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Study on the Management and Planning Methods of Transportation to and from Primary and Secondary Schools in Urban and Rural Areas

Chengbo Gao

College of Transportation, Chongqing Jiaotong University, Chongqing, China

ABSTRACT

The transportation of urban and rural primary and secondary schools leads to traffic congestion in some sections, and the traffic order is chaotic, which seriously affects the travel of surrounding residents and greatly increases the additional traffic delay of pickup. How to effectively manage and plan the transportation of urban and rural primary and secondary schools and rationally plan the channelization of transportation roads have become a topic of great concern to the society. This paper will take several primary and secondary schools with representative traffic environment as the research object, analyze the behavior mechanism of the pick-up process, propose coping strategies for the school pick-up congestion problem under different road conditions, and plan a reasonable road channelization scheme and intersection design scheme. Finally, through the VISSIM simulation software, the proposed scheme and the original traffic environment are simulated and analyzed, and the vehicle delay before and after the improvement is compared, so as to find out whether the traffic planning and management scheme given in response to the school address in different traffic environments is reasonable. Through the simulation results, it is found that it is beneficial to reduce vehicle delay and avoid traffic jam by changing bidirectional to unidirectional on road section. In the vicinity of the intersection, one-way is the main way, and planning multiple drop-off points is helpful to solve the traffic congestion caused by school pick-up.

KEYWORDS

Urban and rural transportation; School shuttle management; Road planning and design; VISSIM simulation.

1. INTRODUCTION

With the sharp increase in the number of private cars in China, this situation also appears in various counties and towns. At the same time, due to the planning gap between urban and rural areas and cities, the transportation planning of urban and rural counties can not keep up with the amplitude of the skyrocketing number of transportation vehicles. By the end of 2023, the problem of road congestion during school trips in urban and rural areas is increasing. Now it is urgent to solve the traffic congestion caused by urban and rural primary and secondary school transportation, including energy consumption [1], emissions and pollution [2]. Only with more reasonable planning and more humane management can this problem be effectively solved from the root.

When it comes to the literature related to school transport, it can be summarized in the following aspects:

School pick-up policies and Regulations: The literature usually covers the details of the development and implementation of school pick-up policies. Including the scope of the school responsible for providing pick-up service, pick-up time and location, pick-up student groups, etc. The literature also includes the requirements and responsibilities of the school pick-up policy and its implementation for students and parents. Evaluation of the effect of school shuttle service: mainly focuses on the effect and influence of school shuttle service. It includes the survey data of students' and parents' satisfaction with the pick-up service [3][4], and the assessment of students' safety and health status under the pick-up service [5]. The influences of school shuttle service on students' academic performance, attendance and discipline were evaluated and analyzed in the literature. Economics and Management of school shuttle service: This literature focuses on the economic aspects and management mechanisms of school shuttle service. It includes the resources and expenses invested by schools in pick-up and drop-off services [6] and the economic benefit assessment of pick-up and drop-off services, such as encouraging green travel [7] and developing school bus travel [8], and reducing car travel. The literature also deals with the management process, staffing and organizational structure of school shuttle service. Safety and risk management of school shuttle service: These documents mainly focus on the safety and risk management of school shuttle service; For example, Singapore, Spain, New York, Beijing, Zhuhai and other countries and cities have successively issued "stop and turn off" laws to stipulate, require or advocate motor vehicles to stop and turn off on roads around schools [9], so as to reduce the damage to children's health caused by motor vehicle idle exhaust. Among them, New York stipulates that "non-stop parking" near public schools cannot exceed 60s[10]. Including the school's management of pick-up vehicles and drivers, safety measures for students to take pick-up vehicles, emergency plans and so on. In the literature, the security risks and risks in the school shuttle service are identified and management strategies are discussed. The summary of the literature is helpful for a comprehensive understanding of the policies, implementation, effects, economic management and security risks related to school transfers.

Wang Xu (2007) [11] chose the space inside and outside the primary school campus as the research object, and studied the problems existing in the existing internal space of primary schools in China by investigating the space, spatial form and constituent space of domestic primary school campus. Lin Zhen (2007) [12] mainly referred to and summarized the theories and practices of campus traffic development at home and abroad, and studied campus traffic at home and abroad. Based on the research of campus transportation system in foreign countries, this paper puts forward some optimization strategies of campus transportation planning and construction in China. Wu Jian and Wang Baohua (2014) [13] put forward measures such as strengthening traffic management to guide the traffic flow around schools, standardize residents' traffic behaviors, and reduce the impact of slow traffic flow on urban roads. Lu Huapu and Zhang Yongbo (2014) [14] put forward strategies and suggestions to solve students' travel problems through the study of traffic safety and the strategy of going to school nearby.

2. PROCESS ANALYSIS OF PICK-UP AND DROP-OFF BEHAVIOR

Studies have shown that lane change and lane occupying parking during the morning rush hour on weekdays will induce road traffic congestion [15]. The road traffic supply around the school cannot meet the demand for car travel, and there are problems such as parking difficulties on the road in front of the school, parking idle on the main and auxiliary roads occupied by the school, and safety risks for students to get off and walk to school [16]. In the process of primary and secondary school transportation, the main problems leading to traffic congestion are as follows:

1) Factors of road environment. At present, there are three kinds of relationships between school site selection and road selection. School site selection is located on the side of road and school site selection is located on the side of intersection (among which, intersection is divided into thong and cross road), because different road environment has obvious influence on the school pick-up behavior process. We will study these situations in depth through the guidelines. The other is the number of motor lanes on the road. The more the number of lanes, the more complex the lane change behavior. On the contrary, the more motorways there are, the more vehicles can fit into the road.

2) Human factors. Personal factors of drivers and passengers also have an impact on pick-up and drop-off behavior. The most obvious impact is on the driving habits of drivers and the disembarkation process of passengers and the way passengers block the flow of traffic behind them when they walk.

2.1. Road environmental factor

For school location, compared with schools near intersections, schools on road sections have fewer traffic conflict points and relatively simple driving environment in Figure 1. The main reasons for traffic congestion are lane change and parking. The school at the intersection is shown in Figure 2. The traffic environment is complex and there are many conflict points, which is more likely to cause congestion.

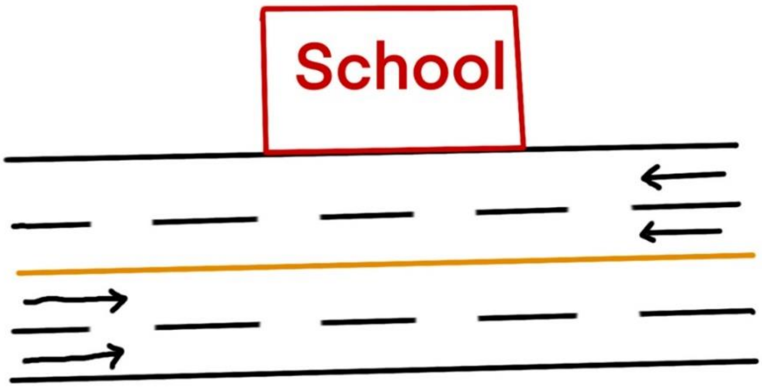

Figure 1. School location

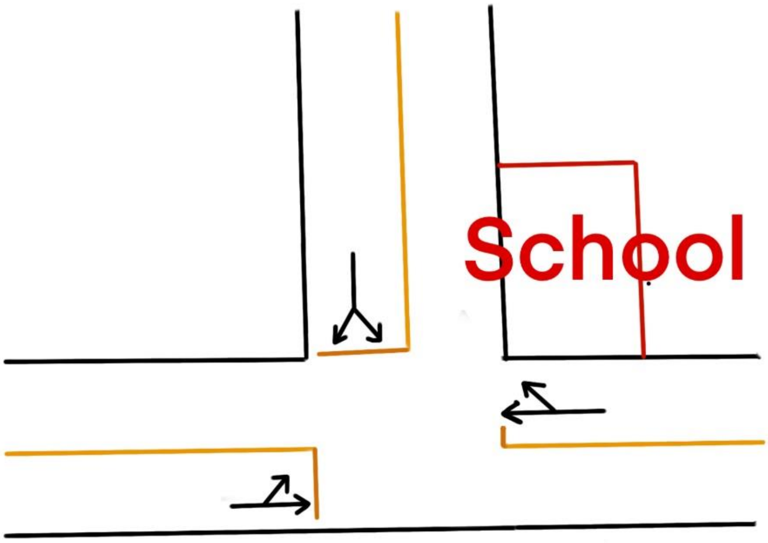

Figure 2. Location of school at intersection

Analysis:

When the school is located on the road, due to the influx of vehicles from only two directions, the traffic management only needs to enhance the traffic throughput of the two ports to reduce the delay on the road. In order to further control the traffic order, the two-way lane is usually changed into a temporary one-way lane.

When the school is located at the intersection, the situation is complicated, and the vehicles will enter the school by each intersection and stop near the school. Therefore, based on the principle of less vehicle direction conflict, the near school lane is planned as a one-way lane and auxiliary drop-off points are added, as shown in Figure 3.

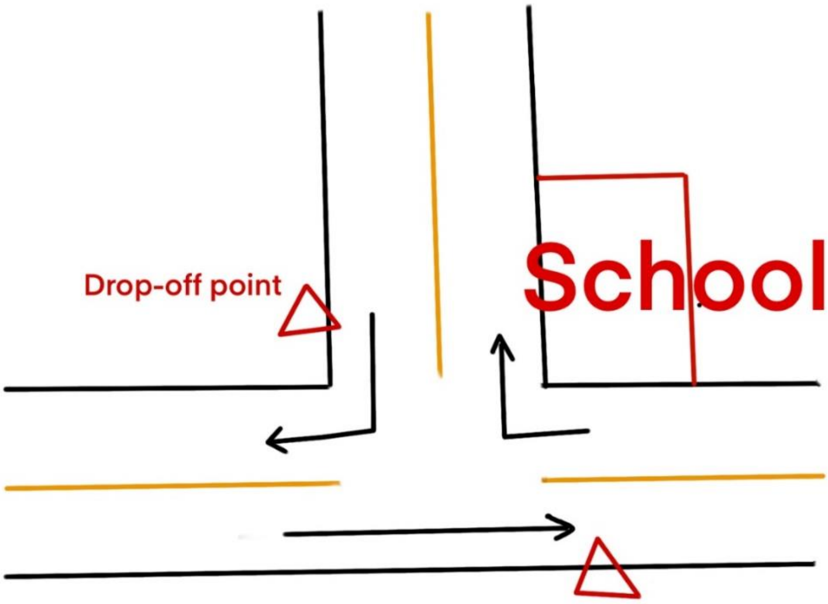

Figure 3. Intersection planning scheme

Another influencing factor is the number of lanes on a road section. The more lanes there are, the greater the amount of traffic received by the road section, but the more lane changing actions made by the vehicle stop. In this paper, two-way two lanes will be used as the basis of simulation.

2.2. Human factor

Human factors include drivers' driving habits and the time it takes passengers to get on and off the bus, etc. Human factors are the most difficult factors to control. For drivers, everyone will have different driving habits, such as the distance from the car, the speed of lane change behavior, and the speed at which the vehicle starts. Therefore, in the simulation process, this paper will use the default driving parameters of VSSIM.

For the passengers. The impact on traffic in the process of pick-up and drop-off lies in the time spent on getting on and off the bus. The longer the time spent, the longer the parking time of the pick-up vehicle, the longer the delay impact on the rear car. In addition, the process of passengers getting on and off the bus from school to school may also affect the overall traffic sequence.

3. VISSIM SIMULATION

3.1. VISSIM simulation built

PTV-VISSIM is a micro, time interval and driving behavior based simulation modeling tool for urban and public transport operations. It can analyze the operating conditions of urban traffic and public transportation under various traffic conditions, such as lane setting, traffic composition, traffic signals, bus stops, etc., and is an effective tool for evaluating traffic engineering design and urban planning schemes. Preliminary simulation modeling of school location selection at sections and intersections was conducted, as shown in Figure 4 and Figure 5.

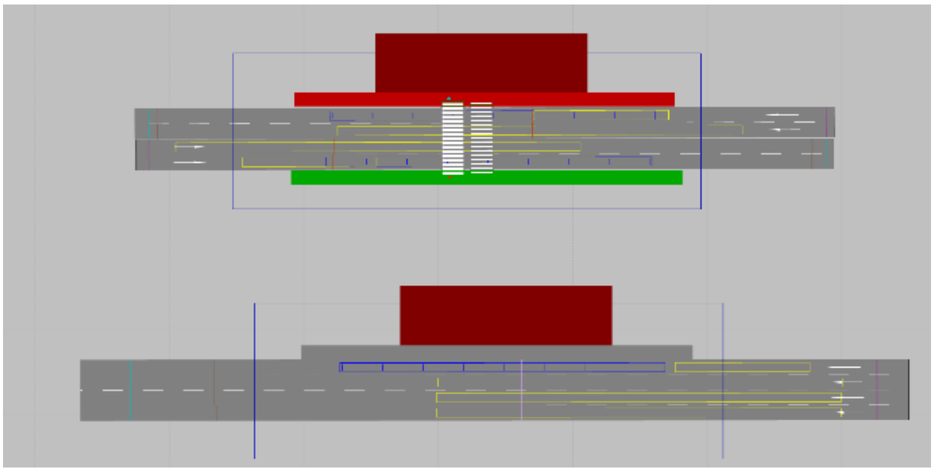

Figure 4. School location

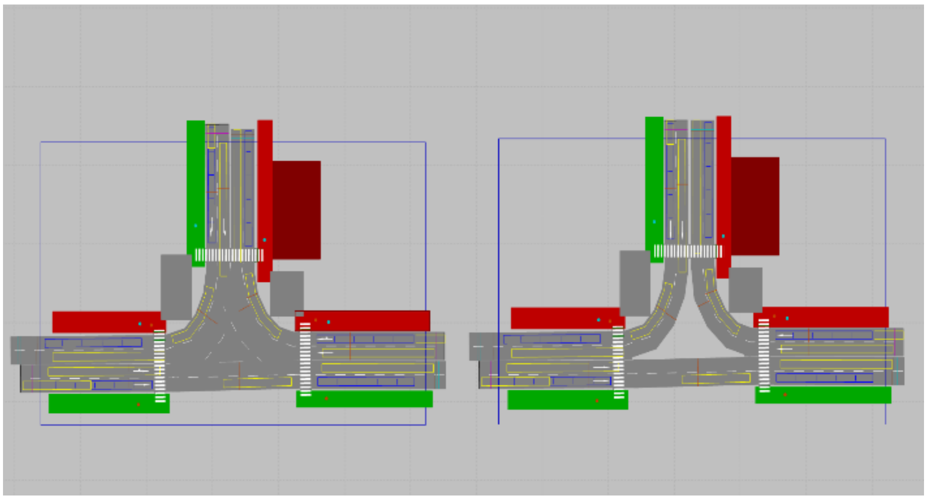

Figure 5. Location of school at intersection

In this paper, the simulation is done under the ideal environment, in which the pedestrian behavior and the driver's driving behavior are the basic templates of the system. In order to make comparability before and after the transformation, the traffic flow before and after is 1200pcu/h; The number of vehicles in the deceleration zone before stopping at the roadside is 5km/h; The expected speed for non-roadside lanes is 30km/h; The vehicle composition is 95% cars, 5% trucks; Pedestrians consist of only children. In addition, it also sets the comity of pedestrians and the maximum stop time to 60s.

3.2. VISSIM simulation results

By comparing and simulating the two traffic environments, the following results are obtained, as shown in Table 1 and Table 2.

Table 1. Economic Data Statistics

Node result							
Node number	Simulation time	Average queue length	Maximum queue length	Vehicle delay time	Per capita delay time	Number of stops	Oil consumption
1	0-3600	50.37	72.33	73.33	73.33	123	0.67
1	0-3600	32.12	54.78	62.34	62.34	116	0.44
1	0-3600	41.22	61.17	67.23	67.23	239	0.58
2	0-3600	22.34	33.54	31.57	31.57	122	0.42
2	0-3600	30.21	41.65	46.89	46.89	142	0.31
2	0-3600	21.56	27.63	23.54	23.54	114	0.19

Before the transformation, the fuel consumption of the whole vehicle was 1.69, the average queue length was 41.23m, and the per capita delay was 67.63s. After the transformation, the fuel consumption of the whole vehicle is 0.92, the average queue length is 24.70m, and the per capita delay is 34s.

Table 2. Results of intersection simulation comparison

Node result							
Node number	Simulati on time	Average queue length	Maximum queue length	Vehicle delay time	Per capita delay time	Number of stops	Oil consumpt ion
1	0-3600	84.31	98.32	73.33	112.65	157	0.77
1	0-3600	75.18	91.32	62.34	97.32	132	0.54
1	0-3600	62.55	71.17	67.23	83.21	133	0.78
1	0-3600	87.72	102.14	31.57	98.43	122	0.62
1	0-3600	63.35	72.64	46.89	79.32	109	0.72
1	0-3600	60.67	69.48	23.54	80.68	111	0.58
2	0-3600	63.65	79.32	57.34	57.34	137	0.62
2	0-3600	61.46	77.56	55.78	55.78	136	0.48
2	0-3600	70.13	87.34	69.12	69.12	127	0.62
2	0-3600	53.76	68.33	53.45	53.45	117	0.43
2	0-3600	52.15	62.26	58.18	58.18	108	0.55
2	0-3600	46.11	57.58	58.83	58.83	103	0.47

Before the intersection transformation, the average delay of the whole vehicle is 91.94s, the fuel consumption is 4.01, and the average queue length is 72.30m. The average delay of the whole vehicle after modification is 58.78s, the fuel consumption is 3.17, and the average queue length is 57.88m.

4. SUMMARY

After the simulation before and after the transformation through VISSIM, it can be concluded that it is correct to reduce road congestion by switching to one-way lanes when the school is located on the road. The results show that the average delay of the modified vehicle is reduced by 33.63s, the queuing phenomenon is significantly reduced, the average queuing length is reduced by 16.53m, and the energy consumption is reduced by 45.56%. When schools are located near intersections, single-lane lanes can be set up to reduce cross-conflict planning to reduce the delay in the process of school pick-up and drop-off. The results show that the average delay of the modified vehicle is reduced by 33.16s, the queuing phenomenon is significantly reduced, the average queuing length is reduced by 14.42m, and the energy consumption is reduced by 20.95%.

CONFLICTS OF INTEREST

The authors declare that they have no conflict of interest.

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