

Research on Campus Road Design Optimization: Taking Qishan Campus of Fuzhou University as an Example

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Abstract: This study focuses on the design optimization of the road system within the Qishan Campus of Fuzhou University, exploring its key role in promoting the development of the university and improving the quality of life of students. Through an in-depth analysis of the existing conditions of the campus and the study of related literature, a set of comprehensive improvement strategies are proposed, covering road widening, rational layout and efficiency of traffic signals, introduction of tidal lanes, optimal configuration of pavement markings, and adjustment of the street lighting system. In particular, a detailed case study on the application of tidal lanes has been conducted, and both practical observation and simulation assessment have confirmed the effectiveness of this scheme in shortening the travelling time of vehicles. The conclusion of the article reiterates that the above optimization measures have a positive effect on alleviating traffic congestion, enhancing road safety and improving the overall smoothness of traffic on campus, which provides a strong data support and theoretical basis for the future planning and infrastructure development of the campus.

Keywords: Road Transport; Design Optimization; Tidal Lanes; Campus Road; College.

1. Introduction

Campus road planning is a key element that directly affects the development process of the university and the daily life of the students, which is related to the organization and management of traffic, road layout, and ensuring the smooth flow of students and teachers. With the continuous expansion of higher education institutions and the increasing multifunctionality of campuses, the importance of scientific and rational campus road design has become more and more prominent, which profoundly affects the learning and living environment of the campus, educational practice and research activities in every aspect. A well-designed road system is not only an effective tool to alleviate the traffic pressure and improve the circulation efficiency of the campus, but also a cornerstone to maintain the smooth running of the daily operation and academic activities of the university. A well-planned road network not only relieves traffic congestion and speeds up traffic flow, but also significantly improves campus safety, reduces the risk of traffic accidents, and creates a safer and more efficient travelling space for all students and teachers. This paper explores the current situation of road design in Qishan Campus of Fuzhou University, aiming to deeply analyze the actual situation of existing design, reveal potential problems, and propose targeted improvement strategies accordingly. This study will help us to fully grasp the characteristics of the campus road system find out the bottlenecks and security risks and provide a solid scientific basis for future campus development planning. In this study, we will focus on the current situation of road design in Qishan Campus of Fuzhou University, with the help of field research, data analysis and other means, to gain an all-round insight into the actual application of campus roads, dig deep into the source of the problem, and then put forward a series of scientific and operational improvement steps, which is expected to provide a useful reference for the future planning of the design of roads in Qishan Campus of Fuzhou University.

2. Literature Review

Guo [1] has launched a wide-ranging exploration of the field of campus transport, deeply exploring the meaning of community transport theory and sustainable development theory. The thesis carefully analyses the implications of these theories in promoting the optimization of campus transport, covering four aspects: campus spatial layout strategies, coordination of dynamic and static transport systems, and improvement of traffic management. By summarizing the challenges faced by campus traffic and their root causes, and proposing innovative improvement strategies, the study provides valuable insights and guidance for the enhancement of the campus traffic environment in universities. Guan et al.[2] conducted a survey on the pedestrian flow on both sides of two typical sections of a road on Tongji University campus, and calculated the appropriate design width. On the other hand, the study by Gao[3] focuses on the optimization analysis of the campus pedestrian transport system with a focus on student travel patterns. Based on the actual situation of colleges and universities in Lanzhou City, the work of Ma[4] systematically examines the current situation of traffic organization on campuses of different sizes through field research and questionnaires combined with the use of post-assessment methodology, revealing the existing problems and exploring the construction of a harmonious co-existence of people and vehicles, especially for the characteristics of campuses of different sizes, and the results of the research have an important reference value for the planning of campus traffic in a similar situation in China. The research results have important reference value for campus traffic planning in similar situations in China. Ma[5] takes the campus of Xinjiang University as a specific case, using GIS-T technology to assist traffic planning, through the collection of on-site data, such as traffic flow and speed, the study points out in detail that the main road should implement effective diversion in order to maintain the smooth flow of traffic, and stresses the

importance of key intersections as traffic bottlenecks and safety hazards, and through the careful design of the three groups of closely linked intersections, successfully improve the efficiency of the road network of Xinjiang University. Through the careful design and modification of three sets of closely interconnected intersections, the operational efficiency of the NKU campus road network was successfully improved.

3. Analysis of the Current Situation on Campus

With the progress of society and the strengthening of the comprehensive strength of the Qishan Campus of Fuzhou University, the scale of the school shows an expansion trend, the number of students grows significantly, and the campus traffic system therefore faces more and more complex and severe challenges. In the meantime, the number of electric vehicles has risen sharply, which has become a prominent feature of the campus traffic field. This new situation puts forward higher requirements and new thinking directions for campus road planning and design.

The continued growth of the student population has contributed to a significant increase in student turnover on campus. As an institution of higher learning for academic research it attracts a large number of students who are thirsty for knowledge especially the flagship campus of Qishan Campus of Fuzhou University. Its huge student group has led to a high concentration of pedestrians and vehicles on the campus. This phenomenon is particularly evident during the peak hours of class frequently causing traffic jams or even jams on campus roads.

With the increasing popularity of electric vehicles in daily life their number on campus is also on the rise. This rapidly popular phenomenon undoubtedly improves the travel efficiency of teachers and students but also poses new challenges to campus management. The daily use of electric vehicles puts stricter requirements on the safety standards of campus roads especially in areas with heavy student traffic. How to make electric vehicles coexist harmoniously with pedestrians bicycles and other modes of transportation has become an urgent problem to be solved which needs to rely on more scientific reasonable and thorough road planning to ensure that all kinds of vehicles are shared orderly and safely on campus roads.

According to the specific situation of campus roads the primary challenge is poor traffic especially the road congestion caused by the dense flow of students during peak hours which directly affects the daily convenience of teachers and students on campus. This problem is not only related to traffic patency but also touches the core level of campus internal management and order maintenance.

Another major challenge in the field of campus road design is the unscientific configuration of intersections. Scientific and reasonable intersection planning is very important to ensure the smooth operation of the road network. On the contrary improper setting can easily cause traffic congestion and safety accidents. Through the implementation of intersection relay exit and efficiency improvement strategy not only can significantly improve the flow of the campus road but also can greatly improve its safety performance.

In addition we should also pay attention to the rationality of the campus road ground marking and street lamp configuration. The reasonable planning of ground markings is

directly related to the traffic rules of vehicles and pedestrians and improper layout of street lamps may lead to insufficient light in local areas which will increase the safety hazards of driving and walking at night. Through the implementation of scientific and reasonable logo planning and street lamp layout not only the overall safety of campus roads can be enhanced but also its beauty can be improved. In summary, the main challenges facing the road system of Fuzhou University Qishan Campus include the increase in the number of students, the increase in traffic flow caused by the surge of electric vehicles, traffic jams, the lack of reasonable design of intersections, the non-standard configuration of ground traffic markings, and the inappropriate setting of street lights in certain areas.

4. Optimization of Road Design

In response to the dilemmas faced by Qishan Campus of Fuzhou University in the area of campus road traffic, a set of systematic innovations in road design schemes have been proposed to effectively address the challenges posed by the significant growth in the number of students and the sharp increase in the number of electric vehicles. These innovative strategies are discussed in more detail below, not only in terms of their effectiveness in practice, but also in depth in terms of their potential impacts.

4.1. Road Width Widening

One of the key factors of traffic congestion on campus is often the existence of crowded road sections. In view of this, we propose a strategy to implement road widening in these bottleneck areas. By extending the lane width the purpose is to improve the efficiency of road traffic so as to effectively alleviate the problem of traffic congestion. In addition scientific planning of non-motorized vehicle lanes and pedestrian lanes to separate areas for electric vehicles bicycle users and pedestrians is another important measure to improve overall traffic smoothness. In addition road widening also helps to reduce the probability of traffic accidents and further enhance the safety of road use.

4.2. Setting and Optimization of Traffic Lights

In order to improve the traffic efficiency and safety level of the intersection, we propose to add traffic lights in this area. Scientific planning of traffic light control strategies can guide the flow of vehicles and pedestrians in an orderly manner thereby reducing congestion and accident risk at intersections. The use of advanced intersection intelligent management system according to the actual situation of the current traffic flow flexible adjustment so as to achieve the optimal allocation of traffic lights timing sequence improve the overall traffic fluency. The reasonable layout of traffic lights is not only the key to ensure smooth traffic, but also directly related to the intersection of safety maintenance and order management, so its optimal configuration has a multi-dimensional positive effect.

4.3. Tidal lane Installation

The introduction of tidal lanes is a strategy worth exploring to deal with the challenges of heavy traffic on campus and uneven daytime traffic. By adjusting the lane function over time the tidal lane mechanism skillfully adapts to the flow fluctuation which can optimize the traffic flow line and improve the overall traffic efficiency without changing the basic structure of the road. Specifically during peak traffic

periods some lanes are flexibly designated as tidal lanes to serve high-traffic driving directions thereby significantly enhancing the capacity of the road. This design innovation not only alleviates traffic bottlenecks, but also demonstrates the potential for smart use of existing infrastructure.

4.4. Ground Marking Adjustment

In view of the unreasonable layout of the existing ground marking lines, we propose adaptation modification and optimization. Reasonable planning of ground marking system plays a key role in maintaining vehicle and pedestrian traffic order. Through the fine setting of lane boundaries crosswalks and other elements it can not only enhance the awareness of road users to abide by the rules effectively restrain illegal behavior but also directly promote the improvement of traffic safety level. When implementing the ground marking adjustment strategy it is necessary to fully consider the actual situation and specific use needs of traffic flow in each region to achieve optimal traffic management and dredging efficiency.

4.5. Street Lighting Adjustment

In view of some areas with improper street lamp configuration some suggestions for adjusting the layout of street lamps are put forward. The reasonable configuration of street lamps has an important influence on the safety of driving at night and the smooth passage of pedestrians. By optimizing the layout position and light intensity of street lights the visibility inside the campus at night can be effectively enhanced thereby reducing the risk of traffic accidents.

Through a series of targeted road design improvement strategies we aim to significantly improve the traffic congestion on the internal roads of the Qishan campus of Fuzhou University and enhance the safety and flow of campus traffic. This promotion not only focuses on solving the current problems but also prospectively prepares for the expansion of the future campus development space and the subsequent increase in traffic volume and builds a solid foundation for the long-term development of the Qishan campus of Fuzhou University. Next we will take the tidal lane configuration as a typical representative to explore the optimization measures in-depth analysis of its benefits and practical significance.

5. Tidal Lane Setup and Analysis

In the field of campus traffic management, especially in those areas with high traffic and uneven distribution of daytime traffic, there is an ongoing challenge to be solved. To address this challenge effectively, we introduced an innovative design concept - the Tidal lane system. The system dynamically adjusts the lane function to meet the traffic needs of different periods of time thus realizing the flexible regulation of campus traffic flow and providing a solid support for improving the efficiency of the overall traffic management system.

5.1. Definition of Tidal Lane

Tidal lane is a design concept that dynamically adjusts some carriageway functions according to the peak and valley changes of road traffic flow. During heavy traffic hours these lanes will be designated in a specific direction to absorb the larger traffic volume in that direction thereby improving the overall traffic efficiency of the road. On the other hand during periods of low traffic these lanes showed flexibility and could

be converted to serve traffic in the opposite direction to meet the relatively small demand at the time.

5.2. Advantages of Tidal Lane

5.2.1. Optimizing Traffic Flows

The core competence of the Tidal Lane System lies in its ability to facilitate smooth traffic flow by dynamically adjusting the lane function without the need to physically alter the road structure. In the traffic control scenario of a school building, there is a significant difference in traffic flow between the morning and evening peak hours, with the former experiencing a surge in traffic while the latter is relatively sparse. By deploying the tidal lane mechanism, the road carrying capacity can be expanded within the peak hour framework, thus providing a powerful relief to the traffic bottleneck phenomenon.

5.2.2. Maximising the Preservation of the Original Appearance of Roads

Compared with the traditional road expansion method, the tidal carriageway design is more inclined to maximise the maintenance of the original state of the road. This not only reduces the ecological intervention on the campus, but also enables better control of traffic flow within the constraints of the existing road resources. This will have a positive effect on maintaining the aesthetics of the campus environment and its long-term sustainability.

5.2.3. Resilience to Flow Fluctuations

Given the significant fluctuations in traffic flow within the campus, the introduction of a tidal lane mechanism provides a more flexible response to such challenges. The method exploits the full potential of road resources by adding additional lanes during peak hours and dynamically adjusting the direction of travel during low peak hours. This flexible design strategy promotes intelligent road management and is well suited to the variable traffic conditions on campus.

5.3. Example Analysis of Tidal Lane Installation

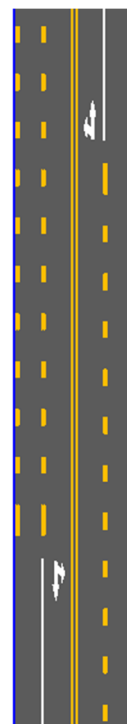


Figure 1. Schematic diagram of tidal lane setup on Wenyuan Road, Qishan Campus of Fuzhou University

Taking Wenyuan Road in Qishan Campus of Fuzhou University as an example, the road is a bidirectional four-lane road, and the outer lanes on both sides are specially tidal lanes, as shown in Figure 1.

5.3.1. Tidal Lane Setting Rules

During peak school hours, the tidal carriageway on the left from the teaching area to the living area is open to traffic travelling from the living area to the teaching area, and during peak dismissal hours, the tidal carriageway on the right from the living area to the teaching area is open to traffic travelling from the teaching area to the living area.

5.3.2. Field Observations of Tidal Lane Effectiveness

At Wenyuan Road (a key access road connecting the living area with the teaching area) in Qishan Campus of Fuzhou University, the location often faced traffic congestion before the installation of tidal lanes. In particular, the problem of traffic congestion became almost inevitable during the peak hours of school commuting, and the congestion was especially serious during the peak school drop-off period, often resulting in the road between the two intersections being so jammed that it often took several minutes for students to get through on their bikes.

However, the situation has obviously improved since the introduction of tidal lanes. The introduction of tidal lanes has provided an effective means of rationalising traffic flow, and although some congestion is still encountered at times, it is clear that traffic conditions have improved significantly compared to the past. Especially during rush hours, students cycling through the tidal lanes were able to pass relatively quickly and no longer had to wait as long as before. To a certain extent, the installation of tidal lanes has improved the efficiency of road traffic and brought about a positive impact on the improvement of traffic problems on campus.

5.3.3. Simulation Analysis of Tidal Lane Effectiveness

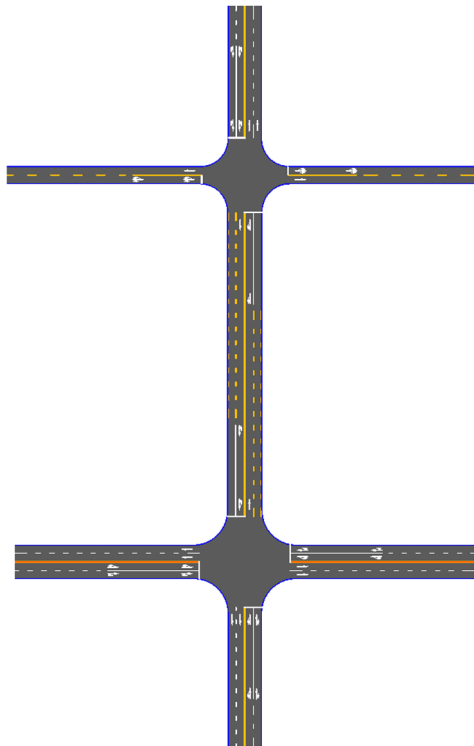


Figure 2. Tidal lane setting and surrounding road environment of Wenyuan Road, Qishan Campus of Fuzhou

Simulation analysis using VISSIM simulation software, as shown in Figure 2, the establishment of Wenyuan Road and the surrounding connected road network, respectively, in the absence of tidal lanes and the setting of tidal lanes to analyse the traffic conditions of Wenyuan Road in the peak hours of the school discharge, controlling the flow of traffic and the initial average speed and other variables are consistent, and measuring the travel time of the vehicle from the intersection of the teaching area to the intersection of the living area to 5min as a group to carry out Three consecutive groups of simulation simulation, the results are shown in Table 1.

Table 1. Average vehicle journey time between two intersections

Times	Time (s)		Percentage reduction %
	No tidal lanes	Installation of tidal lanes	
0:00-0:05	173.9	125.3	27.95
0:05-0:10	147.2	109.5	25.61
0:10-0:15	106.8	82.7	22.57
Average value	142.6	105.8	25.37

As can be seen from Table 1, the tidal lane setting in this road section has a significant effect on reducing the vehicle passing time during peak hours, and the average travelling time of vehicles between the two intersections within 15 min decreases by a percentage of 25.37%, so it can be assumed that the tidal lane at this location has a greater contribution to the improvement of the vehicular congestion, and that the tidal lane setting at this location has a better effect.

6. Conclusion

Through an in-depth study of the campus road design of the Qishan campus of Fuzhou University it is revealed that a scientific and reasonable campus road design is essential to the development of the school and the life of the students. In the face of traffic congestion and other problems in the campus, a series of optimization schemes are proposed, including road width widening, traffic light setting and optimization, tidal lane setting, ground marking adjustment and street light adjustment. Taking the tidal lane setting as an example through field observation and simulation it is proved that the scheme has achieved remarkable results in reducing the traffic time of vehicles. It not only promotes the smooth flow of traffic but also maintains the original landscape of the road to the maximum extent and realizes the effective adaptation to the fluctuation of traffic flow. Through the implementation of these improvement plans we expect to effectively alleviate the congestion of campus roads and enhance the safety and smoothness of campus traffic from two aspects.

At present the campus road design of most colleges and universities in China has not reached the ideal state and there is a large space for improvement. The design optimization of campus roads is not only necessary, but also far-reaching. It can provide scientific programs for improving the road environment, effectively reduce traffic bottlenecks, enhance road safety and traffic fluency, and help improve the school traffic management system and long-term development planning.

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