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Research Progress of Road Intersection Design Analysis

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ABSTRACT

Intersection is one of the most important components of urban roads, and traffic flow is the node that realizes route change. When the vehicle passes through the intersection due to the need for traffic flow route conversion, the driver can slow down, change lanes, park, steer. A series of tasks such as acceleration, etc., must be completed, and this process must be completed at the intersection and its neighboring area. Therefore, a number of traffic conflict points are formed at the intersection and its adjacent area, and the intersection between traffic flows in different directions, Traffic conflicts such as merger and direction change occur. Traffic characteristics of intersections are more complex than road sections, and road traffic bottlenecks and traffic accidents are frequent. Good design of intersections ensures safe and efficient operation of the entire road network. Based on the analysis of the serious causes of urban traffic problems, the importance of intersections in improving road traffic capacity, traffic jams and accidents is analyzed. The basic content, types, forms, advantages and disadvantages of intersections are analyzed in detail. Carry out a specific analysis of the crossover design method classified by the crossover point, and demonstrate the existing and unsolved problems.

Keywords : Road Intersection, Intersection Design, Analysis

I. INTRODUCTION

An intersection is a place where two or more roads intersect, allowing vehicles and pedestrians to gather, turn, and evacuate. Traffic control facilities such as traffic lights and other traffic management facilities are often installed at intersections to ensure traffic safety and smooth traffic. Correctly designing road intersections and rationally organizing and managing intersection traffic is necessary to improve traffic and ensure traffic safety. Therefore, the thesis briefly explains the concept, classification, merits and defects of various intersections that exist, and focuses on the recent intersection design method according to classification.

II. General understanding and classification of intersections

2.1 A serious problem in urban traffic

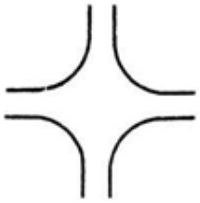
Intersections are the throat of the city's road network and are a frequent occurrence of traffic jams and accidents. For example, the travel time of motor vehicles in large cities in Japan in the city center occurs approximately at intersections, and more than half of traffic accidents occur at level intersections and surrounding US traffic accidents. The traffic problems at intersections in china are more serious. First of all, many cities in china have low road network density, excessively large distance between arterial roads, shortage of branch roads, and chaotic functions. They are low-level traffic systems that are difficult to meet the needs of modern automobile traffic. Secondly, many cities Due to the limited land area and small area of intersections, and there are a large number of non-motorized vehicles and pedestrians, motor vehicles, non-motorized vehicles, and pedestrians are often intertwined to form a mixed traffic flow, which seriously affects the traffic capacity of the intersection. Therefore, rational design of urban intersections, reasonable resolution of various existing problems, and resolution of traffic congestion and safety issues are important links in solving urban traffic congestion problems.

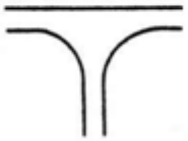
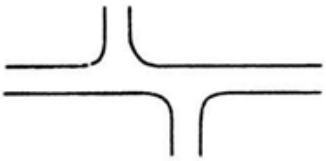
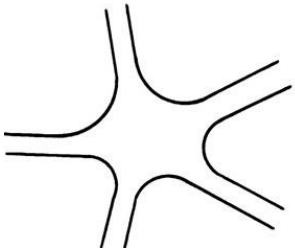
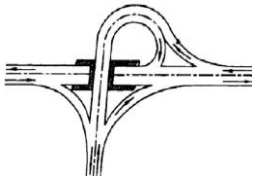
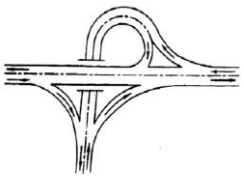
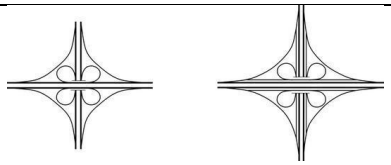
2.2 General understanding of intersection

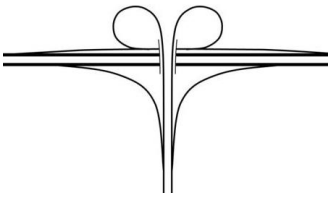
An intersection is the intersection of two or more roads. It is the necessary place for vehicles and pedestrians to gather, turn and evacuate. According to the number of intersecting roads, it can be divided into three forks, four forks and multiple forks. According to the way of crossing, there are plane crossing and grade crossing. In order to ensure traffic safety and smoothness, traffic control facilities such as signal lights and other traffic management facilities are often installed at intersections. Correctly designing road intersections and rationally organizing and managing intersection traffic are indispensable for improving traffic capacity and ensuring traffic safety.

2.3 Classification of intersections

Intersections are divided into plane intersections and grade intersections according to whether the roads intersect in the same plane. The main forms of grade separation and plan intersections and their comparative analysis are introduced below.

Type	classification	advantage	defect	General picture
Plan intersections	Crossing intersection	The form is simple, the traffic organization is convenient, the street corner building is easy to handle, the application scope is wide	There are many conflict points	
	X-intersection	Small footprint, low cost, and wide application range	High requirements for the sharp angle of intersection	
	Y-intersection	The construction cost is small and the area is small.	High requirements for intersection angle	

	T-intersection	Good visibility at intersections, safe driving	The traffic is small.	
	Staggered intersection	Maximize the use of existing resources	Short distance, insufficient interweaving length, and uneven traffic	
	Multi-road intersection	The traffic capacity is relatively high.	The direction of traffic flow is complicated, with many intersections, confluence points and diversion points	
	Roundabout intersection	No need to park, save time, reduce traffic accidents, improve driving safety, simple traffic organization, and increase beauty.	It occupies a large area, the vehicle speed is low, and the traffic capacity is not large. There 3are a large number of intersections, and the construction cost is higher than that of general level intersections.	
Grade separations	Underpass interchange	Less land occupation and less impact on urban space and surrounding environment	High requirements for drainage system design	
	Overpass interchange	The construction is more convenient, the cost is lower, because the excavation is small, the interference with the underground pipeline is small, and the drainage is easy to deal with.	The disadvantages are that the land occupation is large, the line bridge affects the sight and surrounding landscape, the approach road is long or the longitudinal slope is large, which is not conducive to non motor vehicle traffic.	
	separate grade crossing	The utility model has the advantages of less land occupation, simple structure and low cost	The vehicles on and off the road can't change with each other.	

	Interchange	The most perfect connection facilities in highway network	The cost is high, the land occupation is wide, and it has certain complexity in technology.	

2.4 Comparative analysis of grade separation and plane intersections

Grade separation uses space to separate the traffic flow, although it can avoid the formation of conflict points in the traffic flow at the intersection, reduce delays, ensure traffic safety, improve traffic capacity and transportation efficiency, and solve the problems caused by level crossing, but it cannot completely replace the plane intersections. First of all, the overpass project is huge, the construction cost is high, the area is large, and the construction period is long. Secondly, due to the nature of the intersecting roads, land occupation, project investment and other restrictions, it is impossible to construct all the interchanges, and sometimes it is necessary to build some of the interchanges. Type interchanges. This type of interchange retains part of the plane interchanges, and the problem of plane intersections still exists. Building an intersection in the city will also divide the city, affect the sunshine conditions of the neighborhood, interfere with electric waves, obstruct the line of sight, destroy the landscape, and bring pedestrians Inconvenience and other issues. Therefore, level intersections are still the main form of intersections in my country.

III. ROAD INTERSECTION DESIGN

3.1 Basic requirements and design classification of road intersection design

3.1.1 Basic requirements for road intersection design

- ✓ Correctly choose the form of the intersection and determine the geometric dimensions of each component;
- ✓ Carry out traffic organization and rationally arrange various traffic facilities;
- ✓ Check the sight distance of traffic at intersections to ensure safe visibility conditions;
- ✓ Intersection elevation design, arrangement of rainwater outlets and drainage pipes.

3.1.2 Design classification of road intersections

3.1.2.1 Intersection channelization design

① Basic principles of intersection channelization design

Separation principle: The channelization design should minimize the interference between different traffic flows, and guide traffic participants to follow the traffic method of lane separation and separation of mancar through traffic signs and markings, so as to promote each lane.

The principle of diversion: clarify the driving trajectory of different traffic flows, and divert the traffic flow through measures such as one-way traffic, changing traffic, dedicated lanes, and prohibiting left turns.

② Key Points of Intersection Channelization Design

- ✓ The entrance road is appropriately widened to match the traffic capacity of the road section
- ✓ Parking sight distance, curb radius, lane width meet requirements
- ✓ Using the canalized island to keep traffic flow smoothly and reduce hidden traffic hazards
- ✓ Set up pedestrian crossing safety islands and organize bicycle traffic reasonably

- ✓ Pay attention to the landscape of intersections, set up the greening of the intersections reasonably, and pay equal attention to functions and landscapes

3.1.2.2 Vertical design of intersection

① Basic principles of vertical design of intersection

- ✓ When the secondary roads intersect, the vertical and horizontal slopes of the main roads generally remain unchanged, and the vertical and horizontal slopes of the secondary roads can be changed appropriately.
- ✓ When roads of the same level intersect, the longitudinal slope is generally unchanged, and the transverse slope is variable.
- ✓ The design longitudinal slope of the intersection should not be too large, generally not more than 2%, and in difficult circumstances, not more than 3%.
- ✓ The vertical design elevation of the intersection should be coordinated with the elevation of the surrounding buildings.
- ✓ In order to ensure smooth drainage at the intersection, at least one of the longitudinal slopes of the road should face away from the intersection during the design.
- ✓ Reasonably determine the slope point and arrange the gutter.

② Key Points of Vertical Design of Intersection

- ✓ Grid square method:

In the area of the intersection, use the center line of the intersecting road as the coordinate baseline to create a 5m×5m or 10m×10m square grid, measure the ground elevation of each grid point, and calculate and determine the design elevation and the method of excavation and filling construction height That is the grid method. The square grid method is convenient for construction lofting, and is usually suitable for simple intersection design where roads are orthogonal or close to orthogonal.

- ✓ Design contour method:

The design contour method is to select the road ridge line and divide the elevation calculation line network within the design range of the intersection, calculate the design elevation of each point on the road ridge line and the elevation calculation line network, and finally draw the design contour line and calculate Find out the method of filling and digging the construction height at each point. Compared with the square grid method, the design contour method can more clearly reflect the actual terrain and vertical design shape of the intersection; however, it has the disadvantage that it is not easy to stake out the position of each point on the design contour. This method is commonly used in the design of general road intersections.

- ✓ Contour method of grid design

The grid design contour method is a combination of the first two methods, combining the advantages of the two. It first uses the design contour method to design and calculate, and then further uses the interpolation method to calculate the design elevation of each corner of the square grid, and marks the ground elevation and construction fill and excavation height of each corresponding point. The square grid design contour method is suitable for the vertical design of large and complex road intersections.

3.1.2.3 Traffic signal timing design

The timing design of traffic signals is an important link in the design of traffic channelization. How to set the phase sequence and timing reasonably, maximize the function of traffic lights, and improve the efficiency and safety of intersections, the setting of traffic signal lights generally follows the following principles:

- ✓ The number of traffic signal phases should be reduced as much as possible to increase the effective transit time within the cycle.
- ✓ Signal cycle duration Under the premise of meeting the minimum cycle (the time for the traffic flow to safely pass through the intersection), the non-motor vehicle peak period should be as small as possible.
- ✓ The signal timing design should be coordinated with the space design.
- ✓ The signal phase should be flexibly combined according to the actual flow and characteristics of the traffic flow
- ✓ Phase sequence design should follow the principle of minimizing lost time under the premise of ensuring safety.

3.1.2.4 Traffic organization design

- ✓ Vehicle traffic organization method

① Set up dedicated lanes:

Organize vehicles of different driving directions to drive in separate lanes on their own lanes without interfering with each other. According to the width of the lane and the traffic volume of left, straight, and right vehicles, various types can be made combined lane division.

② Traffic organization for left-turning vehicles:
Set up dedicated left-turn lanes; implement traffic control; change left-turning to right-turning.

③ Organize channelized traffic:
Draw lines on the lanes, or use green belts and traffic islands to separate the traffic flow, so that vehicles of various types and speeds can be like the water flow in the channel, without interfering with each other in the prescribed direction driving traffic organization.

Pedestrian and non-motorized vehicle traffic organization:

① Pedestrian traffic organization. The main task of pedestrian traffic organization is to organize pedestrians to walk on the sidewalk and cross the street safely within the crosswalk line to separate people and vehicles with minimal interference.

② Non-motorized vehicle traffic organization: at intersections, non-motorized vehicle lanes are usually arranged between motorized vehicle lanes and sidewalks; in intersections, non-motorized vehicles run on the right side according to traffic rules at random under normal traffic flow, and there is no separation facility ; When the traffic volume is large, separation belts (or piers) can be used to separate motor vehicles and non-motor vehicles to reduce mutual interference; when the traffic volume is large and the interference between aircraft and non-motor vehicles is serious, three-dimensional non-motor vehicles can be considered Train traffic organization and consider it together with pedestrian bridges or underpasses.

3.2 Road intersection design

3.2.1 Plane intersection design

The design research of this intersection is divided into two aspects: the practical part and the theoretical research part. The practical part is based on cross-design specifications, including design-related content. Theoretical research mainly analyzes the effectiveness and methods of design methods from the aspects of plane layout design and cross-sectional design.

① T-shaped intersection design

The VISSIM program was used to analyze the characteristics of changes in traffic performance measurement related to the composition of drivers of various age groups in the traffic flow. In addition, it was combined with micro-simulation output analysis through SSAM (Surrogate Safety Assessment Model) and for verifing the traffic collision, the actual

collision data is compared [1]. It was in the four intersection points of the delivery priority non-limited signal at the intersection of t analyzing the behavior of the receiving gap and the two-wheeled vehicle model [2]. Based on the analysis of the factors affecting the severity of the truck-related crash accident at the t intersection, four partial pro portional odds models including fxed and unfixed parameters were created [3]. Various types of approach behavior were generated at the t-intersection and analyzed according to cooperation readiness, priority driving preference, and safety of the situation through experiments [4]. Solutions and applied approaches to eliminate the risk of blocking the movement of road vehicles found at intersections are presented in the form of an animated uml-based model [5]. The influence of both the driver's intended operation and gap duration on the gap acceptance behavior at the stop control t-intersection using a driving simulator was specifically analyzed [6]. Literature [7] proposed a cellular automaton model to describe the traffic characteristics of unsignaled T-shaped intersections on crosswalks, and studied the characteristics of vehicle flow of various parameters. Various factors are optimized and analyzed for the minimum traffic delay at a three-phase T-shaped intersection [8].

② X–shaped, Y -shaped and Offset intersection design

Using the Vissim and Surrogate Safe ty Assessment models, the data extracted through the video graphic survey were analyzed in detail for the stability of the design at the T intersection and the x intersection using the pedestrian vehicle collision analysis (PVCA) method [9]. Literature [10] focuses on the dilemma of passing at Y-intersections, and uses Intelligent Traffic Point System (ITPS) to design and analyze the simulation system of Y-intersections. Under the influence of pedestrians, the new traffic rules at y intersections proposed a signal distribution formula and provided new ideas for the percentage of time passing through the intersection [11]. In offset intersection, a cellular automaton rule based on analysis of traffic collision process is proposed, and the relationship between road traffic flow and average speed is studied [12]. Literature [13] introduced that based on the sequencing strategy and pre-signal, the problem of low intersection efficiency can be solved at the left and right misaligned intersections through channelization and signal phasing, so that the separation distance is used as the signal to reduce the time loss in the signal cycle.

③ Cross-road intersection design

Age, physical ability, and spatial composition of the road were considered as major components of road safety, and the quality and risk of intersection were analyzed in detail [14].The effectiveness of the newly designed crosswalk sign was evaluated in consideration of the vehicle-pedestrian interaction [15]. In terms of efficiency and safety, a delay model was created and the crossing pattern was analyzed in consideration of traffic and diagonal pedestrian movement [16]. Considering the influence of the upstream signal intersection, the operational performance analysis of the reverse left turn lane (CLL) design was conducted [17]. In order to solve the problem of signal timing optimization at irregular four-step intersections, a new design method based on the calculation of lane design capacity based on the VISSIM program is proposed [18]. At signal intersections, most factors such as pedestrian characteristics (age, movement restrictions, etc.), traffic conditions and signal delays are comprehensively considered and modeled [19].

④ Roundabout intersection design

Environmental sustainability was analyzed by researching and comparing various construction techniques for the road grade, embankment and pavement at the roundabout Intersection [20]. Significant differences in emissions due to the type of

crossover control were analyzed through experiments at roundabout intersections using statistical methods [21]. A vehicle noise emission model considering the acceleration effect was created using an experimental method, and accordingly, traffic noise near the roundabout and signal intersection was studied [22]. Correlation with individual variables such as traffic mode and perception of carousel safety were evaluated, and processed and analyzed using the Ordinal regression method and the Multiple Correspondence Analysis [23]. Literature [24] introduced four relatively new alternative types of roundabouts-"turbo", "lower", "target" and "four cross-border" roundabouts and their design, capacity and traffic volume. Comparison-safe point. By applying the gap acceptance theory widely used in the capacity analysis of roundabouts, we analyzed how the frequency of priority violations varies according to traffic composition and volume, and created a model to examine it in detail [25].

⑤ Multiple intersection design

A new multi-intersection (MI-phase) was proposed and a scalable optimization frame was designed for actual traffic control optimization called the "Lagrangian decomposition using subproblem approximation" approach [26]. In order to capture the inner correlation between sequential traffic flow data, an algorithm was created using a new learning method that includes a relevance vector machine for traffic flow prediction [27]. A cooperative autonomous transport organization design method for CAVs in a multi-intersection road network was proposed [28]. Based on queuing theory and standard technology, a new multi-way intersection general traffic model was developed using M/M/1 single server [28]. Real-time traffic data from multiple intersections are used to analyze adaptive traffic control issues to ease congestion in terms of maximum throughput traffic flow and minimize delays while keeping all network traffic lights fair [29].

In summary, the research on the design of intersections in terms of vehicle passing capacity and pedestrian safety is basically completed. The research object is also based on a large area and few pedestrians, for research analysis and simulation. Without comprehensively considering the parameters in the design, the hypothesis is basically established. The VISSIM program is used for simulation, and the research content and analysis are very simple. The research object is also mainly automobiles, without comprehensive investigation of various factors related to intersection design such as pedestrians and bicycles.

1) 3.2.2 Interchange intersection design

The interchange area is a very critical area to improve vehicle and pedestrian capacity in a limited space. Research on the design of the interchange area is in-depth.

① Overpass and underpass grade separation

From the perspective of topology and beautification, the bridge and the upper-span intersection are studied, and the characteristics of the reinforced soil are analyzed to play a functional potential in the field of building structures [30]. Put forward the management and traffic adjustment methods to obtain the best solution, and use the vissim program to evaluate the adaptability of the intersection, and compare and analyze the analysis results and the modeling results [31].

② Separate grade crossing and interchange intersection

Combining the changeable design ideas and starting from the perspective of survey and design, several issues that should be paid attention to when optimizing the design plan are put forward to choose the best plan and give full play to its functions[32]. It was redesigned as Diverging Diamond Interchange (DDI) by increasing the demand for turning to the left, thus conducting an in-depth analysis of different factors that affect the sustainability performance

(operational and safety) of conventional exchanges[33]. Literature [69] proposed a new Offset Diamond Interchange (OD1) as an alternative design, which showed the potential to alleviate the limitations of service exchange failures related to transportation operations [34].

In summary, the design of interchanges is dominated by the geometric designof interchanges, but from the perspective of traffic flow design, ramp and flow line connection is the focus of current optimization design, and the matching of upstream and downstream traffi c capacity of intersections is also increasingly being af fected by people's concern.

IV. DISCUSSION

4.1 Basic problems at intersections

① Congenital lack of structure design

In many urban road networks, due to inadequate traffic forecasts, unfamiliar environment, and lack of understanding of the actual situation during the construction period of the road, the planning, geometry, and hardware facilities of the intersection are unreasonable during the design. The traffic congestion and chaotic vehicle operation in the intersection increase the risk of traffic accidents.

② Unreasonable management control

Inadequate traffic control at intersections is also one of the reasons for the prominent traffic problems at intersections. Due to improper or even lack of channelization measures, poor phase setting, unreasonable signal cycle design, and improper manual traffic management, the traffic at intersections will be confused.

③ People lack awareness of traffic

Among all the factors affecting traffic, the human factor is the most unstable factor. Because different individuals react differently to different traffic conditions, they have different impacts on traffic. Acts such as forcibly crossing the street, ignoring signals, and violating traffic laws have increased the burden on traffic operation at intersections.

4.2 Ways to improve intersection

① Intersection engineering renovation

A line type of the upstream and downstream sections of the intersection, the geometric line shape of the intersection itself, and the central separation belt shall be reconstructed to a certain extent to compensate for the inherent shortcomings of the intersection.

② Channelized traffic

Channelization means that in order to reduce and improve the staggered number and nature of traffic flow at intersections and intersections, appropriate settings are set at locations that are not used by normal traffic flow. The driving position of vehicles is specified, and vehicles are induced to drive in the normal direction to provide pedestrians with avoidance. At the parking lot, measures aimed at rectifying the traffic flow. It includes motor vehicle channelization and non-motor vehicle channelization, and non-motor vehicle channelization is divided into bicycle channelization and pedestrian traffic channelization. The specific measures adopted often include road markings and markings, physical traffic islands, turn left twice to cross the street, pedestrian bridges and underpasses.

③ Management measures

Intersection management uses the actual situation of each intersection to manage the intersection problem by formulating reasonable rules.

4.3 Development Outlook

Based on the analysis and research on the domestic and foreign intersection design, the multi-purpose optimization theory should be applied to the intersection design to optimize the design of the intersection with high traffic safety and traffic

efficiency, low accident rate, fast passage time, and high economic benefits. Here should comprehensively evaluate and consider various factors of traffic and intersection design, scientifically determine the evaluation table and design coefficients, and optimize the design of various intersections.

V. CONCLUSION

An intersection is the intersection of two or more roads. It is the necessary place for vehicles and pedestrians to gather, turn and evacuate. Correctly designing road intersections and rationally organizing and managing intersection traffic are necessary to improve traffic capacity and ensure traffic safety. Therefore, the thesis briefly explained the concepts, classifications, advantages, and defects of the various intersections that currently exist, and focused on the recent design methods of intersections according to classification. A detailed analysis was conducted on the design methods of various intersections, and the existing problems and problems to be solved in the future were analyzed. In addition, improvement methods of intersections and the development of future intersections were conducted through detailed analysis of various intersections. Briefly mentioned the prospects.

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