to considering the characters of Black spots, the method is better than methods above, and can fix the order that the Black spots is reconstructed though choosing different critical rate. But the critical rate is changing with economy development and standard of living improvement, so the data should be updated to make sure the critical rate based on traffic accident and building fund (Jodi, C. *et al*., 2001).

From the analysis of several methods above, although the several methods identify Black spots from different way, some conditions, such as traffic volume, road condition or severity of accident, can be ignored, this makes veracity of identification result reduce. Therefore, each method should be applied in comfortable condition. When identifying Black spots, it is supposed to take into account these condition to study the method to make the result exact (Sean, T. D. *et al*., 2000).

3. QUALITY CONTROL METHOD

The method to identify Black spots has each merit. Although there are some shortcomings for them, which is limited by application condition, but the method is chosen basing on the road condition. The quality control method is used to identify Black spots in the road which have the same road condition and traffic condition (Hiroshi, 1997).

When applying the quality control method, firstly it is assumed that probability of traffic accident happening obeys Piosson distribution in any condition, i.e. probability of *n* traffic accidents happening can be denoted by formula (1) in *t* time.

$$P(n|\mu,t)=\frac{e^{-\mu t}}{n!}(\mu t)^n \quad (n\geq 0) \tag{1}$$

where, μ denotes accident frequency of road section[4].

Mean and variance of n are as follows:

$$E(n)=\mu t\ ,\quad Var(n)=\mu t \tag{2}$$

If confidence level of the distribution is made 95%, upper limit value R^+ is as follows:

$$R^+=\lambda+1.96\sqrt{\frac{\lambda}{m_i}+\frac{1}{2m_i}} \qquad i=1,\ 2,\ \ldots\ldots n \tag{3}$$

Where, λ is average accident rate of a hundred million vehicle in similar sections (time /a hundred million vehicle), m_i total vehicle number in *i* section (a hundred million vehicle).

$$\lambda=\frac{\sum E(n)}{\sum m_i} \tag{4}$$

When comparing accident rate of a hundred million vehicle with R^+, if it is higher than R^+, this section is regarded as Black spots.

4. IMPROVING METHOD

In the quality control method, as statistical feature of accident frequency is not considered, but takes record value., it makes veracity of the result decrease. In this paper, some document is consulted, Gamma distribution in which formal parameter is n_b and rule parameter is $1/t_b$ is used to express density function, as follows:

$$p(\mu)=\frac{e^{-\mu t_b}\mu^{n_b-1}{t_b}^{n_b}}{\Gamma(n_b)} \quad (\mu>0) \tag{5}$$

The mean and variance of the distribution are as follows:

$$\mu_b=n_b/t_b\ ,\quad {\sigma_b}^2=n_b/{t_b}^2={\mu_b}^2/n_b \tag{6}$$

The parameter n_b and t_b is calculated, as follows:

$$n_b={\mu_b}^2/{\sigma_b}^2\ ,\quad t_b=\mu_b/{\sigma_b}^2 \tag{7}$$

The mean and variance get from the mean and variance of sample.

So, when the accident frequency μ obeys $p(\mu)$ distribution, the boundary distribution of

accident time is as follows:

$$P(n|t)=\int_{\mu}P(n|\mu,t)p(\mu)d\mu=\frac{\Gamma(n+n_b)}{n!\Gamma(n_b)}(\frac{t^n t_b{}^{n_b}}{(t+t_b)^{n+n_b}}) \quad (8)$$

The mean and variance is as follow:

$$E(n|t)=\frac{n_b}{t_b}t=\mu_b t\ ,\quad Var(n|t)=\frac{n_b}{t_b}t(1+\frac{t}{t_b})=\mu_b t+\sigma_b{}^2 t^2 \quad (9)$$

So, the average rate λ may be taken place by formula(10).

$$\lambda=\frac{\sum E(n|t)}{\sum m_i} \quad (10)$$

After finishing identifying Black spots by quality control method improved, accident rate of a hundred million vehicle is arranged by the order from high to low. It is first to improve the section that has high accident rate (Dinesh, 1999).

5. APPLICATION

There were one thousand and four traffic accidents from January, 1994 to June,1995. As the traffic and road condition of section along Shen-Da freeway, quality control method is used to identify Black spots. Through comparing with the accident rate calculated. 35 Black spots have been confirmed, and the order of section improved have been confirmed according to accident rate.

According to traffic data and accident data, Shen-Da freeway is divided into twenty four intervals In each interval accident rate of a hundred million vehicle is shown in table 1.There is plain from one interval to seventy interval, where road design indexes are the same. Average accident rate of a hundred million vehicle is 62.80.There is a mountainous area from eighteen interval to twenty four interval, Average accident rate of a hundred million vehicle is 83.13. Taking confidence of Piosson 95%, table 1 presents upper limit R^+ of every interval

According to traffic accident distribution along Shen-Da freeway, it is divided into three hundred seventy six sections, there are thirty five sections in which accident rate is higher than upper limit (Table 2), which are Black spots. accident rate of a hundred million vehicle is arranged by the order from high to low. It is first to improve the section that has high accident rate (Mohammed, M.S. *et al*., 1999).

6. CONCLUSION

In the quality control method, as statistical feature of accident frequency is not considered, but takes record value., it makes veracity of the result decrease. So, quality control method is improved in paper. On the assumption that accident frequency obeys Gamma distribution and probability of accident happening obeys Piosson distribution, quality control method is developed. it takes the example of Shen-Da expressway to analyze the Black Spots by the

method and achieve the rational result. This improved method may be used to identify Black spots as an avail method.

Table 1. Space Location, Total Vehicle Number and Traffic Accident Indexes

Number	Interval	Mileage mark	Interval length (km)	Total traffic (a hundred million vehicle)	Accident time	Accident rate of a hundred million vehicle (time/ a hundred million vehicle)	Upper limit (time/ a hundred million vehicle)
01	Origination～sujatun	k0～k19+982	19.982	3.55×10^{-2}	58	81.76	159.30
02	Sujiatun～shilihe	k19+982～k35+350	15.368	4.96×10^{-2}	45	59.04	142.62
03	Shilihe～dengta	k35+350～k45+888	10.538	5.09×10^{-2}	20	37.29	141.47
04	Dengta～Xiawangzhuang	k45+888～k62+954	17.066	5.11×10^{-2}	42	48.16	141.29
05	Xiawangzhuang～changuang	k62+954～k68+107	5.153	4.69×10^{-2}	18	70.43	145.18
06	Changuang～Dadaoying	k68+107～k91+561	23.454	4.86×10^{-2}	74	64.92	143.55
07	Dadaoying～Tengao	k91+561～k103+233	11.672	5.04×10^{-2}	35	59.50	141.91
08	Tengao～Dayu	k103+233～k127+403	24.170	4.85×10^{-2}	78	66.54	143.64
09	Dayu～Xiliu	k127+403～k132+656	5.253	4.78×10^{-2}	10	39.83	144.30
10	Xiliu～Huzhuang	k132+656～k149+049	16.393	4.21×10^{-2}	41	59.41	150.38
11	Huzhuang～Xingda	k149+049～k161+726	12.677	3.99×10^{-2}	51	100.83	152.09
12	Yingda～Yinggai	k161+726～k184+421	22.695	3.93×10^{-2}	72	80.73	153.87
13	Yinggai～Tuanshanzi	k184+421～k192+367	7.946	4.63×10^{-2}	17	46.21	145.78
14	Tuanshanzi～	k192+367～	6.258	4.54×10^{-2}	32	107.97	146.71

	Shagangzi	k198+949					
15	Shagangzi～Mianyuquan	k198+949～k209+877	10.928	4.52×10^{-2}	38	76.93	146.92
16	Mianyuquan～Xongyue	k209+877～k219+275	9.398	3.23×10^{-2}	10	32.94	146.70
17	Xongyue～Liguan	k219+275～k239+571	20.296	2.94×10^{-2}	21	35.19	170.39
18	Lliguan～Iutun	k239+571～k256+597	17.026	2.86×10^{-2}	37	75.98	206.28
19	Iutun～Natun	k256+597～k276+440	19.843	2.83×10^{-2}	50	89.04	207.03
20	Natun～Xiaojialu	k276+440～k296+483	20.043	2.53×10^{-2}	44	86.77	215.24
21	Xiaojialu～Zhuangshantou	k296+483～k306+177	9.694	2.70×10^{-2}	13	49.67	210.40
22	Zhuangshantou～Sanshilipu	k306+177～k331+317	25.140	2.82×10^{-2}	51	71.94	207.28
23	Sanshilipu～Jjinzhou	k331+317～k353+686	22.369	4.53×10^{-2}	81	79.93	178.13
24	Jinzhou～houyan	k353+686～k363+405	9.719	5.28×10^{-2}	66	128.61	170.37

Table 2. The Mortality Rate of Ten Thousand Vehicle of Black Spot and Rebuilding Order

Number	Mileage mark of	Accident	Number	Mileage mark of	accident
01	K161~K162	501.25	19	K339+700~K340+200	198.67
02	K363~K363+405	492.44	20	K348~K349	198.49
03	K192+400~K194	462.56	21	K4~K5	197.18
04	K173~K173+700	356.23	22	K79+500~K80+500	195.47
05	K284~K285	355.73	23	K64~K65	191.90
06	K317~K318	355.18	24	K358+K358+400	189.40
07	K332+700~K334+200	308.76	25	K179~K180+300	178.12
08	K68~K69	288.07	26	K10~K11	169.01
09	K200~K201	265.78	27	K133+900~K135+300	166.27
10	K322~K323	248.63	28	K138~K138+800	166.27
11	K327+500~K328+500	248.63	29	K145+K146	166.27
12	K14+800~K15+200	225.35	30	K114+K115	164.95
13	K19+500~K20+500	225.35	31	K122+K123	164.95
14	K343+800~K344+200	220.25	32	K32~K33	161.29
15	K257~K257+500	212.01	33	K35~K35+350	161.29
16	K263+K263+500	212.01	34	K203~K204	154.87
17	K274+500~K275+500	212.01	35	K71~K72	144.03
18	K159+500~K160+500	200.00			

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