The Method of Road Traffic Risk Assessment

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Abstract. In this paper, a method of assessing the level of road traffic risk sources is proposed. First, based on the key elements involved in road traffic safety, all risk sources are divided into two groups, namely the infrastructure-related risk source and the equipment-related risk source. Then, the risk source is further divided into four grades according to the damage that they could cause. Lastly, a LEC method is introduced to evaluate the influence of risk sources quantitatively.

1. Introduction

In recent years, risk management has developed rapidly and been widely applied. However, its application in the field of transportation is still in the initial stage, mainly focusing on the study of technical risks. With the frequent occurrence of road traffic accidents, the risk link in road traffic safety management has attracted worldwide attention. In China, traffic congestion and traffic accidents have seriously affected the development of China’s economy and society, so road traffic risk management is imperative$^{[1]}$[5]. Risk assessment of road traffic safety is an important part of traffic management. It is used to identify high-risk road sections and conduct comprehensive scientific analysis and assessment, so as to provide decision-making basis for traffic managers$^{[2]}$.

Road traffic safety risk assessment is based on the road traffic infrastructure and its traffic environment to the possibility of causing traffic accidents and severity evaluation$^{[3]}$. Road risk assessment is a quantitative and efficient decision-making tool for safety improvement. It is the application of risk management in the road safety industry. Compared with traditional post-accident treatment and analysis, it can be used in the whole process of road planning, design and operation.

Through road traffic safety risk assessment, the passive and delayed state of accident handling is changed, the uncertainty of risk occurrence is controlled at the source, and the theoretical basis is provided for the proposal of targeted measures for road traffic safety$^{[6]}$. This paper applies a risk management mechanism to road traffic safety management in order to make a breakthrough on the basis of existing theories and methods.

The main meanings are:

(1) It has enriched the research system of road traffic safety risk assessment mechanism. Overall, risk analysis and risk management level in our country is still in its infancy and mainly focused on the study of the technical risk. Although some areas began to promote individual departments phase of ascension into the government risk management ability, the systematic study of risk assessment mechanism is still the basis for the blank$^{[4]}$.

(2) To evaluate the risk situation of road traffic safety and study the public's perception of risk. It can provide a reference for the government to make public decisions on transportation$^{[4]}$. This paper will evaluate the road traffic safety risk situation and explore the risk sources to provide technical and material support for the government's traffic risk management.
(3) It is helpful to enrich the theoretical and empirical experience of the study on the risk assessment mechanism of road traffic safety. According to the results of the road traffic safety risk assessment mechanism, appropriate measures should be taken to ensure road traffic safety and reduce the occurrence of traffic accidents[7][8].

The paper is organized as follows. In section 2, a definition of road traffic sources is given, as well as a classification method and related indicators. In section 3, a LEC method is introduced, which can be used to assess the level of risk sources. In section 4, a conclusion is made.

2. Risk sources and assessment indicators

The risk source related to traffic safety is the elements involved in road traffic that could lead to casualties, environment damage, property loss, and negative social effect in some circumstances, including the fundamental infrastructures, the transport and storage equipment, and the objects of transportation. Risk sources may be internal or external to the system that is the target of risk management. Identifying risk sources provides a basis for systematically examining changing situations overtime to uncover circumstances that affect the ability of the project to meet its objectives.

To evaluate the safety state of road traffic, the managers need to identify all risk sources related to road traffic safety and evaluate them quantitatively, in which, for each type of risk source, a group of key indicators that can depict the main characters of them is necessary, which are known as risk assessment indicators. In this section, based on the key elements involved in road traffic, we divide the risk sources of road traffic safety into two groups, namely the infrastructure-related risk source and the equipment-related risk source. Meanwhile, a set of risk indicators is proposed to evaluate the state of them.

To be specific, the infrastructure-related risk sources are those risk sources that relate to the infrastructures in road traffic, such as roads, bridges, and tunnels. Meanwhile, the equipment-related risk sources are those risk sources that relate to the vehicles. The detailed information of the risk sources is shown as Fig. 1. Furthermore, the risk sources can be further divided into four grades to evaluate the level of risk sources, namely the serious risk, great risk, medium risk, and little risk.

![Fig. 1. An illustration of the risk sources related to road traffic](image)

3. LEC Risk Evaluation Method

LEC evaluation method is a semi-quantitative safety evaluation method for hazard sources in potentially hazardous operating environment, which was proposed by American security experts Kenneth J. Graham and Gilbert F. Kinney.

3.1. Introduction of LEC

The method is used to evaluate the risk of operator casualties by multiplying the values of the three factors related to system risk, which are L (likelihood), E (exposure) and C (criticality). Different scores are determined separately for different grades of the three factors, and then the product D (danger) of the three scores is obtained to evaluate the danger of the operation condition.
The higher the value of $D$, the greater the risk of the system, which calls for increasing safety measures, such as reducing the possibility of accidents, the frequency of exposure to dangerous environment as well as the loss of accidents, until it is adjusted to the allowable range.

3.2. Quantitative scoring standard

It is a tedious process to carry out objective scientific calculation on these three aspects and get accurate data. In order to simplify the evaluation process, semi-quantitative evaluation method is adopted. According to previous experience and estimation, these three aspects are classified into different grades and assigned values. The details are as follows:

3.2.1. The Probability of an accident ($L$). The probability of an accident or dangerous event is related to the probability of its actual occurrence. The probability of an absolutely impossible event is 0, and the probability of a certain event is 1. Considering the danger of a system, it is unreasonable that an accident is an absolutely impossible event, that is, it is not exact if the probability is 0. Therefore, the impossible situation is taken as the reference point of "scoring", and the score is set as 0.1. The value of event which is very unlikely to happen is 1, the score for an accident that can be predicted at some point in the future is set at 10.

| Score | The Probability of an accident          |
|-------|-----------------------------------------|
| 10    | Totally predictable                     |
| 6     | Quite likely                            |
| 3     | Maybe, but not often                    |
| 1     | Unlikely and accidentally               |
| 0.5   | Very unlikely but conceivable           |
| 0.2   | Highly unlikely                         |
| 0.1   | Practically impossible                  |

3.2.2. The frequency of exposure to hazardous environments ($E$). The more often and longer the operator is exposed to dangerous operating conditions, the greater the likelihood of injury. The score of exposures that occur continuously in potentially hazardous environments is 10, and the score of rare exposures that occur only a few times a year is 1. Taking 10 and 1 as reference points, the interval is divided according to the frequency of exposure in potentially hazardous operating conditions.

| Score | The frequency of exposure to hazardous environments |
|-------|---------------------------------------------------|
| 10    | Continuous exposure                               |
| 6     | Exposure during daily working hours               |
| 3     | Weekly or occasional exposure                     |
| 2     | Monthly exposure                                   |
| 1     | Several exposures per year                        |
| 0.5   | Very rare exposure                                 |
3.2.3. The consequences of an accident (C). Personal injury or material loss resulting from an accident or a dangerous accident may vary widely. The possible consequences of minor injury requiring rescue with a score of 1 as a baseline; The possible consequences of many people dying is given a score of 100 as another reference point. Then the detailed scores between 1 to 100 is determined:

| Score | The frequency of exposure to hazardous environments |
|-------|---------------------------------------------------|
| 100   | More than 10 people died                          |
| 40    | Three to nine people died                         |
| 15    | One to two people died                            |
| 7     | Serious                                            |
| 3     | Significant disability                            |
| 1     | Attention-getting                                  |

3.3. Risk analysis

After determining the scores of above three potentially dangerous operating conditions, the risk score can be calculated according to the formulation. Accordingly, the degree of risk is assessed according to the following criteria:

| The value of D | Risk level | Degree of hazard                          |
|----------------|------------|-------------------------------------------|
| > 320          | 1          | too dangerous to continue the operation   |
| 160～320       | 2          | Highly dangerous, requiring immediate      |
| 70～160        | 3          | Significantly dangerous, need to be rectified |
| 20～70         | 4          | Generally dangerous, need to be cautious   |
| < 20           | 5          | Slightly dangerous, acceptable             |

As a rule of thumb, a score below 20 is considered as low risk, which is safer than going to work by bike on a daily basis. If the risk score is between 70 and 160, there is a significant risk and it needs to be rectified in time. If the risk score is between 160 and 320, it is a highly dangerous environment that must be rectified immediately. A high score above 320 indicates that the environment is very dangerous and production should be stopped immediately until the environment is improved.

It is worth noting that the classification of risk level by the LEC risk evaluation method is to some extent based on experience, and its limitations should be considered when applying it.

Conclusion

In this paper, the risk management of road traffic is studied, in which the risk sources related to road traffic is divided into two parts, the infrastructure-related and the equipment-related. To assess the potential damage of risk sources, a set of assessment indicators are proposed. Meanwhile, a LEC method is introduced to assess and grade the risk sources. We believe that the indicators and assessment method we proposed could help managers to identify and evaluate road traffic safety risks effectively and improve the level of road traffic safety management.
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