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STANDARDIZED RESEARCH ON THE ANALYSIS AND EVALUATION OF SAFETY HAZARDS AT HIGHWAY INTERSECTION

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Highway intersections are an important part of road traffic, and are also areas prone to traffic accidents. Improving the safety level of highway intersections and reducing the occurrence of traffic accidents is an important issue in the field of road traffic safety at present. The causes of traffic accidents are multifaceted, in addition to the reasons of the traffic participants themselves, there are some potential safety impact factors in the design of highway intersections. This paper takes the highway level intersection as the research object, through summarizing the influence factors of the road level intersection with potential safety hazards, selecting the key factors affecting the safety of the intersection, establishing the level intersection safety evaluation index system, and grading the safety of the level intersection, and then giving the level intersection safety hazard assessment standards. For the causes of intersection traffic accidents and the hidden danger assessment standards to put forward relevant measures and improvement programs to improve the level of safety management and service at intersections, reduce the occurrence of traffic accidents at intersections, and provide a reference basis for management agencies.

Keywords: highway intersection, safety hazard, criteria for evaluation

1. Introduction

Highway intersections are important nodes and hubs for traffic flow on road sections and are key components of the road network. Although highway intersections occupy a relatively small portion of the entire highway network, they are the places where traffic accidents are more concentrated. Traffic accidents usually occur due to traffic participants, especially motorists inappropriate operation, errors, etc., but in practice, in addition to the reasons of traffic participants, our country highway intersection design there are also some potential safety impact factors. Because at present our country on the plane intersection design has not formed a complete design specification, most of the plane intersection is not entrance widening, design left and right turn lanes and set up safety islands and other channelization processing. Although some plane intersections set up drainage facilities, but failed to use reasonable right-of-way allocation and drainage methods for planning and design, and these imperfect facilities design are to a certain extent, affecting the operation of the plane intersection safety. In view of the above, this paper

selects the key factors affecting the safety of intersections, establishes a safety evaluation index system, divides the existing road intersections into safety hazard levels and determines the evaluation standards for the safety hazards of plane intersections, and puts forward the relevant solution measures and improvement programs, so as to improve the safety management and service level of plane intersections and reduce the occurrence of intersection accidents, and to provide a reference basis for the management organizations.

At present, many scholars at home and abroad have conducted more research on the safety evaluation and grading of road intersections and other aspects. Chen Shan used a combination of comprehensive literature method, data collection and data analysis to analyze the traffic characteristics of various types of traffic flows at intersections, summarized the evaluation indexes of operational efficiency of various types of intersections, and put forward the optimization scheme of intersections [1]. Yuan Li et al. analyzed the relationship between traffic flow and traffic conflict at intersections with and without signal control, proposed the concept of comprehensive impact coefficient based on traffic conflict to evaluate the traffic safety of highway level intersections, selected appropriate safety index factors, proposed a method to evaluate the traffic safety of highway level intersections by using the comprehensive impact coefficient k, and classified the safety level into 4 levels [2]. Wang Dunhong from the point of view of reducing the intersection conflict point, the critical mathematical model determined by the intersection of the phase setting experience as the basis for evaluation, to determine the intersection of the right-turn motor vehicle and the same side of the pedestrian should be set up in separate phases, if the results of the evaluation is reasonable then it can be used as one of the improvements to the dangerous intersections, which reduces the backwardness danger of the pedestrians [3]. Yan Taowei et al. conducted research on the safety evaluation system of signalized intersections, by studying the evaluation methods of urban road traffic safety at home and abroad and proposing a new evaluation model by combining the existing data and models [4]. Harwood et al. proposed a safety evaluation model algorithm for rural two-lane highways, which selected road traffic factors such as lane width, shoulder width and form, leveling curves, gradient, traffic density, left-turn lane control, traffic volume, and stopping sight distance as evaluation indicators. The algorithm can provide an evaluation basis for rural road improvement [5]. Based on summarizing the characteristics of rural T-intersections, cross-intersections and stop-controlled intersections, Vogt et al. proposed a rural highway safety conflict evaluation model, which takes the traffic volume, vehicle operation status, flat and longitudinal curves, stopping sight distance, and roadside conditions as factors affecting safety, and through which the safety conflict model is able to evaluate the safety status of intersections on different types of rural highways effectively [6,7].

In summary, these studies focus on the theoretical aspects of the analysis and modeling, and many theoretical studies are aimed at urban road intersections and lack of research on highway intersections. Therefore, according to the characteristics of highway intersection types, this paper analyzes the safety influencing factors, selects the safety evaluation indexes, establishes the evaluation system of highway intersection safety hazards, grades the safety of intersections, and gives the guidelines for evaluating the safety hazards of intersections.

2. Methods

2.1 Analysis of safety influencing factors at plane intersections

The safety hazards of plane intersections include subjective and objective factors, where objective factors mainly refer to factors related to the physical characteristics of the intersection itself, such as the traffic environment, the geometric characteristics of the intersection, etc.; subjective factors mainly refer to human-related factors, such as psychophysiological characteristics, driving behavior, and traffic safety awareness. Some studies have shown that the main cause of traffic accidents at intersections is subjective factors, roads, etc. are secondary factors, but this statement overstates the role of human factors in traffic accidents and ignores the tendency of road conditions to influence the role of traffic accidents in preventing (or inducing) traffic accidents. Soviet scholar Tivo Chikin concluded that poor road traffic conditions are the direct or indirect cause of 70% of traffic accidents [8]. It can be seen that the geometric conditions of the road is the main factor affecting the safety of plane intersections, but we cannot ignore the traffic control and traffic environment aspects of the safety impact factors, these are caused by the influence of unsafe plane intersections.

2.2 Determination of safety evaluation indicators for plane intersections

Since the concept of safety is intended more from the physical conditions of the intersection itself, the study of the level of traffic safety that the intersection itself can provide under normal traffic operating conditions [9]. Therefore, in this paper, the main consideration in the selection of intersection-based safety evaluation indicators is the objective factors, involving the following specific indicators:

1. Traffic Accident

All factors affecting intersection safety will eventually lead to accidents. The most direct way to express traffic safety is through the investigation of the number of traffic accidents occurring at level intersections over a period of time, statistical processing of the traffic accident data obtained from the investigation, and analysis of the intrinsic factors that exist therein, which is also one of the most commonly used indicators and methods for judging traffic accidents.

2. Traffic Conflict

Plane intersection traffic is complex, due to the objective existence of mixed traffic phenomenon, so in the intersection of the inevitable conflict, the existence of conflict points. As long as there is a conflict point at the intersection, the conflict point is the intersection of the actual traffic conflict and traffic accidents occurring at the root cause. According to the different traffic subjects, combined with traffic accident statistics records, the conflict point is identified as three categories: motor vehicles and motor vehicle conflict points, motor vehicles and non-motorized vehicle conflict points, motor vehicles and pedestrian conflict points [10].

3. Traffic Characteristics

At planar intersections, most of the traffic flow is motorized, and accordingly motorized traffic. But it does not mean that non-motorized vehicles and pedestrians are not important, in fact, some intersection accidents occur because of the intersection of pedestrians and non-motorized vehicles are relatively small, so that the driver relaxes his vigilance, when the sudden emergence of non-motorized vehicles or pedestrians, drivers do not have enough time to make a response to the vehicle cannot be stopped in a timely manner, resulting in traffic accidents. Intersection users of traffic awareness is weak, traffic management efforts and other aspects of the reasons, making the intersection of the traffic order chaos, vehicles and pedestrians driving inconvenience, safety hazards increase. Therefore, for motor vehicles, traffic volume can be selected as the influence factor of traffic flow; for pedestrians and non-motorized vehicles, pedestrian operating conditions and non-motorized vehicle operating conditions can be selected as the influence factor of traffic flow.

4. Traffic Physical Characteristics

The geometric alignment, sight distance condition, traffic engineering facilities such as signs and markings, lighting, and pavement of the roadway in the traffic safety impact area of a planar intersection are important data for evaluating its safety. Traffic physical characteristics are mainly selected as five indicators: road geometry, pavement attributes, signal control, signs and markings, and lighting conditions.

In summary, the indicator system was determined as shown in (Figure 1):

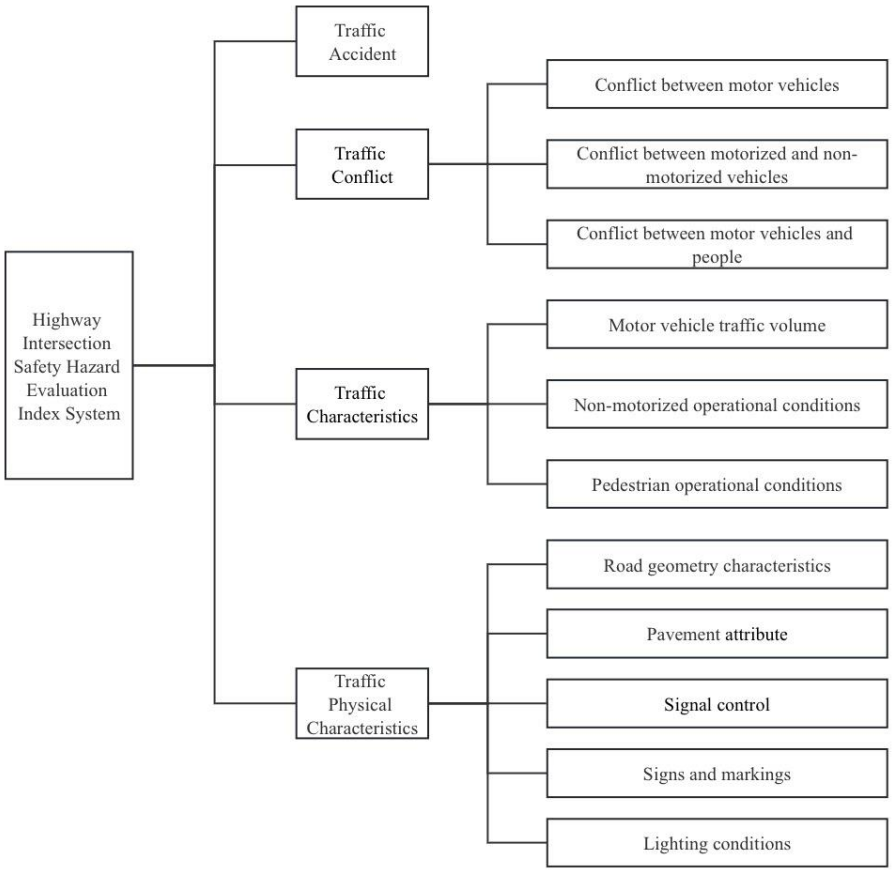

Figure 1 - Highway intersection safety hazard evaluation index system

2.3 Guidelines for evaluating potential hazards at plane intersections based on safety classification

In this paper, for the plane intersection traffic safety grading according to the level intersection of traffic accidents, roads, traffic flow, environmental characteristics and other factors characteristics, provides three grading methods, qualitative analysis based on intuitive discrimination method; quantitative analysis based on the calculation of the comprehensive accident index method; and qualitative and quantitative analysis of a combination of checklists listed in the checklist grading method, the degree of the level of safety and security needs of the intersection for safety and security work Grading. According to different standards, the traffic safety grading of level crossings is divided into four levels: I for little safety and security needs, II for less safety and security needs, III for more safety and security needs, and IV for more safety and security needs.

Highway intersection safety grading intuitive discrimination grading method, traffic accident comprehensive index grading method, checklist item inspection grading method have their own advantages and disadvantages, and there are differences in the applicable conditions, the intuitive discrimination grading method is used for the preliminary and rapid grading of intersections, which can quickly make preliminary conclusions about the safety level of intersections; the traffic accident comprehensive index grading method is suitable for the more

complete traffic accident records to the Traffic accident comprehensive index grading method is applicable to the more complete traffic accident record situation for more accurate grading of the intersection, and the result can indicate the actual operation status of the intersection at a certain stage; Itemized inspection method is used for more detailed and comprehensive investigation and analysis of the intersection, and the analysis result can be used for the safety diagnosis and improvement of the intersection.

Due to the different standards used in the three grading methods and the different reference factors selected, the results obtained by the three grading methods may be different, for example, the intersections that are dangerous by itemized inspection may not necessarily have a higher number of traffic accidents, or the intersections that have a higher number of traffic accidents may be scored relatively less by the itemized inspection results; therefore, the three methods should be used comprehensively in the grading of the safety of highway intersections with the following evaluation guidelines.

(1) In the absence of a record of traffic accidents, grading was performed using the visual discrimination method and the itemized checklist grading method, with the higher of the two grades being used as the safety level for the highway intersection.

(2) With the record of traffic accidents, considering the implementation of various methods, workload and other circumstances, it is recommended to give priority to the use of traffic accidents in the actual work of the comprehensive index grading method, which is at the level of III and IV intersections in the intuitive discriminatory analysis method and the classification method of the list of checklist grading, and finally integrated the three kinds of results of the discrimination, taking into account the accidental nature of the accident, as well as accidents with the volume of traffic and intersection conditions of the relationship between the use of the intersection of the comprehensive traffic safety grading method is as follows:

(a) The intersection safety levels obtained from the visual discrimination method and the itemized checklist classification method were first analyzed, and the higher of the two (the relatively unsafe level) was used as the preliminary value for the safety level of the highway level intersection.

(b) When the Intersection Accident Composite Indicator Method rating is the same as the preliminary safety rating, that value is the safety rating of the intersection.

(c) When the Intersection Accident Composite Indicator Method level differs by one level from the preliminary safety level, the higher level (the level of relative unsafety) is taken as the safety level of the intersection.

(d) When the intersection accident composite index method level is more than the preliminary safety level value of two or more, the intersection roadway accidents should be

analyzed in depth, to study the reasons for the occurrence of each accident and the relationship between the occurrence of accidents and the elements of the intersection, and to exclude accidents that do not have a direct relationship with the factors affecting the intersection to re-calculate the safety level of the intersection accident composite index method, and then to comprehensively determine the safety level of the intersection.

(e) When the preliminary value of the safety level is more than the intersection's Composite Accident Indicator Method level 2 or higher, the preliminary value of the safety level is taken to be one level less as the safety level of the intersection.

2.4 STATUS QUO INTERSECTION IMPROVEMENTS BASED ON SAFETY EVALUATION ANALYSIS

This paper selects a highway intersection in Henan Province, China, and analyzes its traffic safety hazards using an evaluation index system, and suggests improvements to the intersection based on the evaluation of the safety of the intersection.

The main safety issues obtained in response to the analysis and the proposed improvements to these issues are shown in Table 1:

Table 1

Main safety issues and improvements at intersections

Main Safety Issues	Measures to Improve Recommendations
Presence of objects affecting visibility within the intersection triangle	Increase turning radius; remove sight distance obstacles in the sight triangle; limit speeds; place warning signs in front of intersections
Heavy streeting of highways	Strictly enforce the separation of motorized, non-motorized and human; set up large reflective speed limit and intersection warning signs; set up mandatory speed bumps at both ends of the intersection
Intersections on or near larger longitudinal slopes	Addition of slope warning signs and speed reduction devices in the inlet direction
Intersections on or near flat curves	Increase turning radius; limit speed
Failure to provide necessary and reasonable channelization of intersections	Signal control is used for time; various traffic channelization measures such as pavement markings, traffic islands, guide islands, etc. are used for spatial
Failure to provide required pedestrian safety islands at intersections	Installation of additional pedestrian safety islands where conditions permit; generally through the installation of channelized traffic islands, medians and other areas can be used as a safety island for pedestrians to avoid vehicles when crossing the street
Unreasonable feeder access in the intersection area	Reroute feeder roads at intersections; close secondary feeder roads at intersections; close feeder roads within the functional area of an intersection or change feeder road access
Lane demarcation lines not applied	Strictly in accordance with the road design, intersection design, safety facilities specifications and other standards and norms to re-marking, as needed to add other instructions, warnings, prohibit marking; strict
Failure to install guide lane	

Failure to install parking lane	control of marking the use of materials, the use of materials that are not easy to wear and tear, prolonging the service life, reduce the frequency of renewal
Spalling of road markings	
Serious conflicts between pedestrians, bicycles and motor vehicles	The mandatory barrier improves pedestrian and non-motorized vehicle interference with motor vehicles while implementing secondary crossing measures for pedestrians and non-motorized vehicles
Intersections are not equipped with the necessary lighting, or the lighting is not bright enough	Installation of lighting fixtures; increase in brightness of lighting; correction of the manner or location of street lights; timely repair of broken lighting fixtures; installation of additional nighttime lighting fixtures

Countermeasures to improve traffic safety at planar intersections are multifaceted, but, in a comprehensive evaluation, improvements in signing and marking, signal setting, sight distance, and channelization are the main measures that yield large gains, cost little, and produce quick results; small improvements in these areas can bring about considerable safety gains, and they are the main ways to improve traffic safety at highway planar intersections in the near future.

3. Conclusions

This paper takes the highway intersection as the research object, through summarizing the influence factors of the highway intersection with safety hidden danger, from which the key factors affecting the safety of the plane intersection are selected, thus establishing the plane intersection safety evaluation index system, and then proposing three evaluation methods, namely, intuitional discrimination method, comprehensive accident index calculation method and checklist listing and checking classification method, and dividing the level intersection safety grading into the safety grading of plane intersections is divided into four grades. This paper analyzes the safety influencing factors of highway intersections, and then establishes a safety evaluation system and determines the evaluation safety grading standards according to the inspection indexes and safety influencing factors of intersections. Finally, taking a highway intersection in Henan Province of China as an example, it proposes relevant solutions and improvement programs for the causes of traffic accidents at intersections and the evaluation criteria for hidden dangers, to improve the safety management and service level of intersections and reduce the occurrence of traffic accidents at intersections. However, affected by some objective reasons or other factors, there are still some shortcomings: this paper intersection safety hazard grading, mainly based on the analysis of the comprehensive indicators of traffic accidents, and due to the fact that part of the road section intersections are more dense, the individual intersections are close to each other, there is mutual influence, it is difficult to differentiate between the relationship between traffic accidents and the specific intersections, which may have an impact on the grading results, the future research should take into account the distribution pattern of the road section intersections, and research on the

relationship between the distribution of accidents and the intersections to make up for the inadequacies of the safety grading of the plane intersections.

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TOWARDS SUSTAINABLE MOBILITY: DEVELOPING A GREEN TRANSPORTATION STANDARDS FRAMEWORK

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The purpose of this paper is to explore the key issues of sustainable transport and highlight the critical importance of developing a framework of green transport standards in achieving sustainable mobility. International cooperation on a global scale, such as the Global Sustainable Mobility Action Roadmap and the TM - World Bank, has been a key driver in promoting green transport. UN Secretary-General Antonio Guterres has made it clear that sustainable transport is